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Effect of Different Root Canal Obturating Materials on Push-Out Bond Strength of a Fiber Dowel

Vivek Aggarwal, MDS,[1] Mamta Singla, MDS,[1,2] Sanjay Miglani, MDS,[3] & Sarita Kohli, MDS[4]

[1]Assistant Professor, Department of Conservative Dentistry and Endodontics, Faculty of Dentistry, Jamia Millia Islamia, New Delhi, India
[2]Formerly Senior Lecturer, Department of Conservative Dentistry and Endodontics, Institute of Dental Sciences and Technology, Modinagar, India
[3]Associate Professor, Department of Conservative Dentistry and Endodontics, Faculty of Dentistry, Jamia Millia Islamia, New Delhi, India
[4]Professor and head, Department of Conservative Dentistry and Endodontics, Faculty of Dentistry, Jamia Millia Islamia, New Delhi, India

Keywords
Fiber dowel; push-out bond strength; obturation; Guttaflow; Resilon.

Correspondence
Vivek Aggarwal, Department of Conservative Dentistry and Endodontics, Faculty of Dentistry, Jamia Millia Islamia, New Delhi, India.
E-mail: drvivekaggarwal@gmail.com

The authors deny any conflicts of interest.

Accepted November 21, 2011

doi: 10.1111/j.1532-849X.2012.00850.x

Abstract

Purpose: During dowel space preparation, the instrumentation forms a thick smear layer along with sealer-occluded dentinal tubules. The purpose of this study was to evaluate the effect of different obturating materials on push-out bond strength of a fiber dowel.
Materials and Methods: Fifty human uniradicular teeth were decoronated and prepared using the step-back technique. The specimens were divided into five groups on the basis of obturating materials: group I received no obturation; group II (ZOE) gutta-percha and zinc oxide eugenol sealer; group III (ZOAH) gutta-percha and AH plus sealer; group IV (GF) GuttaFlow; and group V (RE) with Resilon Epiphany system. Dowel spaces were made with manufacturer's provided drills, and a fiber dowel was luted. Horizontal slices were obtained from the middle third, and push-out bond strength (S) was evaluated. Statistical analysis was carried out using one-way ANOVA and post hoc Tukey's test.
Results: The push-out bond strength values in the control group, ZOE, ZOAH, GF, and RE were 9.303 ± 0.565 MPa, 8.859 ± 0.539 MPa, 8.356 ± 0.618 MPa, 9.635 ± 0.435 MPa, and 8.572 ± 0.256 MPa, respectively. There was no statistically significant difference between the S values of all the groups ($p > 0.05$).
Conclusion: There was no effect of different tested obturating materials on the push-out bond strength of fiber dowels; however, further studies should be conducted.

Restoration of endodontically treated teeth may involve placement of an intraradicular dowel.[1-4] The function of the dowel is to provide retention to the core.[2,4] Various types of dowels are available, but there has been a shifting trend toward the use of fiber dowels.[4] Fiber dowels offer various advantages over traditional cast metal dowel systems, including better esthetics and ease of handling. The modulus of elasticity of fiber dowels is similar to that of dentin; therefore, it has been reported that use of fiber dowels can reduce the incidence of irreversible root fracture compared to cast metal dowels.[4,5]

Dowels are usually placed in a dowel space prepared by removing the obturating material without compromising the apical seal.[4] Fiber dowels are usually prefabricated and are luted with the help of adhesive cements.[4] The success of a fiber dowel system depends directly upon the quality of bonding between the dowel/cement/dentin. Various factors, including type of cement used, thickness of resin cement, type of etching/bonding system used, and morphology of dentinal surface,[6-9] might affect the bonding between the adhesive cement and the dentin. After shaping and cleaning of the canals, the canal space is three dimensionally filled with obturating materials along with root canals sealers. Traditionally gutta-percha in combination with eugenol-based sealers is used, with a high clinical success rate.[10-11] This system lacks a chemical bonding with the root canal dentin walls, and the eugenol has been shown to inhibit the polymerization of composites.[12-14] In contrast, some studies have shown that eugenol-based sealers do not decrease the adhesion between resin and dentin, compared with noneugenol based sealers.[15,16] The recently introduced Resilon obturating system (Resilon Research LLC, Madison, CT) is a thermoplastic synthetic polymer resin-based root canal filling material. It involves the use of a self-etching primer and a dual-cure resin sealer (Epiphany^{TM}, Pentron Clinical Technologies, Wallingford, CT).[17] Theoretically this system involves the penetration and impregnation of dentinal tubules.[17,18] However, Gesi et al reported that the push-out bond strength of Resilon point and

Epiphany sealer to intraradicular dentin was less than gutta-percha point and conventional sealer.[19]

The morphology of dentin might be affected by the use of different obturating materials.[9,20] The sealers used in obturation may penetrate the dentinal tubules.[9,20] During dowel preparation the instrumentation will form a smear layer over the dentinal surface.[9] This will hamper the formation of a hybrid layer of adhesive luting cement and the dentinal tubules. Very limited reports have studied the effect of different obturating methods on the push-out bond strength of fiber dowels. The present study evaluated the effect of four obturating methods (gutta-percha and eugenol-based sealer; gutta-percha and AH plus sealer; GuttaFlow; Resilon) on the push-out bond strength of fiber dowels luted with an adhesive cement.

Materials and methods

Fifty human uniradicular mandibular premolar teeth, extracted for orthodontic or periodontal reasons, were used in the present study. Teeth having approximately the same width were selected. The soft tissue remnants were removed with help of a hand scaler. The teeth were radiographed to confirm a single canal. The teeth were decoronated under copious irrigation, and the root length was standardized to 16 mm. The root canals were manually shaped till file size 50 using the balanced force technique. The canals were copiously irrigated between each file change, with sodium hypochlorite (5.25%) and EDTA solution (17%) with a 27-gauge needle. The canals were flared using the step-back technique in 2 mm increments for the apical 6 mm. The coronal third was prepared with Gates Glidden burs no. 4 to 2 till the middle third. The canal walls were made confluent with a #50 H-file (Fig 1A, B). The specimens were divided into five groups on the basis of obturating materials. Group I did not receive root canal obturation and was kept as a control group. Group II (ZOE) was obturated using lateral compaction of gutta-percha and zinc oxide eugenol sealer. Group III (ZOAH) was obturated using lateral compaction of gutta-percha and AH plus sealer (Dentsply, deTrey GmbH Konstanz, Germany). Group IV (GF) was obturated using GuttaFlow (Coltene/Whaledent, Alstatten, Switzerland) according to manufacturer's recommendations. The capsule was triturated, and the color of the material was compared with a manufacturer-supplied color scale. GuttaFlow was first applied as a sealer, and then a suitable master cone was placed. The rest of the canal was backfilled with GuttaFlow. No lateral compaction was applied. Group V (RE) was obturated with Resilon and Epiphany sealer (SybronEndo Corp., Orange, CA). The self-etching primer was applied with the help of suitable micro brushes, and excess was removed using absorbent paper points. Epiphany sealer was applied to the canal walls, and a sealer-coated master cone was placed in the canal. Accessory medium-fine Resilon points coated with sealer were laterally compacted into the canal. The excess material was seared off and compacted with a plugger (Premier Dental Products, Plymouth Meeting, PA) 1 mm below the canal opening. The coronal surface was light cured for 40 seconds. A postoperative radiograph was obtained in all groups. The canal entrances in all groups were sealed with Cavit-G (3M ESPE, St. Paul, MN). The specimens were stored at 100% humidity at 37°C for 7 days.

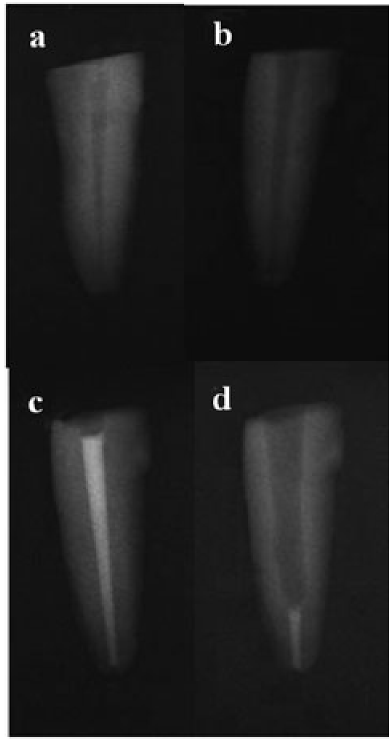

Figure 1 (a) radiographic image of unprepared 16 mm root; (b) radiographic image after shaping of the root canal; (c) postobturation image; (d) radiographic image after dowel space preparation.

All specimens were restored using a fiber dowel (ParaPost Fiber Lux, Coltene Whaledent). Dowel spaces were prepared to a depth of 11 mm using the manufacturers' corresponding dowel drill (size 5.5) system (Fig 1C, D). No solvent or heat was used to remove the obturating material. The dowel spaces were rinsed with 10 ml of 17% EDTA and a final rinse of distilled water. The canals were dried with #60 absorbent paper points. Dual-cure resin cement (ParaCore automix dual cure, Coltene Whaledent) was used to cement the dowels. ParaBond Non-Rinse Conditioner (Coltene Whaledent) was applied to the canals with the help of #60 absorbent paper points. A mixture of Adhesive A and Adhesive B was applied, and excess was removed with a brush. ParaCore automix white pastes were mixed with the help of a mixing tip and were applied into the canal with Lentulo spiral no. 40 (Dentsply Maillefer, Ballaigues, Switzerland). A small amount of the mixture of the cement was applied to the ParaPost, and the dowel was gently seated into the dowel space with the help of finger pressure. The specimens were cured for 40 seconds. Core build-up was done with manufacturer's supplied coreformers, and the specimens were stored for at 100% humidity at 37°C for 7 days.

The roots were embedded in an autopolymerizing resin. After setting of the resin, the roots were sectioned perpendicular to their long axes, and 1.2 mm thick horizontal slabs were obtained. Two horizontal slices were from the middle third of each specimen. The apical (R1) and coronal (R2) diameters were

Table 1 Push-out bond strength (MPa) values of all groups

S (MPa)	GR I Control	GR II ZOE	GR III ZOAH	GR IV GF	GR V RE
Minimum	8.63	8.02	7.65	9.01	8.21
Maximum	10.14	9.68	9.32	10.28	8.92
Mean	9.303	8.859	8.356	9.635	8.572
S.D.	0.565	0.539	0.618	0.435	0.256

measured using a Nikon D3100 digital camera (Nikon USA, Melville, NY). Push-out strength was tested with the help of a 0.70 mm thick cylindrical stylus attached to the testing apparatus of a Universal Instron testing machine (Zwick GmbH and Co, Ulm, Germany). The specimens were stressed to failure at a 0.5 mm/min crosshead speed. The stylus was positioned over the fiber dowel area, and an apico-coronal force was applied. The force (F) at which bond failure occurred was recorded. The push-out bond strength (S) was measured by dividing the force by the adhesion area (A) of the fiber dowel. The adhesion area was calculated on the basis of a previous study[21] using the apical and coronal diameters and the height of the slice. The values of push-out bond strength were recorded for statistical evaluation, using SPSS 11.5 for Windows (SPSS Inc., Chicago, IL). The data were statistically analyzed using one-way ANOVA, and the level of significance was kept as 5%. The mode of fracture was determined using an optical microscope at 10× magnification.

Results

A descriptive analysis of push-out bond strength (S) of all groups is presented in Table 1 and as a boxplot in Figure 2. The variables in this study followed the normal criteria; therefore, one-way ANOVA was used for comparing these variables among the four groups. The significance between the individual groups was calculated, using a post hoc Tukey's test. There was no statistically significant difference between the S values of all the groups ($p > 0.05$). All the specimens predominantly showed adhesive fracture between the dentin and cement interface.

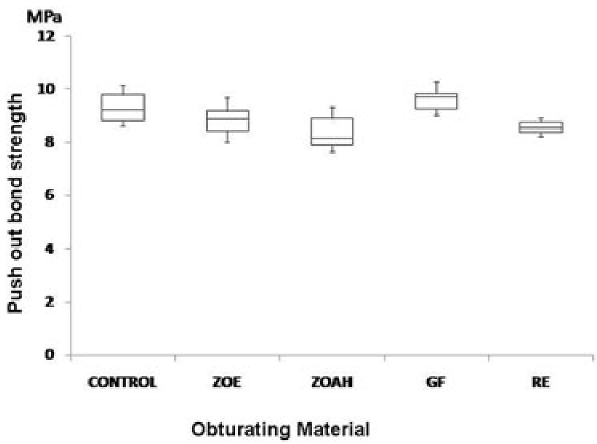

Figure 2 Boxplot diagram of push-out bond strength values of all groups. There was no statistically significant difference between the groups ($p > 0.05$).

Discussion

Fiber-reinforced resin dowels are a useful alternative to traditional cast metal dowels.[3,4] With the advent of resin cement, theoretically they can form a monoblock with the root canal walls.[4] Fiber dowels are luted in a space made in the root canal and gain retention from the root canal dentin/cement/dowel interface.[4] Thus, the success of a fiber dowel may depend upon adequate bonding of the dowel system with the root canal walls.[4,9]

In the present study, the effect of various obturating materials on the resin/cement bond was evaluated. Previous studies have shown that the obturating material/sealer can penetrate deep into the dentinal tubules.[20] During removal of obturating materials, these obturated tubules will be clogged and will negate the formation of a further hybrid layer of resin cement and dentin.[9] Moreover, eugenol-based sealers are commonly used, and eugenol has been shown to retard polymerization of the composites.[14] Thus it was hypothesized that obtuaration of the root canal will reduce the push-out bond strength of a fiber dowel compared with root canals, which were not obturated before (control group). The dowel space was prepared with the manufacturer's provided drill. ParaPost, which is a passive, parallel translucent fiber resin esthetic dowel, was luted into the prepared dowel spaces. Dual-cure resin cement (ParaCore automix dual cure) was used. This cement uses a self-etching primer, which reduces the issues related with the wet bonding technique.

The control group gave a push-out bond strength of 9.303 ± 0.565 MPa. The results were similar to previous reports.[22] The gutta-percha and eugenol sealer group showed an S value of 8.859 ± 0.539 MPa. Some studies have shown that eugenol-based sealers give less push-out bond strength than the control group.[14] The results were based on the fact that eugenol interferes with polymerization, but it has been reported that eugenol-based sealers do not penetrate deep into the dentinal tubules. A majority of other studies have reported no difference between the eugenol-based and eugenol-free root canal sealers on the push-out bond strength of fiber dowels.[15,16]

The resin-based sealer AH plus gave an S value of 8.356 ± 0.618 MPa. This was more than some of the reported literature. A recent study[9] showed that during retreatment with AH plus and eugenol-based sealers, there was a thick smear layer occluding the dentinal tubules. In the present study, the canals were cleansed with 17% EDTA before primer application. This would have removed the smear layer and opened up the dentinal tubules. AH plus sealer is known to penetrate 24 μm to 81 μm (0.024 mm to 0.081 mm).[20]

The push-out bond strength values in the GuttaFlow and Resilon groups were 9.635 ± 0.435 MPa and 8.572 ± 0.256 MPa, respectively. GuttaFlow is a homogenous mixture of powdered gutta-percha, poly-dimethylsiloxane, and silicon, along with nano silver particles and an activator.[23] During root canal obturation with GuttaFlow the majority of the root canal space is occupied by the sealer. Various studies report that GuttaFlow obturation shows voids at all levels and increased microleakage.[24] Ordinola-Zapata et al[25] reported that GuttaFlow has a lesser dentinal tubule penetration than Sealapex (SybronEndo). The Resilon system consists of a resin matrix of Bis-OMA, ethoxylated Bis-OMA, UDMA, and hydrophilic difunctional methacrylates. The dual-cure Epihany sealer provides a chemical bond with dentin walls as well as Resilon cones, thus theoretically providing a monoblock effect.[26-28] However, various literature reports have suggested that the push-out bond strength of Resilon point and Epiphany sealer to intraradicular dentin was less than gutta-percha point and conventional sealer.[19]

All the tested obturating materials gave a lesser value of push-out bond strength compared with the control group, but the differences were not statistically significant. Apart from the usual limitations of an in vitro study, one of the major limitations of the present study was the lack of application of thermal and mechanical stresses. The tooth and the restorative systems are unavoidably subjected to the masticatory stresses and temperature changes in the oral cavity. These stresses affect the interface between the tooth and the coronal restoration,[29] but it is still unclear whether these stresses affect the push-out bond strength of fiber dowels.[30]

Conclusion

Within the limitations of the present study, it can be concluded that the various obturating materials used in this study (gutta-percha and eugenol-based sealer, gutta-percha and AH plus sealer, GuttaFlow, and Resilon) had no effect on the push-out bond strength of fiber dowels luted with dual-cure cement and self-etching primer. Further clinical studies are required to verify the results of the present study. As an alternative approach, in vitro studies using thermomechanical loading and simulation of oral conditions should be carried out.

References

1. Baraban DJ: The restoration of endodontically treated teeth: an update. J Prosthet Dent 1988;59:553-558
2. Fernandes AS, Shetty S, Coutinho I: Factors determining post selection: a literature review. J Prosthet Dent 2003;90:556-562
3. Schwartz RS, Robbins JW: Post placement and restoration of endodontically treated teeth: a literature review. J Endod 2004;30:289-301
4. Qualtrough AJ, Mannocci F: Tooth-colored post system: a review. Oper Dent 2003;28:86-91
5. Santos AF, Meira JB, Tanaka CB, et al: Can fiber posts increase root stresses and reduce fracture? J Dent Res 2010;89:587-591
6. Bouillaguet S, Troesch S, Wataha JC, et al: Microtensile bond strength between adhesive cements and root canal dentin. Dent Mater 2003;19:199-205
7. Goracci C, Fabianelli A, Sadek FT, et al: The contribution of friction to the dislocation resistance of bonded fiber posts. J Endod 2005;31:608-612
8. Mendoza DB, Eakle S: Retention of posts cemented with various dentinal bonding cements. J Prosthet Dent 1994;72:591-594
9. Demiryurek EO, Kulunk S, Yuksel G, et al: Effects of three canal sealers on bond strength of a fiber post. J Endod 2010;36:497-501
10. Saunders W, Saunders E, Sadiq J, et al: Technical standard of root canal treatment in an adult Scottish sub- population. Br Dent J 1997;10:382-386
11. Sjogren U, Hagglund B, Sundqvist G, et al: Factors affecting the long-term results of endodontic treatment. J Endod 1990;16: 498-504
12. Saunders WP, Saunders EM: Assessment of leakage in the restored pulp chamber of endodontically treated multirooted teeth. Int Endod J 1990;23:28-33
13. Schwartz RS, Davis RD, Hilton TJ: Effect of temporary cements on the bond strength of a resin cement. Am J Dent 1992;5:147-150
14. Tjan AH, Nemetz H: Effect of eugenol-containing endodontic sealer on retention of prefabricated posts luted with adhesive composite resin cement. Quintessence Int 1992;23:839-844
15. 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
16. Manicardi CA, Versiani MA, Saquy PC, et al: Influence of filling materials on the bonding interface of thin-walled roots reinforced with resin and quartz fiber posts. J Endod 2011;37:531-537
17. Shipper G, Orstavik D, Teixeira FB, et al: An evaluation of microbial leakage in roots filled with a thermoplastic synthetic polymer-based root canal filling material (Resilon). J Endod 2004;30:342-347
18. Cobankara FK, Adanr N, Belli S: Evaluation of the influence of smear layer on the apical and coronal sealing ability of two sealers. J Endod 2004;30:406-409
19. Gesi A, Raffaelli O, Goracci C, et al: Interfacial strength of Resilon and gutta-percha to intraradicular dentin. J Endod 2005;31:593-598
20. Deus GD, Filho EDG, Ferreira CM, et al: Intratubular penetration of root canal sealers. Pesqui Odontol Bras 2002;16:332-336
21. Aggarwal V: An in vitro evaluation of effect of ionizing radiotherapy on push-out strength of fiber posts under cyclic loading. J Endod 2009;35:695-698
22. Huber L, Cattani-Lorente M, Shaw L, et al: Push-out bond strengths of endodontic posts bonded with different resin-based luting cements. Am J Dent 2007;20:167-172
23. Zielinski TM, Baumgartner JC, Marshall JG: An evaluation of Guttaflow and gutta-percha in the filling of lateral grooves and depressions. J Endod 2008;34:295-298
24. Elayouti A, Achleithner C, Löst C, et al: Homogeneity and adaptation of a new gutta-percha paste to root canal walls. J Endod 2005;31:687-690
25. Ordinola-Zapata R, Bramante CM, Graeff MS, et al: Depth and percentage of penetration of endodontic sealers into dentinal tubules after root canal obturation using a lateral compaction technique: a confocal laser scanning microscopy study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2009;108: 450-457
26. Raina R, Loushine RJ, Weller RN, et al: Evaluation of the quality of the apical seal in Resilon/Epiphany and Gutta-Percha/AH Plus-filled root canals by using a fluid filtration approach. J Endod 2007;33:944-947
27. Bodrumlu E, Tunga U: apical leakage of resilon obturation material. J Contemp Dent Pract 2006;7:45-52
28. Hammad M, Qualtrough A, Silikas N: Effect of new obturating materials on vertical root fracture resistance of endodontically treated teeth. J Endod 2007;33:732-736
29. Aggarwal V, Logani A, Jain V, et al: Effect of cyclic loading on marginal adaptation and bond strength in direct vs. indirect class II MO composite restorations. Oper Dent 2008;33: 587-592
30. Valandro LF, Baldissara P, Galhano GA, et al: Effect of mechanical cycling on the push-out bond strength of fiber posts adhesively bonded to human root dentin. Oper Dent 2007;32: 579-588