Short Communication

Does the Thickness of the Resin Cement Affect the Bond Strength of a Fiber Post to the Root Dentin?

Bianca E. M. Perez, DDS[a]/Silvia H. Barbosa, MSc[b]/Renata M. Melo, MSc[b]/Sandra C. Zamboni, DDS[b]/ Mutlu Özcan, DMD, PhD[c]/Luiz Felipe Valandro, MSc, PhD[d]/Marco A. Bottino, PhD[e]

This study aimed to evaluate the influence of cement thickness on the bond strength of a fiber-reinforced composite (FRC) post system to the root dentin. Eighteen single-rooted human teeth were decoronated (length: 16 mm), the canals were prepared, and the specimens were randomly allocated to 2 groups (n = 9): group 1 (low cement thickness), in which size 3 FRC posts were cemented using adhesive plus resin cement; and group 2 (high cement thickness), in which size 1 FRC posts were cemented as in group 1. Specimens were sectioned, producing 5 samples (thickness: 1.5 mm). For cement thickness evaluation, photographs of the samples were taken using an optical microscope, and the images were analyzed. Each sample was tested in push-out, and data were statistically analyzed. Bond strengths of groups 1 and 2 did not show significant differences ($P = .558$), but the cement thicknesses for these groups were significantly different ($P < .0001$). The increase in cement thickness did not significantly affect the bond strength ($r^2 = 0.1389$, $P = .936$). Increased cement thickness surrounding the FRC post did not impair the bond strength. *Int J Prosthodont 2006;19:606–609.*

As opposed to traditional cast post and cores, fiber-reinforced composite (FRC) posts present the advantage of having an elasticity modulus similar to that of dentin (FRC = 40 GPa; dentin = 18 GPa; metal posts = 150 to 200 GPa), which reduces the risk of root fracture.[1]

FRC posts should be cemented using adhesive systems. Their tensile strengths depend on their adhesion to the root dentin through the resin cement. Some factors may affect the retention of FRC posts: *(1)* cavity configuration considering the root canal shape[2,3]; *(2)* difficult polymerization inside the root canal[2]; and *(3)* chemical incompatibility of the adhesive systems and resin cements.[4] Reduced shrinkage of the thinner resin-cement film results in less stress at the interfaces with the dentin and the post.[5] Therefore, the thickness of the resin cement may be a determining factor in the clinical performance of FRC posts. This may be even more important in situations with extreme loss of the root canal dentin, especially when endodontic treatment is repeated. To the authors' knowledge, no study has evaluated the effect of resin cement thickness on the bond strength of FRC posts to the root dentin.

Therefore, the objective of this study was to evaluate the influence of cement thickness on the push-out bond strength of an FRC post system to the root dentin. The hypothesis was that an increase in cement thickness would reduce the bond strength.

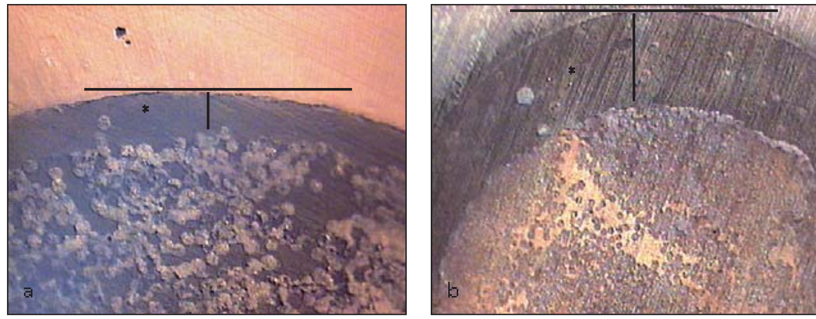
[a]Trainee, São Jose dos Campos Dental School, São Paulo State University, São Jose dos Campos, Brazil.
[b]Graduate Student, São Jose dos Campos Dental School, São Paulo State University, São Jose dos Campos, Brazil.
[c]Adjunct Professor, University Medical Center Groningen, University of Groningen, Department of Dentistry and Dental Hygiene, Groningen, The Netherlands.
[d]Associate Professor, Department of Restorative Dentistry, Federal University of Santa Maria, Santa Maria, Brazil.
[e]Chairman and Professor, São Jose dos Campos Dental School, São Paulo State University, São Jose dos Campos, Brazil.

Correspondence to: *Dr Luiz Felipe Valandro, Federal University of Santa Maria, Department of Restorative Dentistry, R. Marechal Floriano 1184, 97015-372 Santa Maria, Brazil. E-mail: lfvalandro@hotmail.com*

Materials and Methods

Eighteen single-rooted human teeth were cleaned with periodontal curettes and stored in distilled water. The coronal and root portions of the teeth were sectioned at the cervical level under cooling to standardize the length of the specimens at 16 mm. The canals were instrumented sequentially (Profile Orifice Sharpers System, Dentsply/Maillefer) and irrigated with 0.5% sodium hypochlorite.

Root canals were prepared with a low-speed calibrated drill (size 3) for a 2-stage parallel-sided cylindric quartz-FRC post system (Light Post, Bisco) (length: 20 mm; fiber type: 70% by weight pre-impregnated



Figs 1a and 1b Representative optical microscope images (×100) obtained from 2 samples to measure the cement thickness *(asterisks)*: **(a)** group 1; **(b)** group 2.

unidirectional quartz fibers in 30% by weight epoxy resin, $Ø_{fibers} \cong 12$ µm). The cemented post length was standardized at 12 mm.

After preparation of the root canals, 3 mm of the root portion was embedded in a polyvinyl chloride cylinder (height: 5 mm, diameter: 7 mm) using chemically cured acrylic resin (Dencrilay, Dencril) to facilitate immobility of the root during post cementation. The following procedures were performed during embedding: *(1)* grooves were prepared on the external apical portion of the specimens with a diamond bur (no. 3195, KG Sorensen) to provide mechanical retention of the specimens within the acrylic resin; *(2)* the preparation bur of the post system was placed inside the prepared root canal; *(3)* this assembly was attached to an adapted surveyor so that the long axes of the bur, specimen, and cylinder were parallel to each other and to the y-axis; and *(4)* the acrylic resin and its monomer were mixed and poured into the polyvinyl chloride cylinder.

Prior to cementation, the post surfaces were etched with 37% phosphoric acid for 1 minute, rinsed, dried, and silanized with silane coupling agent (Espe-Sil, 3M ESPE). The root dentin surfaces were conditioned with phosphoric acid 37% for 30 seconds, rinsed, and dried with paper points (#80). A multiple-bottle total-etch adhesive system (All Bond 2, Bisco) was then applied to the root dentin, as recommended by the manufacturer, using a microbrush (Cavi-Tip, SDI).

The 18 specimens were randomly allocated to 2 groups (n = 9) according to the thickness of the resin cement:

- *Group 1 (low cement thickness):* Parallel fiber posts of size 3 (Light Post, Bisco) ($Ø_{apical} = 1.4$ mm; $Ø_{middle\text{-}coronal} = 2.2$ mm) were cemented with dual-cure cement (Duolink, Bisco) and light polymerized for 40 seconds (Optilight Plus, Gnatus; light intensity: 500 mW/cm^2) by applying the light from the most superior part of the post.
- *Group 2 (high cement thickness):* Parallel fiber posts of size 1 (Light Post, Bisco) ($Ø_{apical} = 1.0$ mm; $Ø_{middle\text{-}coronal} = 1.4$ mm) were cemented with the same cement as in group 1.

Production of Specimens for Cement Thickness Measurements

The specimens were fixed to a metallic base in the cutting machine (LabCut 1010, Extec) and sectioned perpendicular to the long axis of the root with a diamond disk under cooling. Initially, a 0.5-mm cut was obtained and discarded. Thereafter, 5 samples with approximately 1.5-mm thickness were achieved.

Cement Thickness Evaluation

Photographs of the samples were taken with an optical microscope (Leica Mod DNRXP) (×100 to ×200). The images were analyzed in a computer. The resin cement thickness was measured using the software Image Tool 3.0 (Dental Diagnostics Science). The mean cement thickness (µm) of each sample was obtained from 4 measurements performed on 4 opposite sites of the sample. A virtual tangent line was traced, and measurement was performed perpendicular to this line (Figs 1a and 1b).

Push-Out Bond Test

Each sample was positioned on a metallic device measuring 1 cm in height and 2 cm in diameter, with a central opening larger than the diameter of the root canal. The most coronal portion was always turned downward (load direction: from apical to coronal). The push-out bond test was accomplished by pressing a metallic cylinder (tip diameter: 0.85 mm) onto only the post. Testing was performed in a universal testing machine (Emic DL-1000, Emic) at a crosshead speed of 1 mm/minute. The mean bond strength of each specimen was calculated from 5 samples per tooth.

The push-out bond strength (σ) (MPa) was achieved by the formula $\sigma = C/A$, where C = rupture load of the specimen (N), and A = the bonded area (mm^2). The bonded area was calculated using the following formula for calculation of the lateral area (A) of the

Table 1 Mean Cement Thickness (µm), Push-Out Bond Strength (MPa), and SDs for Groups 1 and 2

Group	Cement thickness*	Bond strength†	F	*df*	*P*
1	87.4 ± 49	8.57 ± 1.6	0.006	17	.936
2	316.7 ± 58	7.01 ± 2.7			

*Significant differences between groups ($P < .0001$).
†No significant differences between groups ($P = .5566$).

Table 2 Failure Modes of Specimens in Groups 1 and 2

	Failure mode		
Group	Type I	Type II	Type III
1	2%	95%	3%
2	1%	99%	–

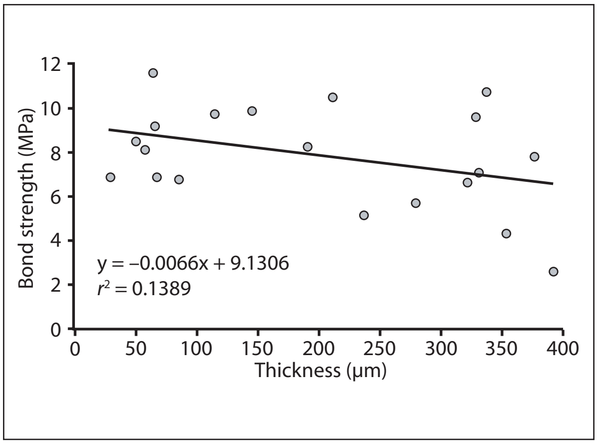
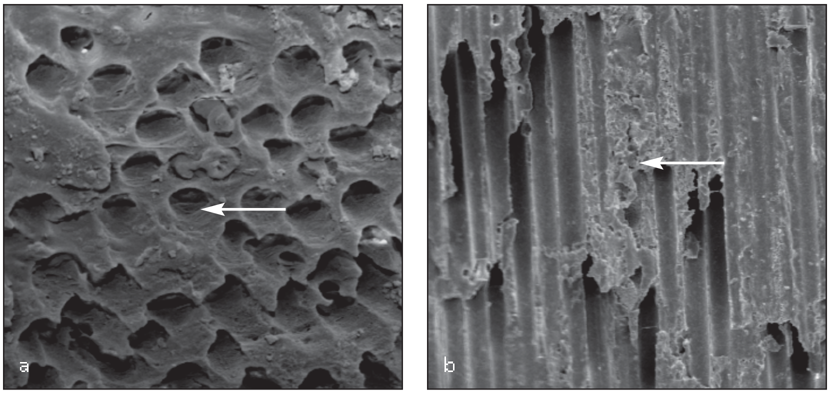


Fig 2 Scatter plots for the correlation between cement thickness and bond strength values.



Figs 3a and 3b Representative scanning electron microscope micrographs after the bond test. **(a)** Adhesive failure between cement and dentin (type I), exposing the root dentin surface; **(b)** adhesive failure between cement and post (type II), with exposed FRC surface.

cylinder: $A = 2\pi rh$, where $\pi = 3.14$, r = radius of the FRC post, and h = height of the sample as measured with a digital caliper. Since the sections did not incorporate the apical convergent part of the post, only the diameter of the cylindric midcoronal part was used for the surface area measurements.

Failure Type Analysis

All samples were further analyzed in an optical microscope (Leica Mod DNRXP) (×80), and failure types were classified as follows: type I: failure at the adhesive between the root dentin and the cement; type II: failure at the adhesive between the cement and the post; and type III: cohesive failure in the cement. The samples were sputter coated with gold-palladium (Desk II) for 2 minutes at a current of 10 mA for scanning electron microscope evaluations (×100 to ×5,000).

Statistical Analysis

Data regarding bond strength and cement thickness were statistically analyzed using analysis of covariance (ANCOVA) ($\alpha = .05$) and Pearson correlation analysis.

Results

The mean bond strength (MPa) values obtained in groups 1 and 2 did not show significant differences ($P = .558$), but the cement thicknesses for these groups were statistically significantly different ($P < .0001$, ANCOVA) (Table 1). The increase in cement thickness did not decrease the bond strength significantly, thus rejecting the hypothesis ($r^2 = 0.1389$, $P = .936$) (Fig 2). Predominantly, type II failure mode was observed in both groups (95% and 99% for groups 1 and 2, respectively) (Table 2 and Figs 3a and 3b).

Conclusions

1. Increased cement thickness surrounding the transparent unidirectional quartz-FRC post did not impair the push-out bond strength of the post to the root dentin.
2. The most frequently observed failure type was adhesive failure between the cement and post, indicating weak adhesion of the resin cement to the post.

References

1. Malferrari S, Monaco C, Scotti R. Clinical evaluation of teeth restored with quartz fiber-reinforced epoxy resin posts. Int J Prosthodont 2003;16:39–44.
2. Mallmann A, Jacques L, 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;30:500–506.
3. Bouillaguet S, Troesch S, Wataha JC, Krejci I, Meyer JM, Pashley DH. Microtensile bond strength between adhesive cements and root canal dentin. Dent Mater 2003;19:199–205.
4. Cheong C, King NM, Pashley DH, Ferrari M, Toledano M, Tay FR. Incompatibility of self-etch adhesives with chemical/dual-cured composites: Two-step vs one-step systems. Oper Dent 2003;28:747–755.
5. Alster D, Feilzer AJ, De Gee AJ, Davidson CL. Polymerization contraction stress in thin resin composite layers as a function of layer thickness. Dent Mater 1997;13:146–150.

Literature Abstract

Effect of core and veneer thickness on the color parameters of 2 all-ceramic systems

The purpose of this in vitro study was to evaluate the effect of varying core and veneer thicknesses on the color parameters of layered disk specimens made from 2 ceramic systems fabricated by different processing procedures. A pressable leucite-reinforced feldspathic core (IPS Empress, 2B shade) and a system using a glass-infiltrated magnesium aluminate spinel core (In-Ceram Spinell, A2 shade) were fabricated in 16-mm-diameter disks of various thicknesses for the study. The baseline measurements of the materials were the minimum required thicknesses of the ceramic systems. For IPS Empress, the baseline core was 0.8 mm and the veneer thickness was 0.2 mm. Additional specimens were made with increasing core/veneer thickness of 0.8/0.7, 1.0/0.5, 1.3/0.2, 0.8/1.2, and 1.8/0.2 mm. For In-Ceram Spinell, the baseline core thickness was 0.5 mm and the veneer thickness was 0.5 mm. Additional specimens were made with increasing core/veneer thicknesses of 0.5/1.0, 0.8/0.7, 1.0/0.5, 0.5/1.5, and 1.5/0.5 mm. Ten specimens were fabricated for each group for a total of 120 disks. Color parameters for each disk were measured using a tristimulus colorimeter on a neutral grey background. A 2-way-analysis of variance was used to investigate the effect of core and veneer thickness on the color parameter for each ceramic system. Linear regression analysis was used to evaluate the association between Delta E and total disk thickness for each system. The core and veneer thickness contributed to the color parameter of the specimens as follows: decrease in L* for In-Ceram Spinell ($P < .0231$), increase in a* and b* for IPS Empress ($P < .0028$), and increase in b* for In-Ceram Spinell ($P < .0272$). The Delta E increased with the increase of thickness of the ceramic materials ($P = .0236$).

Shokry TE, Shen C, Elhosary MM, Elkhodary AM. *J Prosthet Dent* 2006;95:124–129. **References:** 22. **Reprints:** Dr Chiayi Shen, PO Box 100446, 1600 SW Archer Road, Gainesville, FL 32610-0446, USA. E-mail: cshen@dental.ufl.edu—*Alvin G. Wee, OSU College of Dentistry, Columbus, OH*