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The evaluation of displacement resistance of glass FRC posts to root dentine using a thin slice push-out test

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Abstract

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Aim To investigate and compare the displacement resistance of glass fibre reinforced composite (FRC) posts to root dentine after luting with different adhesive systems.

Methodology A total of 32 noncarious extracted human mandibular premolars were prepared for post-cementation using the FRC Postec system (Ivoclar Vivadent, Schaan, Liechtenstein) and divided into four groups ($n = 8$). The posts in each group were luted with one or other of the following materials. Group 1: Variolink II/Excite DSC (etch-and-rinse, dual-curing), group 2: Clearfil Esthetic Cement/ED Primer II (self-etch, dual-curing), group 3: Multilink/Multilink Primer (self-etch, chemical-curing) and group 4: Multilink Sprint (self-adhesive, dual-curing). Specimens were sectioned to obtain slices with the post in the centre and with the root dentine overlaid by the autopolymerizing acrylic resin on each side. The displacement resistance was measured using a Universal Testing Machine at a crosshead speed of 0.5 mm min^{-1}. The displacement resistance of the specimens were calculated and expressed in MPa. Data were analysed with one-way ANOVA and *post hoc* Tukey's test ($P < 0.05$).

Results Mean (SD) values of displacement resistance data in MPa are as follows: group 1, 12.08 (2.13); group 2, 12.39 (2); group 3, 11.3 (1.23); group 4, 14.29 (1.84). There were statistically significant differences amongst the groups ($P = 0.021$). A statistically significant difference was observed for the displacement resistance values between groups 3 and 4 ($P = 0.015$), that is between Multilink/Multilink Primer and Multilink Sprint.

Conclusions Glass FRC posts luted with self-adhesive luting system exhibited higher displacement resistance than when luted with chemical-curing self-etch luting system.

Keywords: etch-and-rinse, glass-fiber post, self-adhesive, self-etch.

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Introduction

Many root filled teeth require post- and core restorations due to extensive structural defects resulting from caries, access cavity preparation as well as further removal of root dentine during canal preparation (Toksavul *et al.* 2005). Posts can be classified into two main categories, custom/cast and pre-fabricated. Custom/cast posts are generally fabricated from metal alloys. Pre-fabricated posts can be subdivided into metallic and nonmetallic. The metallic group includes titanium alloy posts whilst zirconia ceramic, glass fibre-reinforced composites (FRC) and glass-ceramic posts constitute the nonmetallic varieties (Koutayas & Kern 1999, Stewardson 2001).

Glass fibre reinforced composite (FRC) post systems are composed of unidirectional glass fibres in a resin

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matrix that strengthens the structure of the post without compromising the modulus of elasticity (Goldberg & Burstone 1992). The main advantage of glass FRC posts is that their modulus of elasticity is close to that of dentine (Plotino *et al.* 2007). Additionally, they can be easily removed from the root canal when required. It has been reported that the risk of catastrophic fractures of functional teeth restored with glass FRC posts is less, compared with teeth that are supported with zirconia ceramic posts (Cormier *et al.* 2001, Maccari *et al.* 2003). Additionally, it has been shown that the luting of glass FRC posts to root dentine with adhesive luting systems increases retention (Bitter *et al.* 2006).

The technique sensitivity of luting procedures as well as the difficulties associated with determining the ideal luting material for the chosen restoration material raises problems for the clinicians (Hiraishi *et al.* 2007). The recently introduced self-adhesive resin luting cements require no pre-treatment of tooth surfaces, which simplifies the cementation procedure. The use of these cements has been recommended for luting procedures for metal-based and all-ceramic crowns as well as partial coverage ceramic and indirect composite restorations, with the exception of veneers.

Establishing an adequate displacement resistance between the post and the tooth is an important key point for clinical success. Several test methods has been applied to measure the displacement resistance including microtensile, pull-out and push-out tests (Goracci *et al.* 2007). The use of push-out tests for studying bonding to root canal dentine was first reported by Patierno *et al.* (1996). It has been stated that the major advantage of push-out test is that it better simulates the clinical condition (Sudsangiam & van Noort 1999). However, it has also been suggested that a highly no-uniform stress may be developed at the adhesive interface when the push-out test is performed on the entire post (Gallo *et al.* 2002) or on thick root segments (Patierno *et al.* 1996, Sudsangiam & van Noort 1999). The modification of this test technique, by reducing the specimen thickness, is termed a *thin slice technique* and this has been shown to be more advantageous (Goracci *et al.* 2004). Thin slice test techniques have been used rarely for the evaluation of the bonding capability of pre-fabricated glass FRC posts cemented with an adhesive luting system.

Therefore, the aim of this study was to investigate and compare the displacement resistance of glass FRC posts to root dentine after luting with etch-and-rinse, self-etch and self-adhesive luting systems using thin slice push-out test. The null hypothesis was that the use of different luting systems would not influence the displacement resistance of glass FRC posts to root dentine.

Materials and methods

The sample size was determined using data from previous studies which used the push-out test methodology (Bitter *et al.* 2006, Wang *et al.* 2008). According to the power calculation the number of specimens for each group was determined as 7.6 in order to detect a difference of 2.5 MPa with a power of 80% and an error probability of 0.05.

Caries-free, intact human mandibular premolar teeth recently extracted for orthodontic purposes from patients 18 to 25 years old were collected. A preliminary selection procedure was performed to identify teeth that had a length of 15 ± 1 mm between root apices and cemento-enamel junction on the buccal aspect of the crown. Additionally, teeth with curved roots and wide or atypically shaped root canals were eliminated. A total of 32 teeth that corresponded with the selection criteria were included.

All external debris was removed with an ultrasonic scaler. The teeth were stored in 0.9% saline solution at 4 °C and used within 3 months following extraction. Each tooth was marked at a distance of 14 mm from the root apex using a digital caliper to the nearest 0.01 mm (Mitutoyo Corp, Kanogawa, Japan). The coronal section of each tooth beyond this mark was removed perpendicularly to the long axis, using a slow speed diamond saw (Isomet; Buehler, Lake Bluff, IL, USA) under distilled water cooling. This resulted in root lengths of 14 mm for each specimen following this procedure.

The root canals were then shaped to size 60 using Hedström files (Dentsply Maillefer, Ballaigues, Switzerland). After irrigation with 2.5% NaOCl the canals were dried with paper points (Roeko, Langenau, Germany). Each root canal was filled using lateral compaction with Gutta-percha points (VDW, Munich, Germany) and sealer (AH Plus; Denstply, Konstanz, Germany). The roots were stored at 37 °C in distilled water for 1 week.

Prior to post placement, Gutta-percha was removed from the root canals with Gates Glidden burs, leaving 4 mm of root filling in the apical portion. The endodontic post used in the present study was a pre-fabricated conical shape glass FRC post (FRC Postec Plus). The root canals were then prepared with a drill of the same diameter and shape as the post that was available in the FRC Postec Plus kit (Ivoclar Vivadent) (Fig. 1). A length of 10 mm was ensured for each post hole in each root canal. The post holes were rinsed with distilled water and dried with paper points until the last paper point was dry. The teeth were then randomly divided into four groups of eight teeth according to the luting resin system to be used. The resin luting systems used in the present study are as follows: Group 1: Variolink II/Excite DSC (dual-cure, etch-and-rinse) (Ivodar Vivadent, Schaan, Liechtenstein), group 2: Clearfil Esthetic Cement/ED Primer II (dual-cure, self-etch), group 3: Multilink/Multilink Primer (chemical-cure, self-etch) (Ivodar Vivadent) and group 4: Multilink Sprint (dual-cure, self-adhesive) (Ivodar Vivadent) (Table 1). The manufacturer and the chemical composition of the resin luting systems are presented in Table 2.

Figure 1 Prefabricated glass fibre reinforced composite (FRC) post and corresponding drill.

Table 1 Groups in the study

Group	Luting agent	Dentine bonding
1	Varolink II	Excite DSC
2	Clearfil Esthetic Cement	ED Primer II
3	Multilink	Multilink Primer
4	Multilink Sprint	–

In group 1 (Variolink II, Excite DSC), the surface of the pre-fabricated glass FRC post was treated with a silane coupling agent (Monobond S; Ivoclar Vivadent) for 60 s and air-dried. Dentine was etched for 15 s with a 37% phosphoric acid (Email Preparator GS; Ivoclar Vivadent), rinsed for 20 s and dried with paper points. Dentine surfaces were left moist. The single-dose dentine bonding agent (Excite DSC) was activated and applied to both post surfaces and root dentine for 10 s. The bonding agent was air-thinned. Variolink II base and catalyst were mixed on a pad with a plastic spatula, and applied onto the post surface according to the manufacturers instructions. Each post was placed with slight vibration into the prepared root canal. Initial light-polymerization was performed for 10 s. Excess cement was removed with a dental probe. Air block gel was applied and luting agent was polymerized from a coronal direction using visible light with an irradiance of 480 mW cm^{-2} (Optilux; Kerr, Danbury, CT, USA) for 40 s.

In group 2 (Clearfil Esthetic Cement/ED Primer II), the luting surface of the pre-fabricated glass FRC posts are treated with a silane coupling agent (Clearfil Ceramic Primer; Kuraray Medical Inc., Tokyo, Japan) for 60 s and air-dried. Root dentine was also dried with air. Equal amounts of ED Primer II liquids A and B were mixed, applied to the root canal using a microbrush tip (Microbrush International, Grafton, WI, USA) for 30 s and the root canal was thoroughly air-dried. Clearfil Esthetic Cement Paste A and B (Kuraray Medical Inc.) were mixed using the dispenser syringe and applied onto the post surface. Polymerization was performed as for group 1.

In group 3 (Multilink/Multilink Primer), the preparation of the luting surface of the pre-fabricated glass FRC post was performed as for group 1. Multilink Primer A and B (Ivoclar Vivadent) were mixed. The primer was applied for 15 s into the root canal with a microbrush tip and gently air-dried. Equal amounts of Multilink base and catalyst were mixed on a pad with a plastic spatula and applied to the post surface. As Multilink is a chemical-cure luting resin cement, light polymerization was not performed.

Table 2 Materials used in the study

Material	Manufacturer	Batch #, Luting systems	Material composition
Varolink-2/Excite DSC	Ivoclar Vivadent Schaan, Liechtenstein	Etchant: J11093	37% phosphoric acid
		Excite DSC (dual-polymerizing single-bottle bonding agent): J12791	Phosphoric acid acrylate, dimethacrylates, HEMA, highly dispersed silicondioxide, ethanol, catalysts, stabilizers Microbrush: coated with initiators
		Cement base: J13724	Bis-GMA, UEDMA, TEGDMA, filler
		Cement catalyst: J13735	Bis-GMA, UEDMA, TEGDMA, filler
		Silane (Monobond S): J14325	3-methacryloxy propyl-trimethoxysilane, water, ethanol, acedic acid (pH = 4)
		Oxygen inhibiting gel: J08775	Glyserine, silica
Clearfil Esthetic Cement/ED Primer II	Kuraray, Tokyo, Japan	ED Primer A: 00232A	HEMA, MDP, water, accelerator
		ED Primer B: 00110A	Methacrylate monomers, water, initiator, accelerator
		Cement base: 0001AA	Bis-GMA, TEGDMA, other methacrylate monomers, silanated glass filler, colloidal silica
		Cement catalyst: 0001AA	Bis-GMA, TEGDMA, other methacrylate monomers, silanated glass filler, silanated silica,colloidal silica, benzoyl peroxide, di-camphorquinone, pigments
		Silane (Clearfil Ceramic Primer): 00001A	3-methacryloxypropyl trimethoxysilane, 10-methacryloyloxydecyl dihydrogen phosphate, ethanol
Multilink/ Multilink Primer	Ivoclar Vivadent Schaan, Liechtenstein	Primer A: H10145	Aqueous solution of initiators
		Primer B: H09713	Phosphoric acid acrylate, HEMA, TEGDMA, methacrylate modified polyacrylic acid
		Cement base: H12205	Dimethacrylates, HEMA, filler, *t*-amine
		Cement catalyst: H12205	Dimethacrylates, HEMA, filler, dibenzoyl peroxide
Multilink Sprint	Ivoclar Vivadent Schaan, Liechtenstein	Cement base: K05241	Dimethacrylates, Ytterbiumtrifluoride, glass filler, silicon dioxide, initiators, stabilizers and pigments
		Cement catalyst: K05241	Dimethacrylates, Ytterbiumtrifluoride, glass filler, silicon dioxide, adhesive monomer, initiators, stabilizers and pigments

GMA, glycidyl methacrylate; HEMA, hydroxyethylmethacrylate; UEDMA, urethane dimethacrylates; TEGDMA, triethylene-glycol-dimethacrylate; MDP, 10-methacryloyloxydegol dihydrogen phosphate.

In group 4 (Multilink Sprint), the preparation of the luting surface of the pre-fabricated glass FRC post was performed as explained for group 1. Multilink Sprint base and catalyst were mixed on the mixing pad with a plastic spatula, and applied onto the post surface. Polymerization was carried out as mentioned for group 1.

All specimens were stored at 37 °C in distilled water for 1 week. The most coronal tip of each post on each specimen was stabilized using sticky wax on a fixator (Degussa, Hanau, Germany) with vertically moving rods. Specimens were then embedded in autopolymerizing acrylic resin (Meliodent; Bayer Dental, Newbury, UK) surrounded by a plastic mould. The specimens were removed from the plastic mould after the first signs of polymerization. All specimens were stored in distilled water at 37 °C for 24 h prior to the sectioning. Four slices of 1 mm thickness from coronal third section of each root were obtained by sectioning the root with a slow speed diamond saw (Isomet; Buehler) under distilled water coolant (Fig. 2). Thus, a total of 32 slices were obtained for each group. The thickness of each slice was measured using a digital caliper to the nearest 0.01 mm to confirm accuracy and the value was recorded. Each slice was fixed with cyanoacrylate adhesive to a stainless steel platform with a central circular perforation. This assembly was placed under a metallic plunger with a diameter of 1 mm diameter to displace the post (Fig. 2). The thin-slice push-out displacement resistance was measured using a Shimadzu Universal Testing Machine Model AG-50kNG (Shimadzu Co., Kyoto, Japan) with a crosshead speed of 0.5 mm min^{-1}. The load was applied apicocoronally on the apical surface of the slices due to conical shape of the glass FRC post. The load at failure was recorded in Newton (N) by Labtech Notebook software version

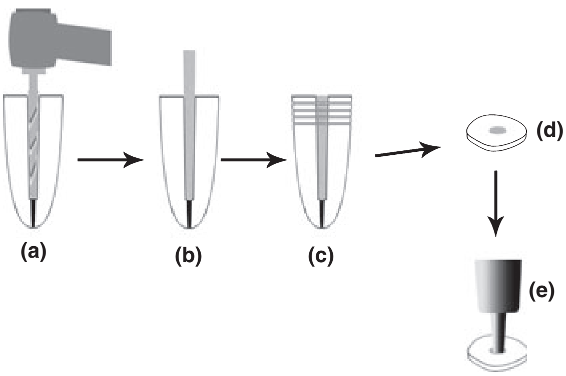

Figure 2 Diagram for specimen preparation. (a) Preparation of post hole using a drill, (b) luted glass FRC post in the root canal, (c) four thin slices from coronal part of root, (d) slice of 1 mm thickness, (e) push-out test.

6.3 (Labtech, Wilmington, MA, USA). Displacement resistance of each slice was calculated and expressed in MPa. Thereafter, a mean displacement resistance value for each tooth and then a mean for each group was calculated. The apical and cervical diameters of the root canal of each slice were also measured using a digital caliper to calculate the bond surface area. The bonding surface was calculated using the formula of a conical frustum (Fig. 3) (Bitter *et al.* 2006).

$$\pi(R_1 + R_2)\sqrt{(R_1 - R_2)^2 + h^2}$$

Failure mode evaluation

After the push-out test, specimens were evaluated to determine the type of failure using the Optical Microscope (Nikon ECLIPSE ME 600; Nikon Co., Tokyo, Japan) at 20× magnification and the images were analysed with the Image Analyzer LUCIA 4.21 (Labtech). Failures were classified as cohesive if more than 75% and adhesive if less than 25% of the luting resin remained on the tooth surface or mixed if certain areas exhibited adhesive fracture.

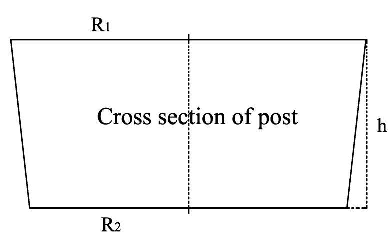

Figure 3 Bonding area of post-cement interface.

Statistical analysis

After assessing the normality of data distribution and homogeneity of group variances, the displacement resistance data were analysed by one-way ANOVA test using SPSS 15.0 (SPSS Inc., Chicago, IL, USA) for Windows. Pair-wise comparisons were performed with the Tukey's test. For the surface analysis data of fracture sites, the Chi-squared test was used. The statistical significance was set at 0.05 for all analyses.

Results

The mean and SD values of displacement resistance values for different luting systems are presented in Table 3. There were statistically significant differences between the four groups for the displacement resistance values ($P = 0.021$). Group 4 (Multilink Sprint) had the highest displacement resistance value followed by group 2 (Clearfil Esthetic Cement/ED Primer II), group 1 (Variolink II/Excite DSC) and group 3 (Multilink/Multilink Primer). The difference between the displacement resistance values for group 3 and group 4 was statistically significant in favour of group 4 ($P = 0.015$).

The failure modes for different luting resin applications are presented in Table 3. Adhesive failure type was the most common mode of failure observed. Most of the specimens in group 1, 3 and 4 had adhesive failures, whilst the distribution of mix and cohesive failures were similar for these groups. The specimens in group 2 had equal numbers of adhesive and mixed failures. No significant differences were observed for failure mode frequencies amongst different groups ($P = 0.097$). Pure dentine and pure glass FRC post-cohesive failures were not observed in the present study.

Discussion

The present study evaluated the displacement resistance between glass FRC post and root canal dentine using the thin-slice push-out test method. The manufacturer's instructions were followed when posts were cemented to ensure that the laboratory procedures were the same as those used clinically. The materials were selected because of different conditioning methods and modes of polymerization.

A variety of methods have been used to evaluate the displacement resistance in root dentine, including pull-out, microtensile and push-out techniques (Goracci

Table 3 Mean displacement resistance (MPa), SD and the modes of failure for all groups

Group	Failure mode					Force to displace (MPa)[a]	
	Adhesive failure between dentine and cement	Adhesive failure between post and cement	Mix	Cohesive failure composite	Cohesive failure dentine	Mean	SD
1	22	–	6	4	–	12.08	2.13
2	13	–	13	6	–	12.39	2.00
3	20	–	6	6	–	11.30	1.23
4	24	–	4	4	–	14.29	1.84

[a]A mean for each tooth and then a mean for each group were calculated in order to obtain the presented Force to displace (MPa) values.

et al. 2007). Push-out test resulted in a shear stress at the interface between dentine and cement as well as between post and cement (Van Meerbeek *et al.* 2003), which was comparable with the stresses under clinical conditions. The push-out test has also been reported to provide a better estimation of the displacement resistance than the conventional shear test due to the parallel occurrence of the fracture to the dentine-bonding interface which enabled performing a true shear test (Drummond *et al.* 1996). However, it should be noted that the use of conical posts in the present study may have impeded the push-out test described above. It has been reported that the thin slice push-out test is an important experimental tool to evaluate the mechanical properties of the interfaces (Goracci *et al.* 2007). The technique has been found to be reliable in bond strength evaluation of 1-mm thick samples (Jainaen *et al.* 2007) which decreases the area of friction and eliminates the risk of overestimation of displacement resistance compared with the use of thicker discs (Goracci *et al.* 2007). Another aspect that increases the risk of friction is the use of cylindrical posts (Wakefield *et al.* 1998). The conical FRC Postec plus posts used in the present study have a constant angle of 5°18′ along their entire length and therefore, friction is minimized by directing the axial force from the smallest to the largest diameter.

The selection of sample teeth (Jainaen *et al.* 2007), the post-space treatment (Erdemir *et al.* 2004), the region inside the root canal (Mallmann *et al.* 2005) and the preferred luting agent (Marques de Melo *et al.* 2008) have all been shown to influence the retention and displacement resistance of fibre posts in previous studies.

The adhesion of resins to sclerose dentine (older dentine) was less strong than to normal dentine due to repeated cycles of demineralization and remineralization (Yoshiyama *et al.* 1996). Therefore, only intact mandibular premolar teeth from patients aged no more than 25 years were used to minimize the effect of continued dentine deposition in older teeth (Jainaen *et al.* 2007). The root canals were rinsed using distilled water instead of NaOCl during post-space treatment. Chemical irrigants such as solutions of NaOCl have been used in previous studies to clean the post-space. However, the influence of NaOCl as an irrigation agent on the retention of fibre posts remains controversial. A negative effect of NaOCl irrigation on the adhesion of resin cement to intraradicular dentine has been shown in some studies (Lai *et al.* 2001, Morris *et al.* 2001, Erdemir *et al.* 2004). NaOCl breaks down into NaCl and oxygen and it has been suggested that the liberation of oxygen may inhibit the polymerization of resinous bonding materials and interfere with resin infiltration into demineralized dentine (Lai *et al.* 2001, Morris *et al.* 2001, Erdemir *et al.* 2004). A recent study reported that although the dentine surface was clean and the dentinal tubules had opened widely after irrigation with EDTA/NaOCl, the push-out strength of the EDTA/NaOCl group was not significantly different from that of the control group (water irrigation) (Zhang *et al.* 2008). The investigators did not recommend a single irrigation with an EDTA/NaOCl as a post-space treatment when luting a fibre post (Zhang *et al.* 2008). Another aspect that may raise concerns is the extent of light curing, which may influence the polymerization of decoronated specimens compared with clinically sound teeth. However, none of the resin cement systems used in the present study was light cure (three dual cure and one chemical cure) meaning that the polymerization of the cements did not depend only on light curing. Therefore, the polymerization was probably not significantly influenced by the nonexistence of the crowns.

The densities of dentinal tubules decreased significantly from coronal to apical root regions (Carrigan *et al.* 1984) which affects the thickness of the hybrid layer (Ferrari *et al.* 2000). This has been reported to negatively influence the displacement resistance of luting materials to root dentine, and higher displacement resistance values in the coronal section of the root canal were reported (Perdigao *et al.* 2004, Mallmann *et al.* 2005). The evaluation of the displacement resistance of fibre posts in different root regions was not the objective of the present study. Therefore, the influence of different luting systems on the displacement resistance of glass FRC posts was investigated and compared using four serial slices from each specimen at the coronal portion of root.

Thermocycling has been considered as an essential aspect of dentine adhesion testing in order to simulate clinical conditions. Purton *et al.* (2003) evaluated the effect of thermocycling on the retention of glass-fibre canal posts and reported no significant differences between thermocycled and nonthermocycled specimens regarding the forces required to cause post-retention failure. The authors suggested that it is unlikely that in normal use, patients will subject their tooth roots to thermal shocks of the kind used in thermocycling tests and that thermocycling should be given less emphasis in tests for the retention of root canal posts luted with resin luting cements (Purton *et al.* 2003). Mechanical cycling is another application that is performed to simulate clinical conditions. A negative influence of mechanical cycling on the displacement resistance of glass-fiber posts to root canal dentine was reported by Albaladejo *et al.* (2008). In the light of these findings test specimens were not completely restored and neither thermal cycling nor mechanical stressing was applied in the present study. These factors may limit the direct application of study results to clinical situations.

The results indicate that the displacement resistance value for self-adhesive resin luting cement system is significantly higher than it is for chemical-curing self-etch luting system (Multilink). The bonding mechanism of self-adhesive cements is not completely understood but differs from self-etch adhesives as no distinct demineralization and hybridization was observed during transmitting electron microscope (TEM) morphological interface examination (De Munk *et al.* 2004). Using the same self-adhesive resin luting cement a recent laboratory study reported that self-adhesive resin luting cement was unable to dissolve the smear layer completely (Monticelli *et al.* 2008). Additionally, in another laboratory study, the same adhesive resin luting systems as used in the present study were used to lute the ceramic to dentine surface. It was reported that the self-adhesive resin luting cement exhibited lowest bond strength value (Toman *et al.* 2008). However, several studies have reported that self-adhesive resin luting cements exhibited higher or the same displacement resistance value than etch-and-rinse and self-etch luting systems (Bitter *et al.* 2006, Zicari *et al.* 2008).

The demineralization of root canal dentine either with phosphoric acid or self-etching systems did not reveal any significant influence on bond strengths in the present study. Alcohol-based etch-and-rinse adhesive application which was also incorporated in the study has been recommended on moist dentine following the so-called wet-bonding technique (Tay *et al.* 1996). However, the degree of moisture cannot be controlled inside the root canal. According to a recent study; no significant difference between etch-and-rinse and self-etch luting systems was observed regarding the displacement resistance to coronal dentine (Frankenberger & Tay 2005). Contrary, in a laboratory study, etch-and-rinse dentine bonding system revealed higher displacement resistance in the coronal thirds of roots than a self-etch dentine bonding system (Marques de Melo *et al.* 2008).

In accordance with the manufacturer instructions; the luting resin cements were applied just onto the post surface and not into the root canal. No voids were observed in the microscopic evaluation of the root slices, however; bubbles were present in a few samples, which might have negatively affected the displacement resistance to root canal dentine. Using a luting cement of similar application, Mannocci *et al.* (1999) reported that many voids and bubbles were observed during microscopic evaluation of the specimens. Voids and air bubbles may impede an appropriate cementation of the post, thus causing its debonding (Ferrari *et al.* 2001). In a recent laboratory study, the investigators reported that the application of luting resin cement into root canal with lentulo spirals increased the displacement resistance of fibre posts (D'Arcangelo *et al.* 2008). Therefore, the use of lentulo spiral instrument may be an effective technique for reducing voids and bubbles within the luting agent (Vichi *et al.* 2002).

The difficulty of moisture control and the lack of direct vision into the root canal have negative influences on all bonding procedures. According to a recent investigation, degradation of collagen fibrils due to bacterial colonization, release of bacterial enzymes and host-derived matrix metalloproteinase in root dentine after clinical function may also negatively influence bonding to root canal dentine. Clinically, restorations rarely fail under an acute tensile or shear stress but failure often occurs after repeated subcritical loads (cyclic loading) well below the ultimate tensile strength of a material or the maximum stress that an interface can resist. Therefore, although statistically significant differences regarding the displacement resistance values were observed, the different resin luting systems used in the present may not show any differences in clinical practice.

Conclusion

Within the limitations of this laboratory study, the null hypothesis was rejected. The displacement resistance of glass FRC post to root dentine obtained with chemical-cure resin luting system containing self-etch dentine bonding was lower than that obtained with dual-cure self-adhesive resin luting cement. Although self-adhesive resin luting cements can make luting procedures faster and simpler, further investigations are needed.

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