

The effect of calcium silicate-based sealer on the push-out bond strength of fibre posts

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ABSTRACT

Background: The aim of this study was to assess the effect of the iRoot SP root canal sealer on the push-out bond strength of fibre posts cemented with self-adhesive resin cement.

Methods: Forty-eight extracted maxillary incisors were randomly divided into four groups according to the tested sealer (n = 12): group 1 – control (only gutta-percha points, no sealer); group 2 – AH Plus Jet (resin-based sealer); group 3 – Endofill (zinc oxide-eugenol-based sealer); and group 4 – iRoot SP (calcium silicate-based sealer). All root canals were filled with gutta-percha, and groups 2–4 additionally received one of the sealers. Fibre posts were cemented with the self-adhesive resin cement Clearfil SA Cement. The specimens were sectioned in the coronal, middle and apical regions, producing three slices of 1 mm thickness. The push-out test was performed. All data were submitted to ANOVA and Tukey tests ($\alpha = 0.05$).

Results: No statistically significant differences were found between the control group, AH Plus Jet and iRoot SP ($p > 0.05$). The Endofill sealer showed significantly lower bond strength compared to the other sealers and the control group ($p < 0.05$).

Conclusions: The calcium silicate-based sealer did not adversely affect the bond strength of the fibre posts cemented with self-adhesive resin cement.

Keywords: iRoot SP, post bond strength, root canal sealer.

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INTRODUCTION

Radicular posts are recommended to aid in the retention of final restorations for the reconstruction of root-filled teeth that have insufficient coronal tooth structure.^{1,2} Traditionally, cast and prefabricated metal posts have been used for this purpose. Unfortunately, they can also cause problems as metal posts have a higher elastic modulus than dentine,² and this may cause cracking or fracture in the remaining tooth structure. Additionally, metal posts are more likely to cause some aesthetic problems. Fibre posts are less rigid, elastically compatible with dentine and can form a homogeneous unit with the surrounding root, producing a favourable stress distribution and resulting in fewer root fractures.^{3,4}

Adhesive resin cements are widely used to bond the post to the root canal. Fibre posts have excellent bonding characteristics to resin cement and dentine.⁵

However, resin cements are more technique sensitive than most other luting cements and therefore require additional steps.³ Self-adhesive resin cements have recently been introduced. They do not require any pretreatment of the tooth surface, which simplifies the luting procedure.^{6,7} The bonding mechanism for self-adhesive resin cements is based on chemical adhesion and micromechanical retention.^{8,9} Studies have shown that self-adhesive resin cements can provide high bond strength and good marginal adaptation at the dentine, which is comparable to other types of resin cements.^{6,10}

When cementing posts, the adhesion of the resin cements to root dentine can be affected by the type of endodontic sealer used for obturation, which may eventually affect post retention.¹¹ Eugenol-based sealers still have considerable popularity among clinicians and researchers because of their long history.^{12,13} Some studies have suggested that eugenol-containing and non-eugenol-containing sealers have a similar effect on

the retention of a post that has been cemented with resin cement,^{14,15} but a significant number of contrasting studies have shown that eugenol-containing sealers have a negative effect on the bond strength of a fibre post that has been cemented with resin cement.^{11,16} AH Plus (Dentsply DeTrey, Konstanz, Germany) is an epoxy-resin-based sealer that has also presented good performance as a sealer.¹⁷ Researchers consider this sealer to be the gold standard against which all new sealers and bondable root canal obturation materials must be compared.¹⁸

Recently, a new calcium silicate-based root canal sealer named iRoot SP (Innovative BioCremix Inc, Vancouver, Canada) has been introduced for the obturation of the root canal space. According to the manufacturer, iRoot SP is an aluminum-free and hydrophilic material that is comprised of calcium and resin. The composition of this sealer is similar to that of white MTA, and iRoot SP has both excellent physical properties and antimicrobial activity.¹⁹ Several studies have found that iRoot SP has good sealing properties and intermediate toxicity.^{20,21} A recent study has shown that the bond strength of iRoot SP to radicular dentine was similar to the bond strength of epoxy resin-based sealer to radicular dentine.²² However, there are no available data regarding the effect of the calcium silicate-based sealer on the bond strength of fibre glass posts.

Therefore, the purpose of this *in vitro* study was to investigate the effect of a new calcium silicate-based root canal sealer on the push-out bond strength of a fibre post cemented with self-adhesive resin cement in three canal regions whilst also comparing these results with those of eugenol-based and epoxy resin-based root canal sealers.

MATERIALS AND METHODS

Forty-eight human maxillary incisor teeth, recently extracted for periodontal reasons, were selected for this study and were stored in a 0.9% saline solution. All of the selected teeth had a straight root with a single canal. Teeth showing caries, curved roots, cracks, open apices or previous endodontic treatments were not included. Remnant tissue and calculus were mechanically removed from the selected teeth. The crowns of these teeth were then removed close to the cemento-enamel junction with a diamond bur, leaving a standard root length of 14 mm. Canal patency was checked with a size #10 K-file (Mani Inc, Tochigi, Japan), and the working length was set 1 mm short of the apical foramen. Root canal preparation was performed using the step-back technique. The same operator instrumented all root canals up to size 40. The coronal and middle portions of the canals were enlarged by using #2 to #4 Gates-Glidden (Mani Inc, Japan) drills. During

the instrumentation phase, the canals were irrigated between the application of each instrument with a 2.5% solution of sodium hypochlorite. Following the final irrigation, the root canals were dried with absorbent paper points.

The specimens were randomly distributed into four groups of 12 teeth each and were filled with gutta-percha points (Diadent Group Int, Seoul, Korea) with the cold lateral condensation technique. Group 1 (control) received gutta-percha points only (no sealer); group 2 resin-based sealer – AH Plus Jet; group 3 eugenol-based sealer – Endofill (Produits Dentaires SA, Vevey, Switzerland); and group 4 calcium silicate-based sealer – iRoot SP. The root canal sealers were prepared and applied according to their respective manufacturer's instructions. Temporary filling material (Cavit G, 3M Espe, Seefeld, Germany) was used to seal the coronal access cavity, and the roots were stored at 37 °C with 100% humidity for 7 days.

After storage, the gutta-percha was removed with a #2 Peaso reamer (Mani Inc, Tochigi, Japan), leaving at least 4 mm of filling material in the apical third. Post spaces were prepared to a depth of 9 mm with a red size #14 drill (Snowpost; Carbotec, Ganges, France). The post space was rinsed with distilled water and then dried with absorbent paper points.

The self-adhesive resin cement (Clearfil SA Cement, Kuraray, Osaka, Japan) was applied to the root canals with special applicators, and the post (Snowpost red size #14; Carbotec, Ganges, France) surface was cleaned with alcohol. The posts were seated to full depth using finger pressure and the resin cement was polymerized for 20 seconds with a LED light curing unit (Monitex BlueLex GT1200, Taipei, Taiwan). Specimens were then kept at 37 °C with 100% humidity for 24 hours.

After 24 hours, each root was individually connected to a cutting machine and sectioned horizontally by using a water-cooled diamond disc (Isomet, Buehler Ltd, Lake Bluff, IL, USA). Slices of approximately 1 mm thickness were obtained, and one specimen of each region (the coronal, middle and apical regions of the post space) was selected at 2, 5 and 8 mm depths. The thickness of each slice was measured using a digital caliper (Mitutoyo, Japan) with an accuracy of 0.01 mm. Each slice was fixed to a stainless steel base with a central circular perforation and attached to a universal testing machine (Elista, Istanbul, Turkey). The push-out test was performed by applying a load at 0.5 mm/min from the apical to coronal direction by using a 1 mm diameter metallic plunger until the post dislodged. The maximum load at failure was recorded in Newtons (N). The push-out bond strength of each slice was calculated and expressed in MPa while considering the bonding area of the post specimens. For this purpose, the diameters of the posts at both the coronal and apical

surfaces were measured with a digital caliper. The push-out bond strength (MPa) = N/A , where N = maximum load (N) and A = adhesion area of the bonded interface (mm^2). The bonding area was calculated using the formula:¹⁰ $\pi(R_1 + R_2) \sqrt{h^2 + (R_1 - R_2)^2}$, where π is the constant 3.14, R_1 represents the larger post radius, R_2 the smaller post radius and h the thickness of the slice.

All debonded specimens were assessed under a stereomicroscope (SZ40 Olympus, Tokyo, Japan) at 20X magnification for the fracture analysis. Failure mode at the fractured interface was classified into five categories:²³ (1) adhesive between the post and resin cement (no cement visible around the post); (2) mixed, with resin cement covering 0–50% of the post surface; (3) mixed, with resin cement covering 50–100% of the post surface; (4) adhesive between resin cement and root canal (post enveloped by resin cement); and (5) cohesive in the dentine (no cement visible on the debonded area).

Since the data were normally distributed, the results were analysed with an ANOVA test using a factorial design with the root canal sealer (control, AH Plus Jet, Endofill and iRoot SP) and the root region (coronal, middle and apical). Multiple comparisons were carried out by using the Tukey *post hoc* test at $\alpha = 0.05$ significance level.

RESULTS

The mean push-out bond strength and standard deviation values are presented in Table 1. The highest push-out bond strength was obtained from the iRoot SP group (2.90 ± 0.72 MPa), while lowest was obtained from the Endofill group (1.30 ± 0.60 MPa). ANOVA showed a significant difference between the groups

($p < 0.01$). Root canal sealers had a significant influence on the results ($p < 0.05$), but there was no significant influence of canal regions (coronal, middle and apical) on bond strength ($p > 0.05$). Multiple comparisons revealed that there were no significant differences between the calcium silicate-based sealer group, the resin-based sealer group and the control group ($p > 0.05$). The eugenol-based sealer group showed significantly lower bond strength than the other sealer groups as well as the control group ($p < 0.05$).

There were no adhesive failures between the post and resin cement, and only one cohesive fracture was observed in the control group (Table 2). The predominant failure mode was adhesive between the self-adhesive resin cement and the dentine, but 50% of the specimens in the calcium silicate-based group had mixed failures (category 3).

DISCUSSION

In the present study, the effect of calcium silicate-based sealer on the push-out bond strength of fibre posts was evaluated. Bond strength can be evaluated with several techniques, including conventional shear, microtensile, pull-out and push-out techniques.²⁴ Push-out test resulted in a shear stress at the interface between the dentine-post-cement,²⁵ which is similar to the clinical conditions. Although conventional shear and tensile tests have been widely used, some researchers have reported that the push-out test provides a better estimation of the displacement resistance than does a conventional shear test.²⁶ The push-out test also seems to be more dependable than the microtensile test because of the absence of premature failures and the variability of data distribution.²⁷ In addition, the

Table 1. Mean bond strengths and standard deviations (in MPa) for the sealers in the different canal regions

	Control (no sealer)	Resin-based sealer (AH Plus Jet)	Eugenol-based sealer (Endofill)	Calcium silicate-based sealer (iRoot SP)
Coronal	2.62 ± 1.20^A	2.66 ± 0.95^A	1.36 ± 0.47^B	2.90 ± 0.72^A
Middle	2.36 ± 0.56^A	2.66 ± 0.95^A	1.39 ± 0.66^B	2.84 ± 1.11^A
Apical	2.34 ± 0.79^A	2.23 ± 1.10^A	1.30 ± 0.60^B	2.61 ± 1.00^A

Different superscript letter indicates statistically significant difference ($p < 0.05$).

Table 2. Failure modes for all groups

Modes	Control (no sealer)	Resin-based sealer (AH Plus Jet)	Eugenol-based sealer (Endofill)	Calcium silicate-based sealer (iRoot SP)
Adhesive: Post-cement	0	0	0	0
Mixed 0–50%	2 (5.5)	3 (8.3)	0	4 (11.1)
Mixed 50–100%	9 (25)	13 (36.1)	6 (16.6)	18 (50)
Adhesive: Cement-dentine	24 (66.6)	20 (55.5)	30 (83.3)	14 (38.9)
Cohesive	1 (2.7)	0	0	0
Total	36	36	36	36

push-out test allows for the evaluation of bonding effectiveness in the different canal regions, indicating precisely the areas where failures occurred.¹¹ Therefore, the push-out test was used in the present study.

In this study, the calcium silicate-based group, the resin-based sealer group and the control group showed similar and higher bond strengths when compared with the eugenol-based sealer. Recent studies have shown that the bond strength to root dentine and the sealing ability of iRoot SP were equivalent to those of AH Plus.^{21,22} A possible explanation for the results of the present study could be the calcium phosphate composition of the iRoot SP root canal sealer. Calcium phosphate residues may react with the resin cement and act as a filler.

Cohen *et al.*²⁸ demonstrated that epoxy-resin does not interact with the free radical initiation of the composite resin. Therefore, the resin-based sealer does not adversely affect the adhesion of the resin cements. The present study showed that the resin-based sealer group had similar bond strength values to those of the control group. These results are corroborated with the results of many earlier studies.^{13,29} Cecchin *et al.*¹⁶ stated that the higher bond strength obtained with resin-based sealers may be associated with those sealers' epoxy resin component, which might have an affinity for components in the resin cement.

The results of the present study are in agreement with previous studies that have determined that eugenol-based sealers decrease the bond strength of resin cements.^{30,31} Menezes *et al.*²⁹ observed that eugenol-based sealers reduced the bond strength of resin cements and suggested that the chemical composition of the sealers had an influence on post bond strength. Moreover, Kielbassa *et al.*³² stated that if eugenol-based sealers are used, some of the eugenol may diffuse to the dentine. It was also reported that eugenol residues on the dentine can inhibit the setting reaction of a composite resin^{12,28} and may negatively affect its adhesive properties.

The results of the present study indicate that the canal region had no significant effect on the bond strength of the post to root dentine. These findings are in accordance with those reported by Ngoh *et al.*³¹ In contrast, several other studies have suggested that bond strength values were lower in the apical third.^{11,29} Foxton *et al.*³³ claimed that this may be due to poor resinous cement activation in regions distant from the light source. However, Yan *et al.*³⁴ suggested that the significant polymerization reaction finished within a 24-hour post-mix or post-light activation for resin cements. In addition, Pereira *et al.*³⁵ concluded that the post space region did not influence the degree of conversion of the dual-cure resin cements.

Examination of the failure modes in the present study by using a stereo microscope showed only one cohesive failure inside the root canal dentine in the control

group. The predominant failure mode was adhesive, and existed between the self-adhesive resin cement and the dentine in the control, resin and eugenol-based sealer groups. Similar findings were reported by Perdigao *et al.*²³ and Boone *et al.*¹ These results might show that there was a poor connection between the resin cement and dentine. Only in the calcium silicate-based sealer group did 50% of the specimens experience mixed failures (category 3), implying that this group had a better adhesion with the dentine walls.¹¹

CONCLUSIONS

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

- (1) The calcium silicate-based sealer did not adversely affect the bond strength of a fibre post cemented with self-adhesive resin cement, and the effect of iRoot SP on the bond strength of the fibre posts to the dentine was equivalent to that of AH Plus Jet.
- (2) The eugenol-based sealer had a negative effect on the bond strength of the fibre posts. Therefore, eugenol-based sealer should be avoided when following the post cementation with self-adhesive resin cement.
- (3) The canal region had no influence on the post bond strength when dual-curable self-adhesive resin cement was used.

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REFERENCES

1. Boone KJ, Murchison DF, Schindler WG, Walker WA 3rd. Post retention: the effect of sequence of post-space preparation, cementation time, and different sealers. *J Endod* 2001;27:768–771.
2. Chuang SF, Yaman P, Herrero A, Dennison JB, Chang CH. Influence of post material and length on endodontically treated incisors: an in vitro and finite element study. *J Prosthet Dent* 2010;104:379–388.
3. Schwartz RS, Robbins JW. Post placement and restoration of endodontically treated teeth: a literature review. *J Endod* 2004;30:289–301.
4. Barjau-Escribano A, Sancho-Bru JL, Forner-Navarro L, Rodriguez-Cervantes PJ, Perez-Gonzalez A, Sanchez-Marin FT. Influence of prefabricated post material on restored teeth: fracture strength and stress distribution. *Oper Dent* 2006;31:47–54.
5. Boschian Pest L, Cavalli G, Bertani P, Gagliani M. Adhesive post-endodontic restorations with fiber posts: push-out tests and SEM observations. *Dent Mater* 2002;18:596–602.
6. Behr M, Rosentritt M, Regnet T, Lang R, Handel G. Marginal adaptation in dentin of a self-adhesive universal resin cement compared with well-tried systems. *Dent Mater* 2004;20:191–197.

7. Toman M, Toksavul S, Sarikanat M, Firidinoglu K, Akin A. The evaluation of displacement resistance of glass FRC posts to root dentine using a thin slice push-out test. *Int Endod J* 2009;42:802–810.
8. Gerth HU, Dammaschke T, Zuchner H, Schafer E. Chemical analysis and bonding reaction of RelyX Unicem and Bifix composites—a comparative study. *Dent Mater* 2006;22:934–941.
9. Zicari F, Couthino E, De Munck J, *et al.* Bonding effectiveness and sealing ability of fiber-post bonding. *Dent Mater* 2008;24:967–977.
10. Bitter K, Meyer-Lueckel H, Priehn K, Kanjuparambil JP, Neumann K, Kielbassa AM. Effects of luting agent and thermocycling on bond strengths to root canal dentine. *Int Endod J* 2006;39:809–818.
11. Teixeira CS, Pasternak-Junior B, Borges AH, Paulino SM, Sousa-Neto MD. Influence of endodontic sealers on the bond strength of carbon fiber posts. *J Biomed Mater Res B Appl Biomater* 2008;84:430–435.
12. Demiryurek EO, Kulunk S, Yuksel G, Sarac D, Bulucu B. Effects of three canal sealers on bond strength of a fiber post. *J Endod* 2010;36:497–501.
13. Hagge MS, Wong RD, Lindemuth JS. Retention strengths of five luting cements on prefabricated dowels after root canal obturation with a zinc oxide/eugenol sealer: 1. Dowel space preparation/cementation at one week after obturation. *J Prosthodont* 2002;11:168–175.
14. Davis ST, O'Connell BC. The effect of two root canal sealers on the retentive strength of glass fibre endodontic posts. *J Oral Rehabil* 2007;34:468–473.
15. Schwartz RS, Murchison DF, Walker WA 3rd. Effects of eugenol and noneugenol endodontic sealer cements on post retention. *J Endod* 1998;24:564–567.
16. Cecchin D, Farina AP, Souza MA, Carlini-Junior B, Ferraz CC. Effect of root canal sealers on bond strength of fibreglass posts cemented with self-adhesive resin cements. *Int Endod J* 2011;44:314–320.
17. Nunes VH, Silva RG, Alfredo E, Sousa-Neto MD, Silva-Sousa YT. Adhesion of Epiphany and AH Plus sealers to human root dentin treated with different solutions. *Braz Dent J* 2008;19:46–50.
18. Brackett MG, Martin R, Sword J, *et al.* Comparison of seal after obturation techniques using a polydimethylsiloxane-based root canal sealer. *J Endod* 2006;32:1188–1190.
19. Zhang H, Shen Y, Ruse ND, Haapasalo M. Antibacterial activity of endodontic sealers by modified direct contact test against *Enterococcus faecalis*. *J Endod* 2009;35:1051–1055.
20. Zhang W, Li Z, Peng B. Ex vivo cytotoxicity of a new calcium silicate-based canal filling material. *Int Endod J* 2009;43:769–774.
21. Zhang W, Li Z, Peng B. Assessment of a new root canal sealer's apical sealing ability. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2009;107:e79–82.
22. Ersahan S, Aydin C. Dislocation resistance of iRoot SP, a calcium silicate-based sealer, from radicular dentine. *J Endod* 2010;36:2000–2002.
23. Perdigao J, Gomes G, Lee IK. The effect of silane on the bond strengths of fiber posts. *Dent Mater* 2006;22:752–758.
24. Goracci C, Grandini S, Bossu M, Bertelli E, Ferrari M. Laboratory assessment of the retentive potential of adhesive posts: a review. *J Dent* 2007;35:827–835.
25. Van Meerbeek B, De Munck J, Yoshida Y, *et al.* Buonocore memorial lecture. Adhesion to enamel and dentin: current status and future challenges. *Oper Dent* 2003;28:215–235.
26. Drummond JL, Sakaguchi RL, Racean DC, Wozny J, Steinberg AD. Testing mode and surface treatment effects on dentin bonding. *J Biomed Mater Res* 1996;32:533–541.
27. Goracci C, Tavares AU, Fabianelli A, *et al.* The adhesion between fiber posts and root canal walls: comparison between microtensile and push-out bond strength measurements. *Eur J Oral Sci* 2004;112:353–361.
28. Cohen BI, Volovich Y, Musikant BL, Deutsch AS. The effects of eugenol and epoxy-resin on the strength of a hybrid composite resin. *J Endod* 2002;28:79–82.
29. Menezes MS, Queiroz EC, Campos RE, Martins LR, Soares CJ. Influence of endodontic sealer cement on fibreglass post bond strength to root dentine. *Int Endod J* 2008;41:476–484.
30. Bergeron BE, Murchison DF, Schindler WG, Walker WA 3rd. Effect of ultrasonic vibration and various sealer and cement combinations on titanium post removal. *J Endod* 2001;27:13–17.
31. Ngoh EC, Pashley DH, Loushine RJ, Weller RN, Kimbrough WF. Effects of eugenol on resin bond strengths to root canal dentin. *J Endod* 2001;27:411–414.
32. Kielbassa AM, Attin T, Hellwig E. Diffusion behavior of eugenol from zinc oxide-eugenol mixtures through human and bovine dentin in vitro. *Oper Dent* 1997;22:15–20.
33. Foxton RM, Nakajima M, Tagami J, Miura H. Bonding of photo and dual-cure adhesives to root canal dentin. *Oper Dent* 2003;28:543–551.
34. Yan YL, Kim YK, Kim KH, Kwon TY. Changes in degree of conversion and microhardness of dental resin cements. *Oper Dent* 2010;35:203–210.
35. Pereira PC, Melo RM, Chaves C, Galhano GA, Bottino MA, Balducci I. The adhesive system and root canal region do not influence the degree of conversion of dual resin cement. *J Appl Oral Sci* 2010;18:477–481.

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