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Relined Fiberglass Post: Effect of Luting Length, Resin Cement, and Cyclic Loading on the Bond to Weakened Root Dentin

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Clinical Relevance

Under mechanical stresses, the luting length is important for the retention of relined fiberglass posts luted to weakened roots with conventional or self-adhesive resin cements.

SUMMARY

This study evaluated the effects of luting length of the post, the resin cement, and cyclic loading on pull-out bond strength of fiberglass posts relined with composite resin in weakened roots. The canals of 80 bovine incisors were endodontically treated and weakened with diamond burs. The teeth were randomly divided into eight groups (n=10) according to the luting procedures of the relined fiberglass post (RFP): In groups 1, 2, 3, and 4, the RFPs were luted with RelyX ARC, and in groups 5, 6, 7, and 8 they were luted with RelyX U200. In groups 1, 3, 5, and 7, the RFPs were luted at a length of 5 mm, and in groups 2, 4, 6, and 8 they were luted at a length of 10 mm. Specimens from groups 3, 4, 7, and 8 were submitted to cyclic loading. Specimens were subjected to a pull-out bond strength test in a universal testing machine. The results (MPa) were analyzed by three-way analysis of variance and the Tukey post hoc test (α=0.05). Six human upper anterior teeth were used to analyze the bond interface by confocal laser scanning microscopy (CLSM). The pull-out bond strength of RFPs luted with RelyX U200 was statistically higher than that of RelyX ARC. Cyclic loading influenced the bond strength only for the luting length of 5 mm. CLSM analysis revealed the formation of resin cement tags for both materials. Luting length is an important factor in retaining RFPs in weakened roots when they are subjected to

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cyclic loading, and RelyX U200 resulted in greater bond strengths to the root canal in comparison with RelyX ARC.

INTRODUCTION

Fiberglass posts have a modulus of elasticity close to that of the remaining tooth structure and distribute the stress more evenly over the tooth in comparison with conventional cast post-core systems, thus reducing the risk of root fractures.[1,2] Prefabricated fiberglass posts do not always adapt perfectly to the root canals, and with compromised frictional retention, the cement is the only thing responsible for retention. Debonding of the post is the main reason for the failure of teeth that are restored with fiberglass posts.[3,4] Thus, one of the techniques proposed is to use fiberglass posts relined with composite resin, especially for the treatment of large root canals.[5]

Among the factors that determine the degree of post retention, the selection of the luting agent has been widely studied, and resin cements have shown positive results with respect to their mechanical properties and adhesive capacities.[6,7] Among the many resins that are available, the self-adhesive resin cements RelyX U100 and RelyX U200 have been shown to have greater bond strength values to root dentin compared with other materials.[8,9] However, many dentists still use resin cements requiring an adhesive system.

Another factor that may influence the retention of fiberglass posts is the length at which they are luted. Adhesion to the root canal walls is more difficult in the apical third as a result of the difficulty involved in controlling moisture and the ability to effectively cure the adhesive/resin cement.[10,11] As a solution to this problem, luting posts at shorter lengths into the canal has been proposed to eliminate the problem of polymerization at the apical region.[12] A recent study[13] has shown promising data for fiberglass posts luted with resin cements up to 5 mm deep into the canal. However, little is known about the performance of relined fiberglass posts luted with different resin cements in different lengths of luting after mechanical cycling, justifying additional studies to evaluate these issues.

Therefore, the aim of the study was to evaluate the pull-out bond strength between relined fiberglass posts and root dentin using two different luting lengths and two different resin cements with and without cyclic loading. The dentin-resin interface was also assessed by confocal laser scanning microscopy (CLSM). This study was conducted using the following null hypotheses: 1) the luting length, 2) the resin cement, and 3) and the cyclic loading do not influence the pull-out bond strength between the relined fiberglass post and weakened root dentin.

METHODS AND MATERIALS

Eighty permanent bovine incisors, extracted at the age of two years, with similar root sizes and lengths were selected. The teeth were cleaned of gross debris and stored in distilled water at 4°C. The water was changed every week, and the teeth were used within three months. The crowns of the bovine incisors were removed below the cemento-enamel junction with a low-speed diamond disc, and the roots were trimmed to a length of 16 mm. A step-back preparation technique was used for the endodontic treatment. The teeth were instrumented at a working length of 1 mm from the apex to a #55 master apical file. A step-back technique was performed with stainless-steel K-files #60 to #80 and Gates Gliden drills #4 to #5. All enlargement procedures were followed by irrigation with a 2.5% sodium hypochlorite solution. The prepared root canals were filled with gutta-percha cones using the lateral condensation technique and Sealer-26 resin sealer (Dentsply, Petrópolis, RJ, Brazil). After the endodontic treatment, the roots were stored at 100% relative humidity at 37°C for 48 hours, and the teeth were randomly divided in eight groups (n=10) (Figure 1).

The gutta-percha was removed with a heated Rhein instrument until it reached the set length of 5 mm (groups 1, 3, 5, and 7) or 10 mm (groups 2, 4, 6, and 8). To obtain standardized weakened canals, they were enlarged using a Largo drill #5 and high-speed conical diamond burs #4138 (larger and smaller diameter of 1.8 mm and 1.2 mm, respectively) and #4137 (larger and smaller diameter of 2.5 mm and 1.8 mm, respectively) (KG Sorensen, São Paulo, SP, Brazil) with water irrigation to a predetermined length (5 or 10 mm) that was controlled with silicone stops. The roots were embedded in a metallic cylinder with self-cured acrylic resin.

The fiberglass posts n.3 (Reforpost; Angelus, Londrina, Brazil) were etched with 37% phosphoric acid for 15 seconds, followed by silane application (Angelus, Londrina, PR, Brazil). A layer of the bond adhesive Scotchbond Multi-Purpose (3M ESPE, St Paul, MN, USA) was applied and light-cured for 20 seconds. The posts were then covered with composite resin Z350 (3M ESPE, St Paul, MN, USA) and inserted into the root canals that were previously lubricated with hydrosoluble gel (K-Y gel, Johnson &

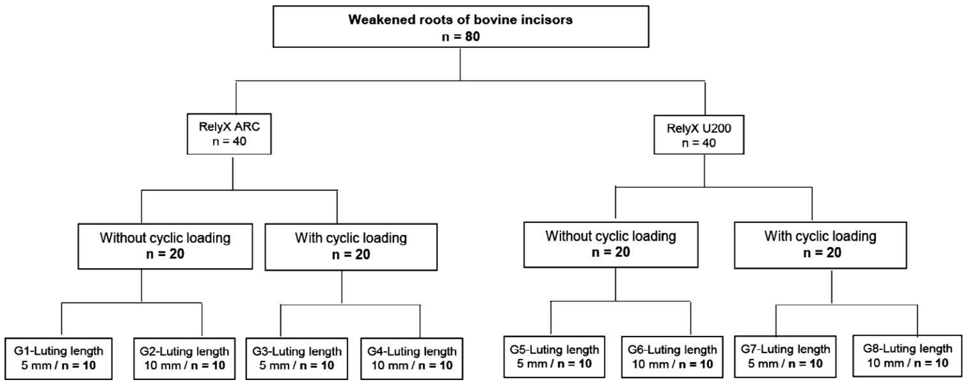

Figure 1. *Schematic diagram of the experimental groups and the sample size according to the resin cement, cyclic fatigue loading, and luting length.*

Johnson, São José dos Campos, SP, Brazil), light-cured for 20 seconds with the curing unit Radii Cal (SDI, Australia) with light intensity of 1000 mW/cm^2, removed from the canal, and light-cured again for 20 seconds. The canals were rinsed for 30 seconds to remove the hydrosoluble gel, followed by drying with absorbing paper points. The resin cements used in the present study and the luting procedures are described in Table 1. In groups 1, 2, 3, and 4, the relined fiberglass posts were luted with RelyX ARC, and in groups 5, 6, 7, and 8 they were luted with RelyX U200. In each relined post, a small notch was made in the composite resin of the coronal portion with a diamond bur to adapt the plunger of the mechanical cycling machine to the specimen.

The same luting procedures were performed for the two luting lengths, and the samples were stored at 100% relative humidity at 37°C for 24 hours. Specimens from groups 3, 4, 7, and 8 were first submitted to cyclic loading of 50 N at 45° using 1,000,000 cycles at 1 Hz in distilled water,[14] followed by the pull-out test. Specimens from groups 1, 2, 5, and 6 were subjected only to the pull-out test.

The pull-out test was performed at a cross-head speed of 0.5 mm/min using a universal testing machine (EMIC, São José dos Campos, PR, Brazil) with a 500-N cell load. The force required to dislodge each relined post was recorded in Kgf and converted to MPa using the following calculation:

$$A = \pi(R + r)\sqrt{h^2 + (R + r)^2}$$

where A denotes area, R indicates the larger radius of diamond bur 4137, r indicates the smaller radius of diamond bur #4137, and h indicates height.

Statistical analysis was performed by applying a three-way analysis of variance followed by the Tukey post hoc test at a 95% confidence level.

For the CLSM analysis, six human maxillary anterior single-rooted teeth were obtained after approval was obtained from the ethics committee (30904114.4.0000.5336). After disinfection with 0.5% chloramine for 48 hours, the crowns were removed with a diamond disc, and the length of the roots was standardized to 15 mm long. The endodontic treatment, the weakening of the roots at the 10-mm length, and the method for relining the fiberglass post were the same as those described for bovine teeth. Luting with RelyX ARC and RelyX U200 was performed in three teeth for each of the resin cements, as described in Table 1. Fluorescein isothiocyanate–dextran (Sigma Aldrich, St Louis, MO, USA) was incorporated into each bottle of Adper Scotchbond Multi-Purpose Plus adhesive system (activator, primer, and catalyst) (40 mg/mL). The dye was mixed directly into the supplied bottle using a mixing device (Vortex Machine, Scientific Industries, New York, NY, USA) for two hours to completely dissolve the dye. Rhodamine B (Sigma) was added to the base resin cement paste and mixed to obtain a paste of uniform shade (0.32 mg/mg).[15] After luting and storage in water at 37°C for 24 hours, 1-mm-thick slices were cut from the apical, middle, and cervical thirds of the root using a diamond disc mounted in a low-speed laboratory cutting machine (Labcut 1010, Extec Corp, London, UK) under cooling. The sections were stored in dark containers and then observed under the CLSM. The CLSM images (LSM 5, Zeiss, Jena, Germany) were obtained in dual fluorescence mode using 20×, 40×, and 63× objectives. An argon laser at 488 nm and He-Ne laser at 543 nm provided excitation energies. The sizes of the recorded images were $187 \times 187\ \mu m^2$ with a resolution of 1024×1024 pixels.

RESULTS

Analysis of variance showed that the resin cement (p=0.0001) and cyclic loading (p=0.0001) had a

Table 1: *Chemical Composition and Bonding Procedures for the Luting Resin Cements Investigated in the Present Study*

Resin Cement/ Manufacturer	Composition	Adhesive Strategy Curing	Dentin Pretreatment	Luting Agent Application
RelyX ARC/3M ESPE, St Paul, MN, USA	Paste A: Bis-GMA, TEGDMA, zirconia silica, pigments, amines and photoinitiator system; Paste B: Bis-GMA, TEGDMA, zirconia silica, benzoyl peroxide	Conventional dual-cure resin cement	The canal walls were etched with 35% phosphoric acid for 15 s, rinsed for 15 s, and gently air-dried. Excess water was removed from the canal with absorbent paper points. The Scotchbond Multipurpose Plus Activator was applied into the root canal with a microbrush of compatible size and air-dried for 5 s. Afterward, the Scotchbond Multipurpose Plus Primer, followed by Catalyst, were applied and air-dried.	The dual-cured resin cement RelyX ARC was mixed and placed over the relined post, which was inserted into the root canal with light pressure. The excess luting material was removed and light-cured for 40 s on the occlusal surface with a Radii curing light.
RelyX U200/3M ESPE, St Paul, MN, USA	Base paste: glass powder treated with silane, 2-propenoic acid, 2-methyl 1,1′-(1-[hydroxymetil]-1,2-ethanodlyl) ester dimethacrylate, TEGDMA, silica-treated silane, glass fiber, sodium persulfate and per-3,5,5-trimethyl hexanoate *t*-butyl; Catalyst paste: glass powder treated with silane, substitute dimethacrylate, silica-treated silane, sodium *p*-toluenesulfonate, 1-benzyl-5-phenyl-acid barium, calcium, 1,12-dodecane dimethacrylate, calcium hydroxide, and titanium dioxide	Self-adhesive resin cement	The root canal was rinsed with water; Excess water was removed from the canal with absorbent paper points.	The mixing tip with endo tip was attached on RelyX U200 Automix syringe. Application of RelyX U200 Automix cement directly into the root canal. The relined posts were inserted, excess cement was removed, and the remaining cement cured for 40 s on the occlusal surface with a Radii curing light.

Abbreviations: Bis-GMA, bisphenol A glycidyl ether dimethacrylate; TEGDMA, triethylene glycol dimethacrylate.

significant effect on the pull-out bond strength, while the luting length was not significant ($p=0.328$). The interaction between cyclic loading and luting length was significant ($p=0.0001$). However, the interaction between resin cement and cyclic loading ($p=0.123$), the interaction between the resin cement and luting length ($p=0.301$), and the interaction among all three factors ($p=0.225$) were not significant. Comparisons using the Tukey test are shown in Tables 2 and 3. The mean pull-out bond strength for RelyX U200 (6.47 MPa) was significantly greater than that of RelyX ARC (5.51 MPa) ($p<0.05$). For a luting length of 5 mm, the pull-out bond strength of the specimens without cyclic loading (6.98 MPa) was statistically superior to that of the specimens with cyclic loading (4.78 MPa) ($p<0.05$). For a length of 10 mm, there was no significant difference between the specimens without (6.17 MPa) and with (6.03 MPa) cyclic loading.

In the CLSM images, the formation of adhesive tags and resin cement tags for RelyX ARC (Figure 2) was observed, and resin cement tags for RelyX U200 (Figure 3) were visible. The resin cement tags in both were visible in the cervical and middle thirds of the

Table 2: *Pull-out Bond Strength Means (MPa) and Standard Deviations Between the Resin Cements[a]*

Resin Cement	n	Mean	Standard Deviation
RelyX U200	40	6.47 A	1.34
RelyX ARC	40	5.51 B	1.18

[a] *Different letters indicate statistically different means according to Tukey test ($p<0.05$).*

Table 3: *Pull-out Bond Strength Means (MPa) and Standard Deviations Between the Different Luting Lengths Without and With Cyclic Fatigue Loading[a]*

Luting Length mm	Cyclic Fatigue Loading	n	Mean	Standard Deviation
5	Without	20	6.98 A	1.18
	With	20	4.78 B	1.32
10	Without	20	6.17 A	0.88
	With	20	6.03 A	0.99

[a] *Different letters indicate statistically different means according to Tukey test ($p<0.05$).*

root canals. Hybrid layer formation was observed in the cervical (Figure 2b), middle, and apical thirds for RelyX ARC.

DISCUSSION

The first null hypothesis was rejected because the pull-out bond strength for RelyX U200 was significantly greater than that for RelyX ARC. Other studies[16,17] have also shown better results for self-adhesive resin cements compared to conventional resin cements.

The RelyX U200 is a self-adhesive resin cement, which eliminates the need for an adhesive system. The bond mechanism of this resin cement to dentin appears to be more chemical than micromechanical in nature. This bond is established by the specific multifunctional phosphoric-acid methacrylates, which are ionized at the time of mixing and react with the hydroxyapatite in the mineralized tissues of the tooth.[18] At the beginning of the reaction, the resin cement has a very low pH.[19] During the polymerization reaction, the acidic monomers interact with the fillers in the resin cement and with the hydroxyapatite in the tooth, neutralizing the reaction and raising the pH. The water that is formed in this neutralization reaction contributes to the cement's initial hydrophilicity, which provides improved adaptation to the tooth structure and moisture tolerance.[20] Subsequently, water is reused by the acidic functional groups during the cement reaction with ion-releasing basic filler particles, resulting in a hydrophobic matrix.[20] Despite the low pH, the interaction with root dentin is superficial, and no evident hybrid layer is observed.[21]

The resin cement RelyX ARC needs an adhesive system, which is responsible for the bond to the root dentin. In the present study, the Scotchbond Multipurpose Plus adhesive system was used in the sequence (etching with phosphoric acid, activator, primer, and catalyst) to make the adhesive a dual material, allowing for self-cure polymerization in regions not irradiated by the LED unit.[22] The bond mechanism of this adhesive system to dentin functions through the formation of a hybrid layer.[23] Because there are several operative steps for using this system, there is greater technical sensitivity compared to that associated with self-adhesive resin cements. However, the bond strength difference between the RelyX U200 and RelyX ARC was 0.96 MPa in the present study, and it is questionable whether this difference is clinically significant.

The relined fiberglass post decreases the thickness of the resin cement in the root canal and exerts pressure on the adaptation of resin cement against the dentinal walls.[24,25] As a result of the thixotropic behavior of RelyX U200, the application of pressure decreases its viscosity and improves its adaptation to the cavity walls.[26] Consequently, the formation of resin cement tags in the cervical and middle thirds of the root canal can be observed in CLSM images. For RelyX ARC, there was penetration of both the adhesive and the resin cement into the dentinal tubules, forming adhesive tags and resin cement tags. It can be speculated that the luting pressure generated by the relined post pushes the resin cement and the adhesive against the walls of the canal, favoring penetration into the dentinal tubules. In addition, CLSM images demonstrated hybrid layer formation of the green-labeled adhesive in the cervical, middle, and apical thirds. Similar images of the hybrid layer were obtained in another study[27] when an etch-and-rinse adhesive system was applied in the root canal.

The null hypothesis that the luting length does not affect the pull-out bond strength was accepted because this factor was not significant. The luting of the post at the 5-mm length allows the LED light to reach the resin cement more effectively, resulting in a greater degree of conversion and,

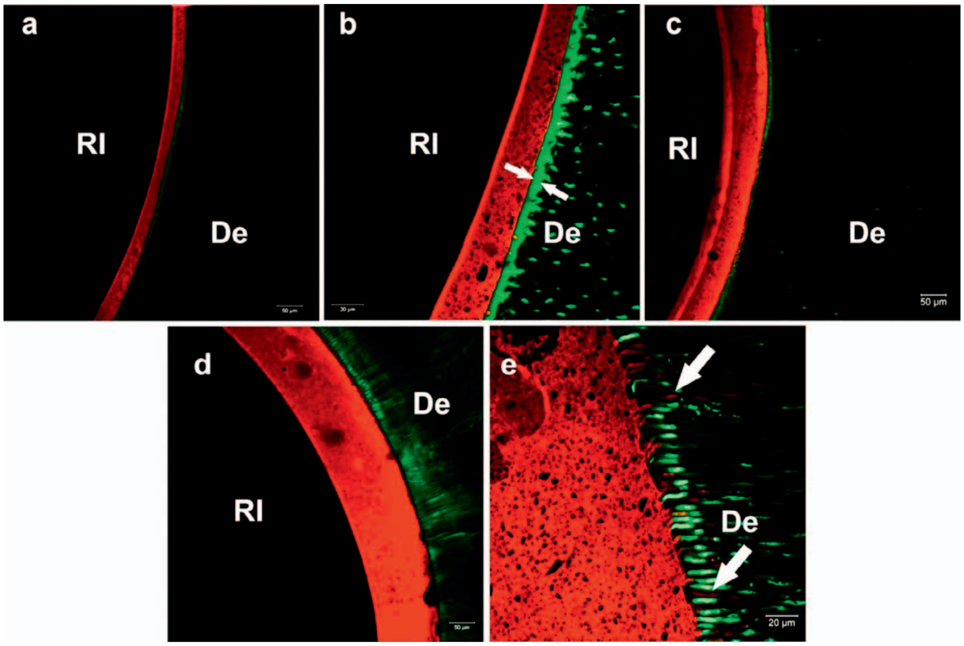

Figure 2. *CLSM image of the interface between a relined fiberglass post and root dentin using RelyX ARC resin cement. Green color: Adper Scotchbond Multi-Purpose Plus Adhesive (activator, primer, and catalyst). Red color: resin cement RelyX ARC. RI: relined fiberglass post; De: dentin. (a) Cervical third (20×); (b) cervical third (40×) showing the hybrid layer formation of the green-labeled adhesive (arrows); (c) middle third (20×); (d) apical third (20×); (e) higher magnification (63×) of the middle third showing the presence of tags from both the adhesive system and the resin cement. Penetration into the dentinal tubules is identified by the arrows.*

consequently, better mechanical properties of the resin cement. Furthermore, there is better penetration of the cement into the root canals at shorter lengths, thus minimizing the formation of bubbles or voids and better controlling the moisture of the substrate.[11,28]

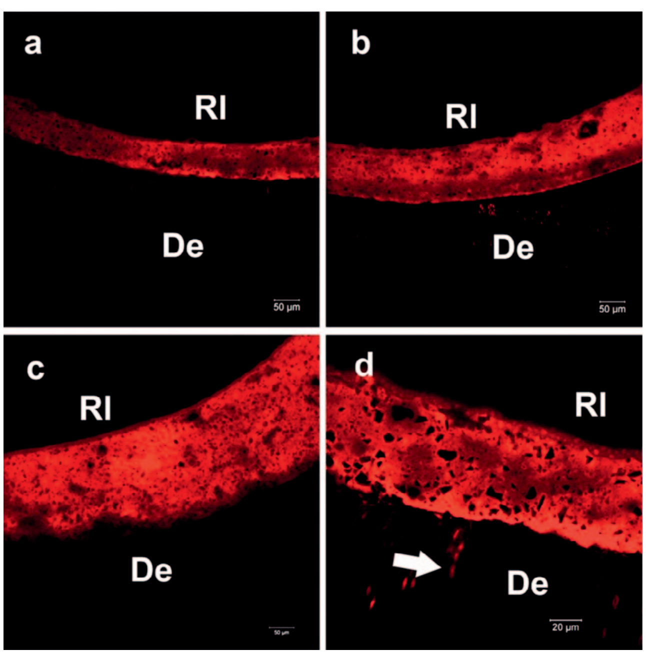

Figure 3. *CLSM image of the interface between the relined fiberglass post and root dentin using RelyX U200. Red color: resin cement. RI: relined fiberglass post; De: dentin. (a) Cervical third (20×); (b) middle third (20×); (c) apical third (20×); (d) higher magnification (63×) of the middle third demonstrates the penetration of the resin cement into the dentinal tubules forming resin tags (arrows).*

In the present study, the interaction between the luting length and cyclic loading was significant. The relined fiberglass posts with a length of 5 mm had weaker bond strength after cyclic loading. Therefore, cyclic loading accelerated the degradation of the bond between the resin cement and the root dentin at the 5-mm length. However, it is important to note that there was no failure of luting during cyclic loading, regardless of the luting length. This probably occurred because of the juxtaposition of the relined fiberglass post to the root dentin, favoring the formation of a thinner resin cement film. Moreover, the fiberglass post and the composite resin have a modulus of elasticity that is close to that of dentin (18 to 20 GPa), so the forces applied to the dental structure are dissipated throughout the fiberglass post.[29] For the 10-mm luting length, there was no significant difference in the pull-out bond strength between specimens with and without cyclic loading, suggesting greater clinical performance of treatments using relined fiberglass posts in weakened roots with 10-mm luting lengths. It has been demonstrated[30] that sliding friction contributes significantly to fiberglass post retention in root canals, with sliding friction being directly proportional to the contact area.

The third null hypothesis was rejected because cyclic loading influenced the pull-out bond strength of relined fiberglass posts to root dentin. The interface between the restorative material and the tooth structure can undergo degradation over time as a result of hydrolysis, temperature changes, and crack propagation when the restoration is retained mechanically.[14] The hostile environment simulated in cyclic loading can lead to catastrophic failure of the restoration over time.[31] Cyclic loading in a wet environment is an aging method that simulates clinical conditions, predicting the clinical behavior of materials or restorative techniques in the oral environment.[31] For dental evaluations, the minimum number of 10^6 cycles, which simulates one year in service, should be applied to restorations when the desire is to approximate the performance of a material relative to clinically relevant service.[14] As the cyclic loading was applied directly on the relined fiberglass post, because there was no restoration, the load of 50 N was selected, which corresponds to approximately half of the maximal bite force for the anterior dentition.[32,33]

The pull-out bond strength test was conducted because it is the only feasible method of evaluating the influence of different luting lengths. Studies indicate the pull-out test as the *in vitro* test that is able to assess precisely the bond strength between the fiberglass post and the root dentin, because this test better distributes the stresses in the post-dentin interface, being a reliable test.[34] The use of bovine teeth in the pull-out test is justified because of difficulty in obtaining a large number of anterior human teeth and because of the morphological and histological resemblance to human teeth of bovine teeth.[35] However, a few human teeth were used for the CLSM analysis. CLSM is a method that allows samples to be studied without vacuum in a humid environment, and this method allows visualizing different components through the use of dyes. In the present study, two dyes, rhodamine B and fluorescein, were used because they have different characteristics.[36,37] Rhodamine B is a molecule added to the resin cement, and Fluorescein is added to the adhesive system components (activator, primer, and catalyst).[38] The same proportion (0.1%) was used for both dyes. Bitter and others[39] showed that fluorescein inserted into the adhesive showed up without diffusing into the red caused by rhodamine B in resin cements, marking a clear distinction between the dyes.

As a result of the limitations of *in vitro* studies, randomized clinical trials are necessary to generate better evidence on luting protocols with relined fiberglass posts.

CONCLUSIONS

In accordance with the results obtained in this study, it was concluded that

- The luting length is an important factor in retaining relined fiberglass posts in weakened roots when subjected to cyclic loading;
- The self-adhesive resin cement RelyX U200 resulted in greater bond strengths to the root canal in comparison with the conventional resin cement RelyX ARC; and
- Resin cement tags were formed in the cervical and middle thirds of the root canals when relined fiberglass posts were luted with RelyX ARC and RelyX U200.

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Regulatory Statement

This study was conducted in accordance with all the provisions of the local human subjects oversight committee guidelines and policies of the Ethics Committee of Pontifical Catholic University of Rio Grande do Sul. The approval code for this study is 30904114.4.0000.5336.

Conflict of Interest

The authors of this manuscript certify that they have no proprietary, financial, or other personal interest of any nature or kind in any product, service, and/or company that is presented in this article.

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REFERENCES

1. Clavijo VG, Reis JM, Kabbach W, Silva AL, Oliveira Júnior OB, & Andrade MF (2009) Fracture strength of flared bovine roots restored with different intraradicular posts *Journal of Applied Oral Science* **17(6)** 574-578.
2. Schmitter M, Hamadi K, & Rammelsberg P (2011) Survival of two post systems—Five-year results of a randomized clinical trial *Quintessence International* **42(10)** 843-850.
3. Monticelli F, Grandini S, Goracci C, & Ferrari M (2003) Clinical behavior of translucent-fiber posts: A 2-year prospective study *International Journal of Prosthodontics* **16(6)** 593-596.
4. Ferrari M, Cagidiaco MC, Grandini S, De Sanctis M, & Goracci C (2007) Post placement affects survival of endodontically treated premolars *Journal of Dental Research* **86(8)** 729-734.
5. Grandini S, Sapio S, & Simonetti M (2003) Use of anatomic post and core for reconstructing an endodonti-

cally treated tooth: A case report *Journal of Adhesive Dentistry* **5(3)** 243-247.

6. Gaston BA, West LA, Liewehr FR, Fernandes C, & Pashley DH (2001) Evaluation of regional bond strength of resin cement to endodontic surfaces *Journal of Endodontics* **27(5)** 321-324.
7. Bouillaguet S, Troesch S, Wataha JC, Krejci I, Meyer JM, & Pashley DH (2003) Microtensile bond strength between adhesive cements and root canal dentin *Dental Materials* **19(3)** 199-205.
8. Amaral M, Rippe MP, Bergoli CD, Monaco C, & Valandro LF (2011) Multi-step adhesive cementation versus one-step adhesive cementation: Push-out bond strength between fiber post and root dentin before and after mechanical cycling *General Dentistry* **59(5)** e185-e191.
9. Nova V, Karygianni L, Altenburger MJ, Wolkewitz M, Kielbassa AM, & Wrbas KT (2013) Pull-out bond strength of a fiber-reinforced composite post system luted with self-adhesive resin cements *Journal of Dentistry* **41(11)** 1020-1026.
10. Ferrari M, Mannocci F, Vichi A, Cagidiaco MC, & Mjör IA (2000) Bonding to root canal: Structural characteristics of the substrate *American Journal of Dentistry* **13(5)** 255-260.
11. Vichi A, Grandini S, Davidson CL, & Ferrari M (2002) An SEM evaluation of several adhesive systems used for bonding fiber posts under clinical conditions *Dental Materials* **18(7)** 495-502.
12. McLaren JD, McLaren CI, Yaman P, Bin-Shuwaish MS, Dennison JD, & McDonald NJ (2009) The effect of post type and length on the fracture resistance of endodontically treated teeth *Journal of Prosthetic Dentistry* **101(3)** 174-182.
13. Zicari F, Van Meerbeek B, Scotti R, & Naert I (2012) Effect of fiber post length and adhesive strategy on fracture resistance of endodontically treated teeth after fatigue loading *Journal of Dentistry* **40(4)** 312-321.
14. Wiskott HWA, Nicholls JL, & Belser UC (1995) Stress fatigue: Basic principles and prosthodontics implications *International Journal of Prosthodontics* **8(2)** 105-116.
15. Arrais CA, Miyake K, Rueggeberg FA, Pashley DH, & Giannini M (2009) Micromorphology of resin/dentin interfaces using 4th and 5th generation dual-curing adhesive/cement systems: A confocal laser scanning microscope analysis *Journal of Adhesive Dentistry* **11(1)**15-26.
16. Leme AA, Coutinho M, Insaurralde AF, Scaffa PM, & da Silva LM (2011) The influence of time and cement type on push-out bond strength of fiber posts to root dentin *Operative Dentistry* **36(6)** 643-648.
17. Sarkis-Onofre R, Skupien JA, Cenci MS, Moraes RR, & Pereira-Cenci T (2014) The role of resin cement on bond strength of glass-fiber posts luted into root canal: A systematic review and meta-analysis of in vitro studies *Operative Dentistry* **39(1)** E31-E44.
18. Gerth HUV, Dammaschke T, Züchner H, & Schäfer E (2006) Chemical analysis and bonding reaction of RelyX Unicem and Bifix composites—A comparative study *Dental Materials* **22(10)** 934-941.
19. Saskalauskaite E, Tam LE, & McComb D (2008) Flexural strength, elastic modulus, and pH profile of self-etch resin cements *Journal of Prosthodontics* **17(4)** 262-268.
20. Radovic I, Monticelli F, Goracci C, Vulicevic ZR, & Ferrari M (2008) Self-adhesive resin cements: A literature review *Journal of Adhesive Dentistry* **10(4)** 251-256.
21. Cantoro A, Goracci C, Vichi A, Mazzoni A, Fadda GM, & Ferrari M (2011) Retentive strength and sealing ability of new self-adhesive resin cements in fiber post luting *Dental Materials* **27(10)** e197-e204.
22. Arrais CA, Giannini M, & Rueggeberg FA (2009) Effect of sodium sulfinate salts on the polymerization characteristics of dual-cured resin cement systems exposed to attenuated light-activation *Journal of Dentistry* **37(3)** 219-227.
23. Sarr M, Kane AW, Vreven J, Mine A, Van Landuyt KL, Peumans M, Lambrechts P, Van Meerbeek B, & De Munck J (2010) Microtensile bond strength and interfacial characterization of 11 contemporary adhesives bonded to bur-cut dentin *Operative Dentistry* **35(1)** 94-104.
24. Grandini S, Goracci C, Monticelli F, Borracchini A, & Ferrari M (2005) SEM evaluation of the cement layer thickness after luting two different posts *Journal of Adhesive Dentistry* **7(3)** 235-240.
25. Schetini DFF, Ferreira FJR, Amaral FLB, Miranda ME, & Turssi CP (2014) Root canal flare: Effect on push-out strength of relined posts *International Journal of Adhesion and Adhesives* **55** 139-144.
26. De Munck J, Vargas M, Van Landuyt K, Hikita K, Lambrechts P, & Van Meerbeek B (2004) Bonding of an auto-adhesive luting material to enamel and dentin *Dental Materials* **20(10)** 963-971.
27. Bitter K, Paris S, Mueller J, Neumann K, & Kielbassa AM (2009) Correlation of scanning electron and confocal laser scanning microscopy analyses for visualization of dentin/adhesive interfaces in the root canal *Journal of Adhesive Dentistry* **11(1)** 7-14.
28. Faria e Silva AL, Arias VG, Soares LE, Martin AA, & Martins LR (2007) Influence of fiber-post translucency on the degree of conversion of a dual-cured resin cement *Journal of Endodontics* **33(3)** 303-305.
29. Plotino G, Grande NM, Bedini R, Pameijer CH, & Somma F (2007) Flexural properties of endodontic posts and human root dentin *Dental Materials* **23(9)** 1129-1135.
30. Goracci C, Fabianelli A, Sadek FT, Papacchini F, Tay FR, & Ferrari M (2005) The contribution of friction to the dislocation resistance of bonded fiber posts *Journal of Endodontics* **31(8)** 608-612.
31. Grandini S, Chieffi N, Cagidiaco MC, Goracci C, & Ferrari M (2008) Fatigue resistance and structural integrity of different types of fiber posts *Dental Materials* **27(5)** 687-694.
32. Helkimo E, Carlsson GE, & Helkimo M (1977) Bite force and state of dentition *Acta Odontologica Scandinavica* **35(6)** 297-303.
33. Pereira-Cenci T, Pereira LJ, Cenci MS, Bonachela WC, & Del Bel Cury AA (2007) Maximal bite force and its

association with temporomandibular disorders *Brazilian Dental Journal* **18(1)** 65-68.

34. Castellan CS, Santos-Filho PC, Soares PV, Soares CJ, & Cardoso PE (2010) Measuring bond strength between fiber post and root dentin: A comparison of different tests *Journal of Adhesive Dentistry* **12(6)** 477-485.

35. Schilke R, Lisson JA, Bauss O, & Geurtsen W (2000) Comparison of the number and diameter of dentinal tubules in human and bovine dentine by scanning electron microscopic investigation *Archives of Oral Biology* **45(5)** 355-361.

36. Wang Y, & Spencer P (2004) Exploring the nature of acid-resistant hybrid layer with wet bonding *Operative Dentistry* **29(6)** 650-655.

37. Bitter K, Gläser C, Neumann K, Blunck U, & Frankenberger R (2014) Analysis of resin-dentin interface morphology and bond strength evaluation of core materials for one stage post-endodontic restorations *PLoS One* **9(2)** e86294.

38. Aguiar TR, Andre CB, Arrais CAG, Bedran-Russo AK, & Giannini M (2012) Micromorphology of resin–dentin interfaces using self-adhesive and conventional resin cements: A confocal laser and scanning electron microscope analysis *International Journal of Adhesive and Adhesion* **38** 69-74.

39. Bitter K, Paris S, Pfuertner C, Neumann K, & Kielbassa AM (2009) Morphological and bond strength evaluation of different resin cements to root dentin *European Journal of Oral Science* **117(3)** 326-333.

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Errata:

Operative Dentistry apologizes for the table 3 error in the manuscript, "Relined Fiberglass Post: Effect of Luting Length, Resin Cement, and Cyclic Loading on the Bond to Weakened Root Dentin" published as an online only article attached to volume 41 issue 6 p. e178. The correct table is shown here:

Table 3: *Pull-out Bond Strength Means (MPa) and Standard Deviations Between the Different Luting Lengths Without and With Cyclic Fatigue Loading*[a]

Luting Length, mm	Cyclic Fatigue Loading	n	Mean	Standard Deviation
5	Without	20	6.98 A	1.18
	With	20	4.78 B	1.32
10	Without	20	6.17 A	0.88
	With	20	6.03 A	0.99

[a] *Different letters indicate statistically different means according to Tukey test ($p<0.05$).*