The Effect of Surface Treatments on the Bond Strength of Fiber Post to Root Canal Dentin

Nimet Gençoglu¹, Pelin Sezgin¹, Mustafa Gündoğar², Can Şivet¹

Abstract
It's known that many factors such as root canal dentin or post surface treatment may effect the retention of post. The purpose of this in vitro study was to evaluate the effect of different surface treatments on the bond strength of fiber post with luting agent to root canal dentin. 75 extracted single root teeth were used in this study. The canals were prepared with rotary instruments and obturated by AH Plus and lateral condensation technique. After post space preparation, 75 fiber-posts (Rebilda, Voco) were divided into 5 groups and treated with one of the following surface treatment procedures: no treatment (control), silanization, etching by % 9.6 hydrofluoric acid, sand blasting with 50 milimicron Al2O3 and bonded (15 of each). After that, posts were bonded with dual polimerizing resin based luting material. The specimens were embedded in acrylic resin blocks and sliced from the apical, middle, coronal part of the roots. A push out bond strength test was performed by a universal testing machine at across head speed of 1mm/min. Data were analyzed with one-way Anova and Tukey tests. Although silanization showed the least and sanding the best bond strength, only statistical difference was found between silanization and etching (p<0.05) and between sanding and bonding (p<0.05). Bonding group showed the highest bond strength in coronal section, and sandblasted group in middle and apical section (p<0.05). The different surface treatment affected the bond strength of fiber post to root canal dentin.

Keywords: Fiber post, push-out test, sanding, silanization, bonding

Introduction
Endodontically treated teeth may often require post and core restoration to restore the missing tooth structure (1). Traditionally used prefabricated or costumized metal posts weaken roots and may lead to root fracture (1, 2). The rigidity of the post should be close to that of the root to distribute the occlusal forces along the length of the root (2, 3). Fiber posts are introduced as an alternative to cast posts and metal dowels due to their modulus elasticity being closer to that of dentin and this feature reduces the risk of root fracture (4-6). Fiber based posts are essentially composite materials and composed of fibres of silica surrounded by a matrix of polymer resin, usually an epoxy resin (7).

Studies have shown that the failure ratio of fiber posts systems are lower than metal post-cores due to their physical and mechanical properties similar to the tooth structure (8, 9). Also, they have some other advantages such as biocompatibility, improvement of light transmission and the optical effects of esthetic restoration (7, 10). Since most failures of fiber posts are because of decementation, the bonding effectiveness into the root canal is crucial for the retention of these posts.

In literature, many studies have focused on the dentin-cement interface or on the combined sandwich dentin-cement-post assembly (11). It's been suggested that applications performed on dentin surface or post surface treatment possibly enhance the bonding ability (12). Irrigants such as sodium hypochlorite (NaOCI), hydrogen peroxide, EDTA, chlorexidine digluconate, citric acid (10%, 20%, and 50% orthophosphoric acid and their combinations are used to increase the micromechanical retention of the cement by removing the smear layer. As a result of smear layer removal, the cement can penetrate into the dentinal tubules (13, 14). Meantime, dentin tubul densities and root canal orientation may affect the adhesion quality on root dentin.

Regarding surface pre-treatment of fiber posts, both chemical and micro-mechanical treatment protocols have been proposed to enhance the bond strength at the post-cement interface (12). Chemical post-surface treatment that are employed clinically, involve coating of the post with a silane primer, and with an adhesive resin, this is potentially combined with beforehand acid-etching of the post surface (7, 15-18). Although it's indicated that silane application may improve the bonding ability of fiber post, Wrbas et al. (19) did not find any significant effect. Most common micro-mechanical post surface pre-treatment is sandblasting which is intended to remove the top layer of resin and make the glass fiber reachable for chemical interaction (20, 21). Silicate-coated alumina particles are used for sandblasting in Cojet system (3M ESPE, Germany).
Considering the literature, studies on that matter are limited and quite contradictory.

The aim of this study was to evaluate the effects of various surface applications on fiber post system by using push-out test.

Materials and Methods

Seventy five extracted human maxillary central incisors were used in this study. The teeth were stored in distilled water at room temperature until used. The inclusion criteria were absence of caries, root crack or fracture. External debris was removed using a ultrasonic scaler. The crown of each tooth was removed to the cemento-enamel junction, using a slow-speed diamond bur under copious water cooling, to standardize root canal length to 18 mm. The roots were endodontically instrumented at a working length of 1 mm from the apex using Ni-Ti rotary instrument of Protaper universal system (Dentsply, Maillefer, Switzerland). Irrigation was performed using a 1ml. 5% solution of sodium hypochlorite after each change drill through the shaping process. The canals were rinsed with distilled water, dried with paper points and then obturated with gutta-percha cones and AH Plus sealer (Dentsply, Maillefer, Switzerland) using a lateral condensation technique.

Post Space Preparation

Root canal filling was removed by using #2 Rebilda post drill (Rebilda post system, Voco, Germany) and 4 mm of filling was left in the root canal. Post space was irrigated by using 5 % NaOCl and 17% EDTA, then rinsed by distilled water. After that, the canals were dried with paper points. Seventy five, #2 Rebilda posts were divided into 5 groups of 15 each.

Group 1 (Control group): No surface treatment was performed on post surface.

Group 2 (Silan group): Posts were treated with a silane coupling agent for 60 seconds using a disposable brush and then dried.

Group 3 (Bonding group): Posts surface treated with bonding agent (Fütura Bond DC, Dual curing self etching bond, Cuxhaven, Germany).

Group 4 (Sandblasting group): Posts surface was coated with sandblast using Cojet system (3M ESPE, Seefeld, Germany) at 2-3 bar for 15 seconds from 10 mm. distance.

Group 5 (Etching group): Posts surface treated with 9.6 % hydrofluoric acid for 15 seconds.

Specimen Preparation and Push Out Test

Fiber posts were luted using dual polymerize resin cement (Rebilda DC, VOCO, GmbH, Cuxhaven, Germany) to post space. Specimens were stored at %100 humidity at 37°C for 1 week. Tooth were embedded in acrylic resin mold. Resin blocks were attached to the arm of a low-speed saw and sectioned perpendicular to the long axis under water cooling by Isomet device (Isomet, Buehler, USA). Three slices (each 1-0.06 mm thick) were obtained from apical, middle and coronal sections of each root.

Push out bond strengths were measured with a Universal testing machine (Shimadzu Corporation AutoGraph AGS-X Series, Kyoto-Japan) at a crosshead speed of 1 mm/min. The peak force, which was the force applied at the point of extrusion of the post segment from the test specimen, was taken as the point of bond failure and was recorded in Newtons (N). Then all data were converted to MPa and analyzed using 1 way ANOVA and Post Hoc Tukey HSD tests (p < 0.05) using Graphpad prism 5.0 program.

Results

The result of this study showed that sanding and bonding procedure enhanced bonding ability. However, statistically no difference was found between control and experimental groups (p > 0.05). When the experimental groups were compared, silanization showed the least and sanding the best bond strength, but only statistical difference was found between silanization and etching and between sanding and bonding groups (p < 0.05). According to the location, bonding group showed the highest bond strength in coronal section and sandblasted group in middle and apical section (p < 0.05) (Table 1, 2).

Table 1. Mean and standard deviation values for all groups (MPa).

<table>
<thead>
<tr>
<th>Group</th>
<th>Control</th>
<th>Etching</th>
<th>Silan</th>
<th>Bonding</th>
<th>Sandblasting</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Mean</td>
<td>Mean</td>
<td>Mean</td>
<td>Mean</td>
</tr>
<tr>
<td>Coronal</td>
<td>9.79 ± 5.8</td>
<td>12.16 ± 4.2</td>
<td>9.81 ± 4.9</td>
<td>15.49 ± 8.3</td>
<td>12.91 ± 5.25</td>
</tr>
<tr>
<td>Middle</td>
<td>10.53 ± 4.6</td>
<td>9.3 ± 4.5</td>
<td>9.36 ± 2.8</td>
<td>14.17 ± 8.9</td>
<td>13.20 ± 4.31</td>
</tr>
<tr>
<td>Apical</td>
<td>10.63 ± 3.8</td>
<td>9.84 ± 7.62</td>
<td>9.97 ± 5.8</td>
<td>9.79 ± 5.8</td>
<td>13.23 ± 8.02</td>
</tr>
<tr>
<td>p&lt;0.05</td>
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Table 2. Tukey’s Test Results

<table>
<thead>
<tr>
<th>Tukey’s Multiple Comparison Test</th>
<th>S.( p &lt; 0.05)</th>
<th>N.S.(p&gt;0.05)</th>
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</thead>
<tbody>
<tr>
<td>Silan versus Sanding</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Control versus etching</td>
<td>X</td>
<td></td>
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<tr>
<td>Control versus Silan</td>
<td>X</td>
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<tr>
<td>Control versus Sanding</td>
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<tr>
<td>Control versus Bonding</td>
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<tr>
<td>Etching versus Silan</td>
<td>X</td>
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<tr>
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<tr>
<td>Etching versus Bonding</td>
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<tr>
<td>Silan versus Bonding</td>
<td>X</td>
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<tr>
<td>Sanding versus Bonding</td>
<td>X</td>
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</tbody>
</table>

Discussion

The results of the present study showed that the post surface treatments affected bond strength of fiber-post system to dentin. It’s found that bond strength of bonding or sanding groups were significantly better than other groups. Besides that, silane or acid treatment had no significant effect on bond strength (p<0.05).

In literature, contradictory results have been demonstrated with regards to the bonding effect of post surface treatments. Vano et al. (22) found hydrofluoric acid enhancing in post-to composite bond strength and remarkable surface alteration in their study. Albashaieh et al. (23) demonstrated hydrofluoric acid application had no significant effect on bonding ability. In the present study,
also, hydrofluoric acid (9.6 %) treatment was not found effective. D’Arcangelo et al. (24), found that hydrofluoric acid and sandblasting treatment enhanced bond strength of post. Valandro et al.(2) reported that hydrofluoric acid or phosphoric acid treatment had lower bond strength than sanding in their study. In the present study, sanding group also showed the highest bond strength. Contradictory results of the studies may be related to the type of etching or fiber post used. As regards to silanization, our findings collaborated to Wrbas et al’s (19) findings which found no significant effect of silanization (19). However, Goraci et al. (17) found significant bond strength of silanization. Matinlinna et al. (25) stated that mechanical and chemical adherence by silanization could not have been clarified yet. Cross-linked polymer matrix on fiber post has no chemical reaction with silane molecule. With this mechanism, the effect of silane can easily be seen on the surface of fiber post and post types having intensive superficial fiber (25). Monticelli et al. (12) announced that there was no any chemical bonding between epoxy resin and methacrylate-based resin within the post material regard to different chemical structure. The composition of silan (ph, solvent content, molecule size), application mode may affect the results (12,26). On the other hand, Ozcan et al. (26) used H_2O_2 to solve epoxy resin matrix for increasing silanization effect and found successful results. However, H_2O_2 was not used in the present study. Choi et al. (27) evaluated the effect of different treatments on DT Light fiber post surface and found that sanding was more effective than silanization. Soares et al. (28) compared sanding, H_2O_2 application, and hydrofluoric acid treatment on post surface and they observed sanding procedure was the most effective. Collaborate to these finding, Pritthwaraj et al. (29) also found sanding procedure more effective than ethyl alcohol and resin primer application. Amaral et al. (30) announced that none of any silane, hydrofluoric acid and H_2O_2 applications were effective in adherence of fiber post and considered etching application as inadequate. Albarshaireh et al. (31) investigated artificial aging, phosphoric acid or air bone particle abrution on post surface and found only the air abrasion procedure was effective. Shmage et al. (32) compared silane, etch (hydrofluoric acid) and CoJet systems with different composite materials on post surface and observed that CoJet system was found to be effective when used with only RelyX Unicem or MultiCore Flow composites. So they stated that besides surface treatments, the type of luting cements and composite are all important for bonding. Cleleux et al. (33) applied chloroform, sanding or silan on fiber posts and found that chloroform application and sanding procedure enhanced bonding ability and also they stated that sanding was more effective when used after silan. In the present study, sanding and bonding procedure increased the bonding effect although the difference was not significant. Ferrari et al. (10) reported no substantial improvement in bond strength by the separate application of silane and a different formulation of dentin adhesives on methacrylate-based quartz fiber posts. Studies have shown that, beside post surface treatment, dentin surface treatment also affected bond strength of post system. Different irrigation solutions were used to clean dental wall for better adaptation. Usage of NaOCl with EDTA can remove smear layer and removing the smear layer provides better adaptation of material into dentin tubules (34, 35). It's demonstrated that canal sealers and residuals disappeared during smear layer removal but inter-tubular and peri-tubular dentin were also demineralized. Irrigation solution can dehydrate dental wall during cleaning procedure and dehydratation might affect the bonding strength (14, 32). Demiryürek et al. (14) investigated the effect of different irrigation solutions on bond strength of fiber post and found that different acids (citric, orthophosphoric or EDTA) and acetone based cleansing agent (Sikko Tim) increased bonding strength. The type of adhesive system can also affect the adherence of fiber post (13). Previous studies stated that adhesion to root canal dentin can be obtained with each of the tested luting strategies, but revealed controversial results. Wang et al. (36) analyzed the post bond strength in different adhesive systems and found that the total etch system provides better luting than self etch system. In contradiction to this finding, Zicari et al. (6) found self adhesive system more effective than the multi-step composite cements. In collaboration to this, Biter et al. (16) also demonstrated higher bond strength with self adhesive system (RelyX Unicem) than total etch system (Panavia F, Variolink II). In the present study, self adhesive system (Rebilda DC, VOCO, GmbH, Cuxhaven, Germany) was used and not compared with other adhesive systems. According to the present study, bonding and sanding procedure on fiber post increased bond strength to dentin. Beside in vitro studies, clinical studies are needed to confirm this study results.

Acknowledgements

This study is supported by Marmara University’s Scientific Research Projects Committee (Project no: SAG-A-080410-0067)

References


