copyright by all rights reserved Quintessenz

# Effects of Different Root Canal Obturation Techniques on the Bond Strength of Fiber Post to Intraradicular Dentine

Chang Yuan ZHANG[1]*, Hao YU[1]*, Qi LIN[2], Yohsuke TAIRA[3], Hui CHENG[1]

**Objective:** *To evaluate the bond strength of fiber posts to intraradicular dentine pretreated with two root canal obturation techniques and three postspace irrigation solutions.*

**Methods:** *A total of 96 human premolars were collected and treated with complete or partial root canal obturation techniques. The roots were further divided into three subgroups (n = 16) based on postspace irrigation solutions: 2.5% NaOCl, 37% phosphoric acid etching, and distilled water. The fiber posts were bonded with self-adhesive resin cement, and the roots were sectioned into three slices (cervical, middle, and apical regions) after 5,000 thermocycles. The push-out bond strengths were determined and subjected to analysis of variance ($\alpha = 0.05$). A stereomicroscope was used to observe the failure modes of the specimens.*

**Results:** *The irrigation solution, root canal obturation technique, and root region had significant effects on bond strength ($P < 0.001$). The completely obturated root canals showed significantly lower bond strength than the partially obturated root canals. The 2.5% NaOCl treatment produced the highest bond strength among the three irrigation solutions. Among the root regions, the cervical part showed significantly greater bond strength than the middle and apical parts. The most common failure mode was mixed failure.*

**Conclusion:** *The partial root canal obturation technique provided better bond strength of the fiber post to intraradicular dentine. Irrigation with 2.5% NaOCl solution and phosphoric acid etching before cementation improved the push-out bond strength of the fiber posts to intraradicular dentine.*

**Key words:** *root canal obturation technique, post space irrigation, bond strength, dentine*
*Chin J Dent Res 2019;22(3):189–196; doi: 10.3290/j.cjdr.a43113*

An intraradicular post is often required to restore an endodontically treated tooth, especially when it contains extensive coronal structural defects resulting from dental caries or trauma[1,2]. The use of a fiber post has been widely accepted in dentistry due to its suitable elastic modulus, ease of use, and high success rate[3-7].

1 Department of Prosthodontics, School and Hospital of Stomatology, Fujian Medical University, Fuzhou, Fujian Province, P.R. China.
2 Department of Endodontics, School and Hospital of Stomatology, Fujian Medical University, Fuzhou, Fujian Province, P.R. China.
3 Department of Applied Prosthodontics, Graduate School of Biomedical Sciences, Nagasaki University, Nagasaki, Japan.
* These two authors contributed equally to this work.

**Corresponding author:** Dr Hui CHENG, School and Hospital of Stomatology, Fujian Medical University, 246 Yangqiao Zhong Road, Fuzhou 350002, Fujian Province, P.R. China. Tel: 86 591 83736420; Fax: 86 591 83720599. Email: huicheng.fjmu@yahoo.com.

This study was financially supported by the Youth Funding of Fujian Provincial Health and Family Planning Commission (No. 2014-1-68).

Establishment of reliable bonding at the root-cement-post interface is critical to the long-term success of both the fiber post and definitive restoration[8,9]. Given that the most common failure mode of fiber posts is post debonding at the dentine-resin cement interface, extensive efforts have been directed toward improving the adhesion of resin cements to intraradicular dentine[10,11], and pretreating the dentine with laser was a common method used by researchers. Strefezza et al[12] reported that the diode laser irradiation can enhance the bond strength between post and dentine. Pelozo et al[13] reported that dentine pretreatments with erbium:yttrium aluminium garnet (Er:YAG) laser improved bond strength of cement-post-dentine interfaces. Many variables that affect the bond strength of resin cements to the post and intraradicular dentine have been proposed, including postspace preparation[14], postspace irrigation[15,16], anatomical and morphological characteristics of the dentine substrate[17,18], limited light penetration into the apical region of the root canal[19,20], and poten-

copyright by all rights reserved Quintessenz

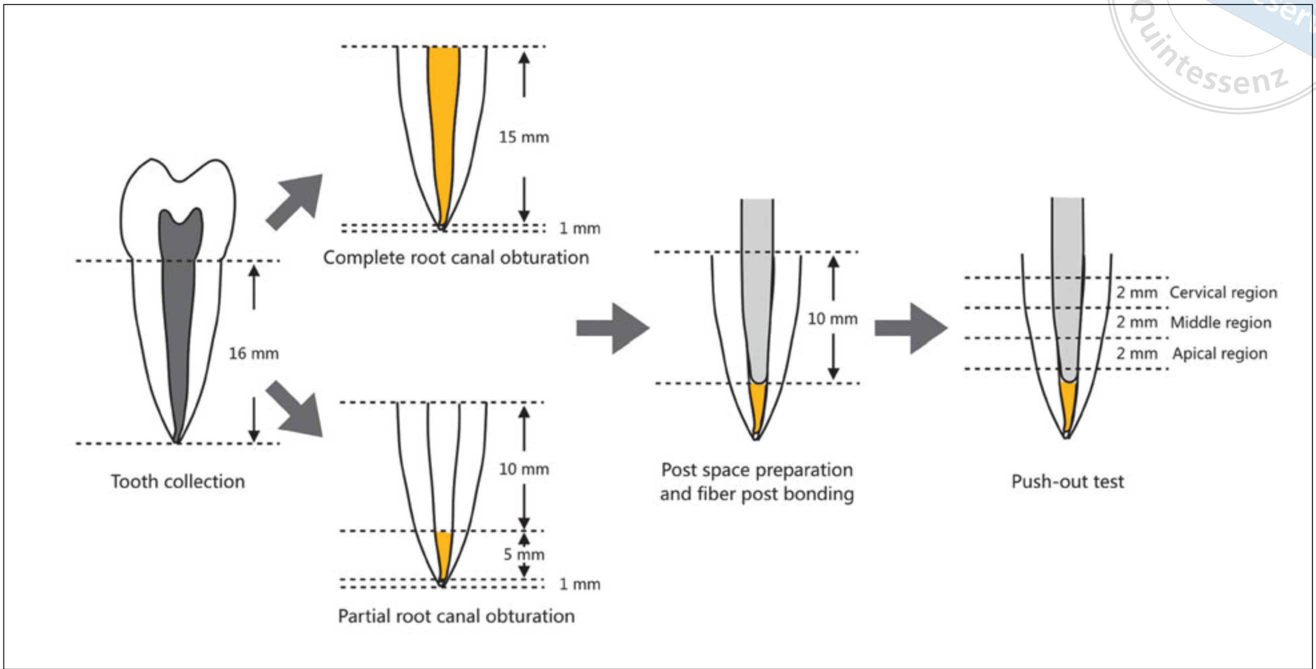


**Fig 1** Study flowchart.

tial incompatibility between the adhesive system and resin cement[21].

During postspace preparation, a smear layer consisting of gutta-percha remnants, the root canal sealant, and inorganic components are created by drilling motions[22,23]. Moreover, the gutta-percha remnants may be plasticised by the friction heat generated from postspace preparation[23]. The presence of a smear layer can occlude dentinal tubules, hinder the penetration of the adhesive resin cement, and results in low bond strength at the dentine-resin cement interface[24]. Removal of the smear layer has been shown to improve the fluid-tight sealant of the root canal system and the bond strength of the resin cement to the intraradicular dentine, and can be achieved by using irrigation solutions, such as sodium hypochlorite (NaOCl), hydrogen peroxide, and ethylenediamine tetraacetic acid (EDTA)[25-30]. Although conflicting results have been reported[28,31,32], systematic reviews concluded that self-adhesive resin cement (SARC) is a less technique-sensitive protocol and exhibits better performance than conventional resin cements[33,34]. However, only a few studies have evaluated the bond strength of SARC to intraradicular dentine pretreated with different irrigation solutions[35-37]. Scanning electron microscopy indicated that phosphoric acid application can reduce the thickness of the smear layer, although this is less effective than EDTA and/or NaOCl application[38]. Kul et al[37] evaluated different postspace irrigation treatments on the push-out bond strength of SARC (RelyX U200) to fiber posts and intraradicular dentine. The results showed that postspace irrigation using EDTA in combination with NaOCl improves the adhesion between fiber posts and SARC. In contrast, Moura et al[39] reported that the push-out bond strength values of SARC were not affected by NaOCl and/or EDTA irrigation.

Apart from the above-mentioned variables, the effects of the root canal obturation procedure seem to be underestimated in the literature. Thermoplastic root canal obturation is a well-established technique for endodontically treated teeth, enabling obturation of the root canal at any level[40]. The partial root canal obturation technique seals only the apical third of the root and leaves the middle and cervical thirds free of gutta-percha and root canal sealant. Postspace preparation of a partially obturated root canal may result in a thinner smear layer than a completely obturated root canal, affecting the bond strength of the fiber post to the intraradicular dentine. However, limited information is available in the literature.

Therefore, the present study aimed to evaluate the effects of different root canal obturation techniques on the bond strength of fiber posts to intraradicular dentine pretreated with three postspace irrigation methods. The null hypotheses were proposed as follows: 1) different root canal obturation techniques do not affect the push-out bond strength of the fiber post to intraradicular dentine; 2) different postspace irrigation methods do

copyright by all rights reserved Quintessence

not alter the push-out bond strength of fiber posts to intraradicular dentine; and 3) different regions of the intraradicular dentine exhibit similar push-out bond strength values.

## Materials and methods

### *Tooth collection*

The research protocol was reviewed and approved by the Research Ethics Committee of the School and Hospital of Stomatology, Fujian Medical University (no. FMUSS-21749). The study design is depicted in Figure 1. A total of 96 human premolars of similar sizes and shapes with a fully formed apex were selected for the present study. The teeth were recently extracted for orthodontic reasons from patients who provided an informed consent. The inclusion criteria were: a single root canal (as verified radiographically); absence of caries, root cracks, internal resorption, and previous endodontic treatment; and a root length greater than 16 mm[41]. External debris was removed with a periodontal curette. Each tooth was sectioned below the cemento-enamel junction using a low-speed diamond blade saw (Isomet, Buehler, IL, USA) under constant and copious water cooling. The roots were cut to a uniform length of 16 mm from the apical end. The working length was determined by subtracting 1 mm from the length of an inserted no. 10 K-file (Dentsply Maillefer, Ballaigues, Switzerland) with its tip visualised at the apical foramen. The roots were stored at 4°C in 100% humidity until use[3].

### *Root canal obturation*

All the roots were instrumented and finished using ProFile .06 (Dentsply DeTrey, Konstanz, Germany). The canals were irrigated with 3 ml of 2.5% NaOCl solution between each file size. The root canals were dried with absorbent paper after the final irrigation, and obturated using warm vertical compaction with an Elements Obturation Unit (Sybron Endo, Orange, USA). A .06 tapered master gutta-percha point (Dentsply DeTrey) was selected and assessed for apical tug-back. The master point was covered with AH Plus resin-based sealant (Dentsply DeTrey) and placed into the root canal. A heat plugger was activated and utilised to sear off the master point until 5 mm from the apical terminus. Half of the filled roots were assigned to group P (partial root canal obturation), and the other half of the roots were filled completely using a backfilling technique and assigned to group C (complete root canal obturation). All procedures were performed by a trained endodontic specialist. After root canal obturation, the endodontic accesses were sealed using glass ionomer cement (Ketac-Fil, 3M ESPE, St. Paul, MN, USA). The roots were then stored at 37°C for seven days in 100% humidity[42].

### *Specimen preparation*

After storage, the sealant was removed, and root canals were prepared for a post with a length of 10 mm using the rotary drill burs of a glass fiber post system (RelyX Fiber Post, 3M ESPE, St. Paul, MN, USA) to match the corresponding RelyX fiber post (2# Fiber Post, 3M ESPE). The diameter of the fiber post was 0.80 mm in the apical and 1.60 mm in the coronal. New drills were used for every five roots. The postspace was viewed with a stereomicroscope (x100, MM400, Nikon, Tokyo, Japan) to completely remove the root canal filling. The samples were then randomly divided into three subgroups (n = 16) according to the postspace irrigation solutions used: subgroup NaOCl, 5 ml of 2.5% NaOCl followed by 10 ml of distilled water for 30 seconds; subgroup PA, 37% phosphoric acid (Ivoclar Vivadent AG, Schaan, Liechtenstein) for 10 seconds followed by 10 ml of distilled water for 20 seconds; and subgroup DW, 10 ml of distilled water for 30 seconds.

After respective postspace preparation, the postspace was dried with absorbent paper points (Dayading Medical, Shenyang, China). The post was tried in the prepared postspace and then cut with a low-speed diamond blade saw to the selected length. After the try-in procedure, the posts were cleaned with ethanol (Spark Medical, Fuzhou, China). SARC (RelyX Unicem, 3M ESPE, St. Paul, MN, USA) was applied to the root canal with an elongation tip according to the manufacturer's instructions. The fiber posts were immediately inserted into the prepared postspaces with finger pressure. A LED-light-curing unit (Elipar S10, 3M ESPE, St. Paul, MN, USA) was used to illuminate the cement and post through the cervical portion of the root for 40 seconds at a light intensity of 1,200 mW/cm$^2$. During the curing procedure, the light curing tip was kept close to the surface of the tooth. The power of the LED-light-curing unit was assessed with a radiometer (Bluephase II, Ivoclar Vivadent AG, Schaan, Liechtenstein) before use.

### *Push-out test*

All specimens were stored at 37°C in 100% humidity for 24 hours before thermocycling. Thermocycling was performed for 5,000 cycles at bath temperatures of 5°C

copyright by
all rights reserved
Quintessenz

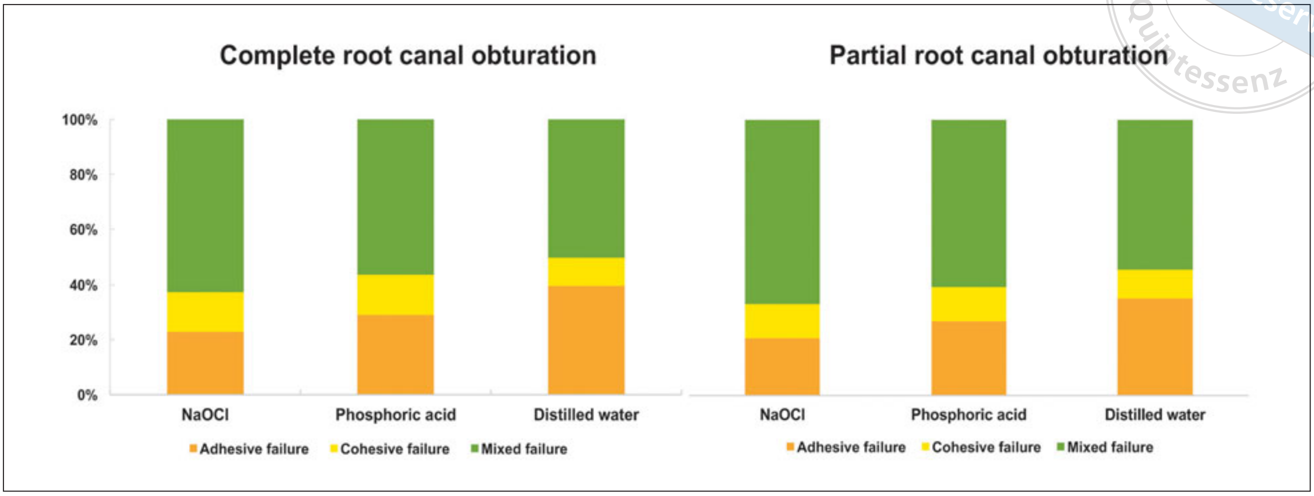


**Fig 2** Failure mode distribution among the groups tested.

and 55°C using a thermal cycling machine (TC-501F, Weier, Tianjin, China). The dwell time was 30 seconds in each bath, and the transfer time was 10 seconds[43]. This procedure corresponds to a 5-year period of oral temperature conditions[44]. After thermocycling, each specimen was sectioned perpendicular to its long axis into 2-mm-thick slices with a low-speed diamond blade saw. The slice from the top with a thickness of 1 mm was discarded to prevent misinterpretation of push-out bond strength values due to the influence of residual resin cement on the root surface[3]. Ultimately, three slices were obtained from each specimen, representing the coronal, middle, and apical regions of the specimen. Due to the tapered design of the fiber posts, the post diameters were measured on both the coronal and apical surfaces of all slices using a digital caliper (Mitutoyo, Kawasaki, Japan). A piston with a cylindrical tip (0.6 mm diameter) was attached to a universal testing machine (AGS-X, Shimadzu, Kyoto, Japan) and positioned at the apical surface of the section. The piston was pointed directly on the centre of the post. A load was applied at a speed of 0.5 mm/minute until the post was extruded. The maximum failure load (Newtons) was recorded and converted into Megapascals (MPa) by dividing the load that produced failure by the post interface area (A). The post interface area was calculated with the following equation[45]:

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

where $\pi = 3.14$, R = coronal post radius (mm), r = apical post radius (mm), and h = thickness of the slice (mm).

After the push-out test, a stereomicroscope was used to observe the failure modes of all slices. The failure modes were classified into three types: 1) adhesive failure, the fracture occurring between the dentine and the resin cement; 2) cohesive failure, the fracture occurring between the resin cement and the post; and 3) mixed failure[37].

### *Statistical analysis*

The data were analysed using SPSS software, version 20.0 for Windows (SPSS, Chicago, IL, USA) at $\alpha = 0.05$. The assumption of normality was confirmed using the Kolmogorov-Smirnov test and the equality of variances was confirmed with the Levene test. The push-out bond strength values were analysed with three-way analysis of variance (ANOVA) and the Tukey Honestly Significant Difference (HSD) post hoc test. The frequencies of different failure modes among the groups were evaluated.

## Results

The three-way ANOVA revealed that the postspace irrigation solution, root region, and root canal obturation technique significantly affected the push-out bond strength values ($P < 0.001$). Significant interactions were found between the root canal obturation technique and the root region, and between the root region and the postspace irrigation treatment (Table 1).

The mean and standard deviation of push-out bond strength are presented in Table 2. Significant differences in push-out bond strength values were found among the postspace irrigation treatments ($P < 0.001$). The NaOCl irrigation exhibited the best push-out bond strength value among the three postspace irrigation treatments,

copyright by all rights reserved Quintessence

**Table 1** Three-way ANOVA results for the push-out bond strength tests.

| Source of variance | Sum of squares | df | Mean square | F | P |
|---|---|---|---|---|---|
| Post space treatment | 96.024 | 2 | 48.012 | 115.558 | < 0.001 |
| Root region | 761.864 | 2 | 380.932 | 916.849 | < 0.001 |
| Root canal obturation technique | 22.687 | 1 | 22.687 | 54.604 | < 0.001 |
| Post space treatment x Root region | 5.074 | 4 | 1.268 | 3.053 | 0.018 |
| Post space treatment x Root canal obturation technique | 0.543 | 2 | 0.272 | 0.654 | 0.521 |
| Root region x Root canal obturation technique | 5.088 | 2 | 2.544 | 6.123 | 0.003 |
| Post space treatment x Root region x Root canal obturation technique | 0.285 | 2 | 0.071 | 0.171 | 0.953 |
| Error | 77.279 | 186 | 0.415 | - | - |

**Table 2** Mean and standard deviation (MPa) of the push-out bond strength of each treatment group.

| Root region | Group C (complete root canal obturation) | | | Group P (partial root canal obturation) | | |
|---|---|---|---|---|---|---|
| | NaOCl | Phosphoric acid | Distilled water | NaOCl | Phosphoric acid | Distilled water |
| Cervical | $9.59 \pm 0.87^{a,A}$ | $8.99 \pm 0.71^{a,A}$ | $7.53 \pm 0.80^{a,B}$ | $10.73 \pm 0.47^{a,A}$ | $10.09 \pm 0.67^{a,B}$ | $8.58 \pm 0.47^{a,C}$ |
| Middle | $6.79 \pm 0.51^{b,A}$ | $6.31 \pm 0.82^{b,A}$ | $5.40 \pm 0.52^{b,B}$ | $7.30 \pm 0.48^{b,A}$ | $6.51 \pm 0.37^{b,B}$ | $5.75 \pm 0.58^{b,C}$ |
| Apical | $4.91 \pm 0.74^{c,A}$ | $4.35 \pm 0.67^{c,A}$ | $3.72 \pm 0.41^{c,B}$ | $5.69 \pm 0.83^{c,A}$ | $4.88 \pm 0.66^{c,B}$ | $4.09 \pm 0.66^{c,C}$ |

Note: Values marked with same superscript lower case letter were not significantly different within the same column. Values marked with the same superscript upper case letter were not significantly different within the same group and root region ($P \geq 0.05$).

whereas distilled water irrigation produced the lowest push-out bond strength values. Group P (partial root canal obturation technique) resulted in significantly greater push-out bond strength values than group C (complete root canal obturation technique) ($P = 0.049$). Significant differences in push-out bond strength were found among different root regions ($P < 0.001$). The cervical region showed the best push-out bond strength, followed by the middle region and the apical region.

The frequencies of the different failure modes are shown in Figure 2. The mixed failure was the most common failure mode, followed by adhesive failure between the dentine and resin cement and the cohesive failure in the resin cement.

## Discussion

The present study aimed to compare the bond strength of fiber post to intraradicular dentine pretreated with two root canal obturation techniques and three postspace irrigation treatments. Based on the current findings, the null hypotheses were rejected: different root canal obturation techniques did not affect the push-out bond strength of fiber posts to intraradicular dentine; different irrigation methods did not alter the push-out bond strength of fiber posts to intraradicular dentine; and different regions of the intraradicular dentine exhibited similar push-out bond strength values.

During the preparation of the post pace, drills create a smear layer rich in gutta-percha, root canal sealant, and inorganic components, which compromises the bond strength of fiber posts to the intraradicular dentine[16,37]. Removal of the smear layer is therefore essential to the bonding of fiber posts to the intraradicular dentine[24]. The bonding mechanism of SARC is based on the chemical bond between an acid monomer and a hydroxyapatite through the formation of calcium phosphates[46]. The existing smear layer and debris along the post space canal walls would hinder this process and lead to further reduction in the bond strength. The lower

copyright by all rights reserved Quintessenz

push-out bond strength of group C (complete root canal obturation) indicated that the rotary post drill failed to sufficiently remove the smear layer. Therefore, partial obturation of the root canal system can improve the bonding strength of the fiber post. In addition, partial obturation techniques can also reduce the clinical treatment time. Thus, partial obturation techniques can be applied to root canal treatments in the teeth that require fiber posts for restoration. SARC cannot establish sufficient chemical interactions and micromechanical retention when a thick smear layer is present[37,46]. Although the manufacturer 3M ESPE (St. Paul, MN, USA) recommends NaOCl irrigation, previous studies have shown the effects of various postspace irrigation procedures on the bond strength of SARC[30,36,37]. Bitter et al[36] concluded that the use of NaOCl irrigation together with EDTA increased the SARC bond strength. Similarly, in the present study, the NaOCl irrigation group showed the best push-out bond strength among the irrigation treatment groups. The phosphoric acid exhibited lower effectiveness, possibly due to insufficient dissolution of the smear layer with the use of SARC[37,46]. However, in the present study, the completely obturated roots exhibited significantly lower push-out bond strength than the partially obturated roots, even after NaOCl irrigation. The present findings may indicate that NaOCl irrigation alone is incapable of providing sufficient dissolution of the smear layer[29], especially when the root canal is completely obturated.

Our findings also showed that the push-out bond strength of fiber posts to the intraradicular dentine varied in different root regions. Significantly higher push-out bond strength was observed in coronal dentine than in the middle and apical sections, which is consistent with reports from previous studies[47,48]. The most likely explanation could be the limited light energy received in the apical region due to greater distance from the light source[49]. Moreover, the greater push-out bond strength in the coronal and middle regions than in the apical region, can be partially explained by differences in the density and distribution of dentinal tubules along the canal walls, which decrease from the cervical area to the apical area[50].

Failure mode implies the quality of cementation[51]. The most common fracture mode in this study was the mixed failure between cement and root canal, which is consistent with reports from previous studies[37,52]. Moreover, the specimens subjected to 2.5% NaOCl irrigation had the fewest adhesive failures, which correlated well with the findings for the push-out bond strength. In contrast, some studies have reported that the failures observed after the push-out test were predominantly adhesive failures followed by mixed and cohesive failures[36]. This discrepancy may be explained by the different resin cement systems used.

The limitations of the present study were that no topographical observations were conducted at the resin-dentine interface. This study revealed that the partial root canal obturation technique is recommended when a fiber post is required in further treatment. However, due to the limitations of in vitro studies, future clinical studies are required to confirm the present findings.

## Conclusions

Within the limitations of present study, the following conclusions can be drawn:

- The partial root canal obturation technique provided better bond strength of the fiber post to the intraradicular dentine than the complete root canal obturation technique;
- Irrigation with 2.5% NaOCl solution and phosphoric acid etching before post cementation improved the push-out bond strength of fiber posts to intraradicular dentine.

## Conflicts of interest

The authors reported no conflicts of interest related to this study.

## Author contribution

Dr Chang Yuan ZHANG performed the fiber post bonding procedure and wrote the manuscript; Dr Hao YU collected the teeth, prepared the specimens, performed the push-out tests and the statistical analysis; Dr Qi LIN performed root canal treatment of all the specimens; Prof. Yohsuke TAIRA reviewed the manuscript; Prof. Hui CHENG designed the study.

(Received Aug 13, 2018; accepted Feb 14, 2019)

copyright all rights reserved Quintessenz


## References


1. Castro CG, Santana FR, Roscoe MG, Simamoto PC Jr, Santos-Filho PC, Soares CJ. Fracture resistance and mode of failure of various types of root filled teeth. Int Endod J 2012;45:840–847.
2. Farina AP, Chiela H, Carlini-Junior B, et al. Influence of Cement Type and Relining Procedure on Push-Out Bond Strength of Fiber Posts after Cyclic Loading. J Prosthodont 2016;25:54–60.
3. Pereira JR, Lins do Valle A, Ghizoni JS, Lorenzoni FC, Ramos MB, Dos Reis Só MV. Push-out bond strengths of different dental cements used to cement glass fiber posts. J Prosthet Dent 2013;110:134–140.
4. Asmussen E, Peutzfeldt A, Heitmann T. Stiffness, elastic limit, and strength of newer types of endodontic posts. J Dent 1999;27:275–278.
5. Cagidiaco MC, Goracci C, Garcia-Godoy F, Ferrari M. Clinical studies of fiber posts: a literature review. Int J Prosthodont 2008;21: 328–336.
6. Goracci C, Ferrari M. Current perspectives on post systems: a literature review. Aust Dent J. 2011 Jun;56 Suppl 1:77–83.
7. Roperto RC, Porto TS, Lang L, et al. Microtensile bond strength between a UDMA fiber post and different resin cements: Effect of pre-surface treatment. Dent Mater J 2016;35:923–928.
8. Hatzikyriakos AH, Reisis GI, Tsingos N. A 3-year postoperative clinical evaluation of posts and cores beneath existing crowns. J Prosthet Dent 1992;67:454–458.
9. Bergman B, Lundquist P, Sjögren U, Sundquist G. Restorative and endodontic results after treatment with cast posts and cores. J Prosthet Dent 1989;61:10–15.
10. Monticelli F, Grandini S, Goracci C, Ferrari M. Clinical behavior of translucent-fiber posts: a 2-year prospective study. Int J Prosthodont 2003;16:593–596.
11. Kırmalı Ö, Üstün Ö, Kapdan A, Kuştarcı A. Evaluation of Various Pretreatments to Fiber Post on the Push-out Bond Strength of Root Canal Dentin. J Endod 2017;43:1180–1185.
12. Strefezza C, Amaral MM, Quinto J Jr, Gouw-Soares SC, Zamataro CB, Zezell DM. Effect of 830 nm Diode Laser Irradiation of Root Canal on Bond Strength of Metal and Fiber Post. Photomed Laser Surg 2018;36:439–444.
13. Pelozo LL, Silva-Neto RD, Corona SAM, Palma-Dibb RG, Souza-Gabriel AE. Dentin pretreatment with Er:YAG laser and sodium ascorbate to improve the bond strength of glass fiber post. Lasers Med Sci 2019;34:47–54.
14. Gu XH, Mao CY, Kern M. Effect of different irrigation on smear layer removal after post space preparation. J Endod 2009;35:583–586.
15. Bonfante EA, Pegoraro LF, de Góes MF, Carvalho RM. SEM observation of the bond integrity of fiber-reinforced composite posts cemented into root canals. Dent Mater 2008;24:483–491.
16. Martinho FC, Carvalho CA, Oliveira LD, et al. Comparison of different dentin pretreatment protocols on the bond strength of glass fiber post using self-etching adhesive. J Endod 2015;41:83–87.
17. Ferrari M, Mannocci F, Vichi A, Cagidiaco MC, Mjör IA. Bonding to root canal: structural characteristics of the substrate. Am J Dent 2000;13:255–260.
18. Pedreira AP, Pegoraro LF, de Góes MF, Pegoraro TA, Carvalho RM. Microhardness of resin cements in the intraradicular environment: effects of water storage and softening treament. Dent Mater 2009;25:868–876.
19. 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.
20. Mao H, Chen Y, Yip KH, Smales RJ. Effect of three radicular dentine treatments and two luting cements on the regional bond strength of quartz fibre posts. Clin Oral Investig 2011;15:869–878.
21. Giachetti L, Scaminaci Russo D, Bertini F, Giuliani V. Translucent fiber post cementation using a light-curing adhesive/composite system: SEM analysis and pull-out test. J Dent 2004;32:629–634.
22. Pirani C, Pelliccioni GA, Marchionni S, Montebugnoli L, Piana G, Prati C. Effectiveness of three different retreatment techniques in canals filled with compacted gutta-percha or Thermafil: a scanning electron microscope study. J Endod 2009;35:1433–1440.
23. Serafino C, Gallina G, Cumbo E, Ferrari M. Surface debris of canal walls after post space preparation in endodontically treated teeth: a scanning electron microscopic study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2004;97:381–387.
24. Vichi A, Grandini S, Ferrari M. Comparison between two clinical procedures for bonding fiber posts into a root canal: a microscopic investigation. J Endod 2002;28:355–360.
25. Shahravan A, Haghdoost AA, Adl A, Rahimi H, Shadifar F. Effect of smear layer on sealing ability of canal obturation: a systematic review and meta-analysis. J Endod 2007;33:96–105.
26. Khoroushi M, Sheikhi M, Khalilian-Gourtani A, Soleimani B. Effect of root canal rinsing protocol on dentin bond strength of two resin cements using three different method of test. J Clin Exp Dent 2016;8:e246–e254.
27. Ertas H, Ok E, Uysal B, Arslan H. Effects of different irrigating solutions and disinfection methods on push-out bond strengths of fiber posts. Acta Odontol Scand 2014;72:783–777.
28. Akman M, Eldeniz AU, Ince S, Guneser MB. Push-out bond strength of a new post system after various post space treatments. Dent Mater J 2016;35:876–880.
29. Habelitz S, Balooch M, Marshall SJ, Balooch G, Marshall GW Jr. In situ atomic force microscopy of partially demineralized human dentin collagen fibrils. J Struct Biol 2002;138:227–236.
30. Elnaghy AM. Effect of QMix irrigant on bond strength of glass fibre posts to root dentine. Int Endod J 2014;47:280–289.
31. Akgungor G, Akkayan B. Influence of dentin bonding agents and polymerization modes on the bond strength between translucent fiber posts and three dentin regions within a post space. J Prosthet Dent 2006;95:368–378.
32. Oskoee SS, Bahari M, Kimyai S, Asgary S, Katebi K. Push-out Bond Strength of Fiber Posts to Intraradicular Dentin Using Multimode Adhesive System. J Endod 2016;42:1794–1798.
33. Skupien JA, Sarkis-Onofre R, Cenci MS, Moraes RR, Pereira-Cenci T. A systematic review of factors associated with the retention of glass fiber posts. Braz Oral Res 2015;29. pii: S1806–83242015000100401.
34. Sarkis-Onofre R, Skupien JA, Cenci MS, Moraes RR, Pereira-Cenci T. The role of resin cement on bond strength of glass-fiber posts luted into root canals: a systematic review and meta-analysis of in vitro studies. Oper Dent 2014;39:E31–44.
35. Dimitrouli M, Geurtsen W, Lührs AK. Comparison of the push-out strength of two fiber post systems dependent on different types of resin cements. Clin Oral Investig 2012;16:899–908.
36. Bitter K, Hambarayan A, Neumann K, Blunck U, Sterzenbach G. Various irrigation protocols for final rinse to improve bond strengths of fiber posts inside the root canal. Eur J Oral Sci 2013;121:349–554.
37. Kul E, Yeter KY, Aladag LI, Ayrancı LB. Effect of different post space irrigation procedures on the bond strength of a fiber post attached with a self-adhesive resin cement. J Prosthet Dent 2016;115:601–605.
38. Demiryürek EO, Külünk S, Saraç D, Yüksel G, Bulucu B. Effect of different surface treatments on the push-out bond strength of fiber post to root canal dentin. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2009;108:e74–e80.
39. Moura AS, Pereira RD, Rached FJ Junior, et al. Influence of root dentin treatment on the push-out bond strength of fibre-reinforced posts. Braz Oral Res 2017;31:e29.
40. Tennert C, Jungbäck IL, Wrbas KT. Comparison between two thermoplastic root canal obturation techniques regarding extrusion of root canal filling--a retrospective in vivo study. Clin Oral Investig 2013;17:449–454.
41. Rueggeberg FA. Substrate for adhesion testing to tooth structure - review of the literature. Dent Mater 1991;7:2–10.

copyright by all rights reserved Quintessenz


42. Aleisa K, Alghabban R, Alwazzan K, Morgano SM. Effect of three endodontic sealers on the bond strength of prefabricated fiber posts luted with three resin cements. J Prosthet Dent 2012;107:322–326.
43. Deng D, Huang X, Huang C, et al. Effects of chlorhexidine on bonding durability of different adhesive systems using a novel thermocycling method. Aust Dent J 2013;58:148–155.
44. Andrade de Freitas SL, Brandt WC, Miranda ME, Vitti RP. Effect of Thermocycling, Teeth, and Polymerization Methods on Bond Strength Teeth-Denture Base. Int J Dent 2018;2018:2374327.
45. Sadek FT, Goracci C, Monticelli F, et al. Immediate and 24-hour evaluation of the interfacial strengths of fiber posts. J Endod 2006;32:1174–1177.
46. Monticelli F, Osorio R, Mazzitelli C, Ferrari M, Toledano M. Limited decalcification/diffusion of self-adhesive cements into dentin. J Dent Res 2008;87:974–979.
47. Park JS, Lee JS, Park JW, Chung WG, Choi EH, Lee Y. Comparison of push-out bond strength of fiber-reinforced composite resin posts according to cement thickness. J Prosthet Dent 2017;118:372–378.
48. Kalkan M, Usumez A, Ozturk AN, Belli S, Eskitascioglu G. Bond strength between root dentin and three glass-fiber post systems. J Prosthet Dent 2006;96:41–46.
49. Juloski J, Goracci C, Tsintsadze N, et al. Influence of luting agent translucency on fiber post retention. Eur J Oral Sci 2015;123:116–121.
50. Cunha LG, Alonso RC, de Souza-Junior EJ, Neves AC, Correr-Sobrinho L, Sinhoreti MA. Influence of the curing method on the post-polymerization shrinkage stress of a composite resin. J Appl Oral Sci 2008;16:266–70.
51. Rebholz-Zaribaf N, Özcan M. Adhesion to zirconia as a function of primers/silane coupling agents, luting cement types, aging and test methods. J Adhes Sci Technol 2017;31:1408–1421.
52. Zicari F, Couthino E, De Munck J, et al. Bonding effectiveness and sealing ability of fiber-post bonding. Dent Mater 2008;24:967–977.