

# Push-out bond strength of fiber post after post space surface pretreatment

Il-Joo Song, Kyeol Koh, Hyung-Hoon Jo, Ho-Keel Hwang\*

Department of Conservative Dentistry, School of Dentistry, Chosun University, Gwang-ju, Korea

## ORCID ID

Il-Joo Song,  <https://orcid.org/0000-0002-8448-8001>

Kyeol Koh,  <https://orcid.org/0000-0003-2480-6810>

Hyung-Hoon Jo,  <https://orcid.org/0000-0003-3566-1821>

Ho-Keel Hwang,  <https://orcid.org/0000-0003-3237-232X>

## ABSTRACT

### Push-out bond strength of fiber post after post space surface pretreatment

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Department of Conservative Dentistry, School of Dentistry, Chosun University, Gwang-ju, Korea

**Objectives:** This study aims to compare the push-out bond strength of fiber posts luted with self-adhesive resin cement with various pretreatments.

**Materials and Methods:** Twenty-one single-rooted human premolar teeth were treated endodontically using a Ni-Ti rotary file and obturated with gutta-percha points and a sealer. The post room was immediately prepared to a depth of 12 mm with a post drill, while the teeth were divided into three groups: 1) no pretreatment (control); 2) pretreatment with 17% ethylenediaminetetraacetic acid (PE), and 3) pretreatment with 32% phosphoric acid (PP). Self-adhesive resin cement (G-CEM LinkAce) was applied directly to the post room. After application, a fiber post (LuxaPost) was immediately seated and light-cured for 40 s. The specimens were transversally sectioned to measure the regional push-out bond strengths.

**Results:** The push-out bond strength was highest for all groups in the coronal parts and lowest in the apical parts ( $p < 0.05$ ). No significant differences according to the pretreatment were observed in the coronal part and middle parts. However, in the apical part, a significant difference was observed between the control and PE groups and between the control and PP groups ( $p < 0.05$ ).

**Conclusion:** Considering the limitations of this study, pretreatment with EDTA or phosphoric acid did not improve the push-out bond strength of fiber posts cemented with self-adhesive resin cement.

**Key words :** fiber post, pretreatment, push-out bond strength, self-adhesive resin cement

## Corresponding Author

Ho-Keel Hwang, DDS, MSD, PhD, Professor

Department of Conservative Dentistry, School of Dentistry, Chosun University, 309 Pilmun-daero, Dong-gu, Gwang-ju, Korea.

Tel : +82-62-220-3840 / Fax : +82-62-223-9064 / E-mail : rootcanal@hanmail.net

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## I. Introduction

Severely damaged endodontically treated teeth are commonly restored via post-retained restorations. Fiber posts have been proposed as an alternative to metal casting posts that involve a more complex restoration procedure and are dependent on laboratory work. There is also a mismatch problem between the modulus of elasticity of stainless-steel posts (200 GPa) and dentin (20 GPa). Metal posts can also cause root fracture and post-retained core failure under overloaded stress<sup>1)</sup>. In contrast, fiber posts are more resistant to root fracture because their modulus of elasticity is similar to that of dentin. The color of fiber posts is translucent for improved aesthetic and polymerization results<sup>2)</sup>. Furthermore, the bonding procedures of fiber posts require less chairside time compared with those of casting post and core restoration<sup>3)</sup>. Accordingly, fiber posts have largely replaced metal casting posts in modern dental practice.

Although a homogeneous unit consisting of the post, cement, and dentin is ideal, luting to the root dentin can be difficult. After post space preparation and cleaning, smear layers and a humid environment inhibit adhesion between the post and root dentin. High polymerization stress can cause adhesive failure. Moreover, it is difficult for the curing light to reach the apical part of the post room, thereby causing unpolymerized cement and debonding from the root dentin<sup>4,5)</sup>. Hence, dual-cured resin cement has been used for luting the post to the dentin. However, with the development of ad-

hesive systems and the simplification of procedures, cement has also evolved. In particular, self-adhesive resin cement is now widely used, which has eliminated the need for pretreatment and can be applied in one step. Their bond strength has also improved and has been reported to be similar to that of dual-cured resin cements<sup>6)</sup>.

According to manufacturers' instructions, the use of self-adhesive resin cement does not require pretreatment. However, after post space preparation and cleaning, the root surface becomes humid and filled with an excessive smear layer over the root dentin. Moreover, the demineralization and hybridization of dentin are difficult because self-adhesive resin cement is mildly acidic<sup>7)</sup>. Although 17% ethylenediaminetetraacetic acid (EDTA) or 32% phosphoric acid can be used to demineralize intertubular dentin,<sup>8)</sup> the effects of post space pretreatment with self-adhesive resin cement remain controversial. Therefore, this study aims to compare the push-out bond strength of fiber posts luted with self-adhesive resin cement with various pretreatments.

## II. Materials and Methods

### 1. Specimen preparation

The study protocol was approved by the Institutional Review Board of Chosun University Dental Hospital (CUDHIRB-1503-008). Twenty-one single-rooted human premolar teeth that were extracted for orthodontic treatment were used in this study.

Teeth with resorption, fracture, and dental caries were excluded from the study. The crown was removed to prepare a uniform length of 17 mm from the root apex with a diamond bur. A conventional access cavity was prepared, and a size 10 K-file was used to establish apical patency. The working length of the root canal was determined to be 1 mm shorter than the root apex. The root canals were prepared with ProTaper rotary files (Dentsply, Ballaigues, Switzerland) using the crown-down technique from SX to F3 file, and irrigated with 5.25% sodium hypochlorite after each preparation. The canals were dried with paper points and obturated with gutta-percha cones and AH plus sealer (Dentsply, Ballaigues, Switzerland) using the continuous wave compaction technique. The post space was immediately prepared with a  $\varnothing$  1.25 mm LuxaPost drill (DMG, Hamburg, Germany) to a depth of 12 mm, and rinsed with an air-water syringe. The prepared post space was examined with a dental operating microscope (OPMI Pico; Carl Zeiss, Gottingen, Germany) at 20X magnification, and dried with paper points. The specimens were then randomly divided into three groups of seven teeth each according to the pretreatment of the post space surface: Group 1 (control) no pretreatment, Group 2 (PE) pretreatment with 17% EDTA (MD-Cleanser; Meta Biomed, Cheongju, Korea) for 60 s; and Group 3 (PP) pretreatment with 32% phosphoric acid (Uni-Etch; Bisco, Schaumburg, IL, USA) for 20 s. After each pretreatment, the root canals were rinsed with an air-water syringe and dried with paper points.

## 2. Post cementation procedure

Before light-curing, the teeth were covered with 1 mm thick black paper at the CEJ level to resemble the clinical situation and prevent the curing light from penetrating the root. Self-adhesive resin cement (G-CEM LinkAce; GC, Tokyo, Japan) was auto-mixed and then applied directly to the post space with an elongation application tip. After application, a translucent LuxaPost ( $\varnothing$  1.25 mm; DMG, Hamburg, Germany) was immediately seated and light-cured with an LED curing unit (B&Lite; B&L biotech, Ansan, Korea) for two cycles of 20 s each. The specimens were stored in water at 37 °C for one week.

## 3. Push-out bond strength test

The specimens were vertically embedded into a cylindrical plastic block with acrylic resin. After polymerization, an approximately 0.5 mm thick coronal slice was cut and removed to render a flat aspect and prevent misinterpretation of the results. Then, the specimens were transversally sectioned with a water-cooled low-speed diamond saw (R&B, Daejeon, Korea) to produce six post-dentin slices with a thickness of 1 mm (Fig. 1A). The six slices were obtained from each tooth and divided into two coronal, two middle, and two apical slices. Each slice was marked with a sign on the apical side. The thickness was measured with a digital caliper and positioned upward for the push-out test along the apical-coronal direction in a universal testing machine (AG-10KNX; Shimadzu, Kyoto, Japan)

at a crosshead speed of 0.5 mm/min (Fig. 1B). The plunger tip was positioned to touch only the post area without pressing on the surrounding root dentin. The push-out strength values were measured in Newton (N) when the post was separated from the specimen. After the push-out test, the thickness of the slice and the coronal and apical diameters of the fiber post were measured with a digital micrometer with a 0.01 mm accuracy (Fig. 1C). The measured value was then converted into MPa by dividing the strength that caused the failure (N) by the post interface area (A) using the following formula of a conical frustum<sup>9)</sup> (Fig. 1B).

$$\text{Debonding stress (MPa)} = \text{Load(N)/A}$$

$$A = \pi(R_1 + R_2)\sqrt{(R_1 - R_2)^2 + h^2}$$

$R_1$ : Coronal diameter of post

$R_2$ : Apical diameter of post

$h$ : Thickness of slice

#### 4. Statistical analysis

The differences in the mean push-out bond strength between groups in each region were statistically analyzed using two-way analysis of variance (ANOVA) and Scheffe tests. Statistical analysis was performed using SPSS (version 23.0; SPSS Inc., Chicago, IL, USA). In all statistical tests, the significance level was  $p < 0.05$ .

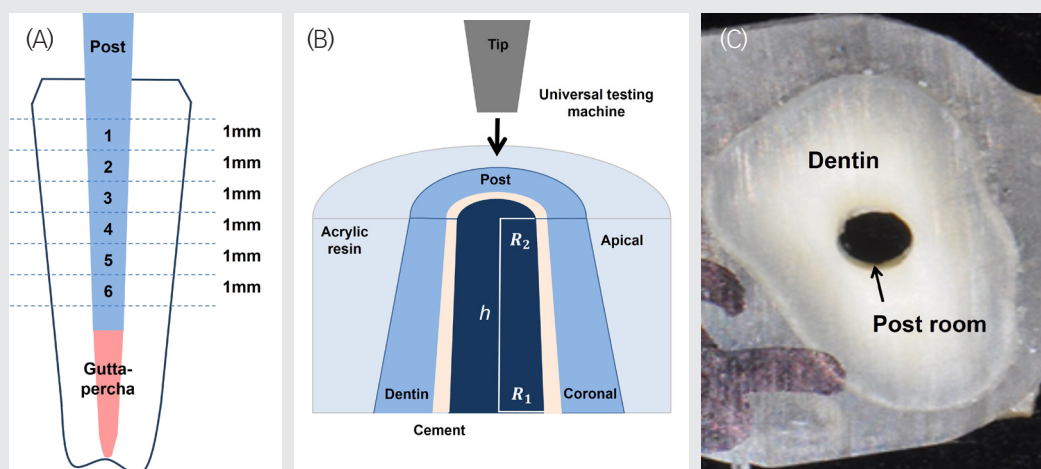


Figure 1. Schematic description of specimen preparation (A) and push-out bond strength test (B). Representative image of a specimen after the push-out test (C).

### III. Results

The mean push-out bond strengths of the specimens are presented in Table 1 and Fig. 2. The push-out bond strength was highest for all groups in the coronal parts and lowest in the apical parts ( $p < 0.05$ ). And there were no significant differences between each coronal and middle parts among all groups. However, in the apical parts, there was a significant

difference between the control group and PE group, and between the control group and PP group ( $p < 0.05$ ). There was no significant difference between the PP and PE groups in the apical parts.

### IV. Discussion

In this study, the specimens were uniformly cut to

Table 1. Push-out bond strength between the fiber post and radicular dentin for experimental groups (mean  $\pm$  SD in MPa)

	Coronal	Middle	Apical
No pretreatment (Control)	6.86 $\pm$ 3.70 <sup>Aa</sup>	3.75 $\pm$ 2.17 <sup>Ba</sup>	2.96 $\pm$ 1.93 <sup>Ca</sup>
Pretreatment with EDTA for 60 s (PE)	6.73 $\pm$ 1.89 <sup>Aa</sup>	3.79 $\pm$ 3.27 <sup>Ba</sup>	1.08 $\pm$ 0.50 <sup>Cb</sup>
Pretreatment with phosphoric acid for 20 s (PP)	6.96 $\pm$ 2.24 <sup>Aa</sup>	4.78 $\pm$ 3.44 <sup>Ba</sup>	0.97 $\pm$ 0.70 <sup>Cb</sup>

Different superscript capital letters (A, B, C) indicate statistically significant differences between root levels and different lowercase letters (a, b, c) indicate statistically significant differences between pretreatment conditions ( $p < 0.05$ ).

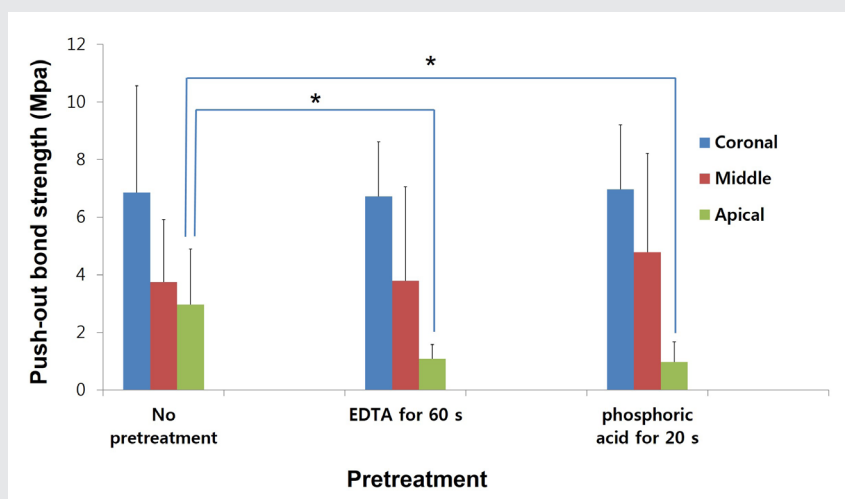


Figure 2. Diagram of the push-out bond strength of each group. The asterisk represents a significant difference between pretreatment groups ( $*p < 0.05$ ).

17 mm to standardize the experimental conditions. Post spaces were prepared to be 5 mm from the apex to ensure apical sealing. The cemented post was cured for 40 s with blinding over the CEJ level to reproduce the clinical situation in which the curing light does not reach the subgingival area. Then, the specimens were immersed in distilled water for 24 h to ensure that the unpolymerized resin cement was self-cured.

The push-out bond strength test is a three-point bending test conducted with a universal testing machine. This test was used to measure the regional bond strength between the post-cement-dentin unit at the post that was separated from the specimen. Microtensile bond strength test was used to compare the bond strength between the cement and dentin<sup>10</sup>. However, specimen preparation was difficult with a high incidence of pre-testing failure during specimen preparation<sup>11</sup>. In contrast, in the push-out bond strength test, a low incidence of pre-testing failure was reported<sup>10</sup>. The finite element analysis results showed a more homogenous stress distribution and fewer variations in the push-out test than in the microtensile bond strength test<sup>11</sup>. However, there were also experimental limitations in the push-out test. To calculate the bond strength, the push-out force [N] was converted to MPa by dividing it by the adhesion area. In the apical part, the gap between the post and post-space surfaces can be ignored mathematically. However, in the coronal part, the gap cannot be ignored, which causes errors in the calculated results.

The efficiency of an adhesive system is directly

related to dentin and collagen integrity<sup>12</sup>. The selection of an adhesive system is important in post cementation because the root dentin is an unfavorable environment for adhesion. Moisture in the root dentin and insufficient penetration of the curing light to the apical part disturb adhesion between the cement and root dentin. Dual-cured resin cement or self-adhesive resin cement could be a potential solution to this problem. In particular, self-adhesive resin cement has been introduced to deal with the complex cement application, receptivity to moisture, and postoperative sensitivity of conventional resin cement. Such cement reduced the need for an additional pretreatment step for the dentin surface according to the manufacturer's instructions<sup>3,13</sup>. The self-adhesive resin cement used in this study (G-CEM LinkAce; GC, Tokyo, Japan) has been reported to have the highest bond strength in an unfavorable environment with a self-cured mode<sup>14</sup>.

In this study, the bond strength was the highest in the coronal part and lowest in the apical part in all groups ( $p < 0.05$ ). This result is in accordance with previous studies that report higher bond strength in the coronal region than apical region<sup>2,5,15~17</sup>. However, other studies reported no significant difference between root levels,<sup>18,19</sup>. And another study reported adverse results that bond strength was highest in the apical region<sup>20</sup>. These differences in results can be attributed to differences in study design, specimen preparation, and types of post and cement used. The result of this study can be explained because the coronal third is more accessible to adhesives and light-curing energy<sup>18</sup>. The difficulty in delivering the

curing light to the apical part has been demonstrated by evaluating the depth of the light-initiated polymerization of fiber-reinforced composites in the root canal<sup>2,21</sup>. To overcome this limitation, light-guiding attachments have been introduced to enable light to penetrate the apical part<sup>22</sup>. Although many self-curing initiators have been added to compensate for the insufficient curing light penetration, dual-cured resin cement displays higher bond strength when accompanied by light curing<sup>23</sup>.

In this study, the post space surface was pretreated with EDTA or phosphoric acid to modify or remove the smear layer, to form a uniform hybrid layer and increase the bond strength between the cement and dentin<sup>11</sup>. However, no significant difference according to the pretreatment was observed in the coronal and middle parts. And a negative effect was observed in the apical part. This result was partially confirmed with previous study which reported a final rinse of EDTA did not improve retention of fiber posts<sup>24</sup>. In contrast, Wu et al<sup>22</sup> reported smear layer removal by EDTA and NaOCl improved adhesive properties. Pretreatment with 37% phosphoric acid showed similar result with EDTA. In contrast, Durski et al<sup>16</sup> reported conditioning with 37% phosphoric

acid prior to self-adhesive cementation resulted in higher bond strength because additional conditioning steps can compensate low acid concentration of self-adhesive cement. Phosphoric acid removes the smear layer, demineralizes the dentin surface, opens dentinal tubules, and increases the microporosity of the intertubular dentin<sup>25</sup>. The overwet phenomenon occurs when the dentinal tubule fluid flows out, contaminates the post room surface, and disturbs the adhesion hydrophobic resin tag. This phenomenon may be caused by the removal of the smear layer by phosphoric acid, which could reduce the bond strength in this study. Studies showed controversial results with post-space pretreatment. The differences between studies depend on the concentrations and application periods of the solutions<sup>9</sup>. And the type of cement, application techniques, study design may also be caused the differences in research results.

Despite the aforementioned limitations of this study, we can conclude that pretreatment with EDTA or phosphoric acid did not improve the push-out bond strength of fiber posts luted with self-adhesive resin cement.

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