ORIGINAL ARTICLE

Effect of cement types and timing of cementation on the retentive bond strength of fiber posts

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KEYWORDS
cement types; fiber posts; retentive bond strength; timing of post preparation and cementation

Abstract Background/purpose: To evaluate the effect of early versus delayed post space preparation and cementation and the types of cement on the retention of fiber posts in canals obturated using an epoxy resin sealer.

Materials and methods: Seventy-two extracted single-rooted teeth with straight root canals were decoronated and obturated with gutta-percha and an epoxy resin sealer (AH26). Post spaces were prepared to a depth of 8 mm and 1.5 mm diameter. Parallel-sided, prefabricated fiber posts were used. The teeth were distributed into two groups (36 in each), according to the period elapsed between canal obturation and post cementation (Group 1: cementation after 24 hours and Group 2: cementation after 2 weeks). Each group was further subdivided into three groups (n = 12) according to the cement types (RelyX Unicem, ParaCore and Variolink II). Each specimen was vertically secured in the universal testing machine and was subjected to a pull-out test. Data were statistically analyzed using two-way analysis of variance.

Results: The mean post bond strength in the ParaCore and Unicem groups was significantly higher than that in Variolink II group. There was no significant difference between post bond strength values achieved after 24 hours and those achieved after 2 weeks for the ParaCore and Unicem groups (P = 0.538). However, posts cemented with Variolink II showed an increase in retention after 2 weeks (P < 0.05).

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Introduction

The use of posts in teeth after endodontic treatment may be required to aid in the retention of a core and the final coronal restoration. Several factors have been reported to influence the survival of the final restoration; these include the retentive capacity of the post, its shape and design, its length and diameter, the type of luting agent used to cement it and the endodontic obturation sealer.

In addition, the timing of post space preparation and cementation plays an important role. However, there is no agreement on the time interval between obturation of the canals and post space preparation and cementation. Clinically, the ideal time needed for the sealers to set should be neither too fast nor too slow. Therefore, depending on the type of sealer and the experimental technique, a wide range of setting times has been recorded. Posts can be cemented immediately after completion of the endodontic treatment or at a later stage after full setting of the sealer. Immediate post space preparation is considered less time consuming and associated with less apical leakage. However, the negative effect of the unset sealer and the resultant unavoidable contamination may interfere with the set of the luting resin cement during post cementation, and therefore negatively affect post retention.

Epoxy resin root canal sealers have been recommended and have gained recent popularity among clinicians as an alternative to eugenol-based sealers to overcome the effect of the presence of eugenol on the canal walls which had been reported to adversely affect post retention.

Previous studies were conducted to investigate the influence of immediate versus delayed fiber post cementation on the retentive strength of fiber posts in canals obturated using a resin sealer. However, no published reports compared the effect of timing (early and delayed) of post space preparation and cementation and the types of resin cement (RelyX Unicem, ParaCore and Variolink II) on the retentive strength of fiber posts. The null hypothesis tested was that there will be no significant differences between early (after 24 hours) and delayed (after 2 weeks) and among the three different resin cements investigated that could affect the retentive strengths of fiber posts.

Materials and methods

Seventy-two caries-free, recently extracted single-rooted human mandibular first premolar teeth with straight root canals were used in this study. The teeth were subjected to radiographic examination, stored in an antimicrobial preservative container (0.5% Chloramine-T, Delchimica Scientific Glassware, Napoli, Italy) at 4°C, and used within 6 weeks after extraction. Teeth were sectioned 2 mm coronal to the most incisal point of the cemento-enamel junction by using a low-speed diamond saw (Isomet 2000, Buehler Ltd, Lake Bluff, NY, USA) under copious water coolant.

The pulpal tissues were removed with a barbed broach of an appropriate size (Dentsply Maillefer, Ballaigues, Switzerland). Working length was established at 1 mm from the root apex. The canals were prepared with a rotary system (X-Smart, REF A 1004; Dentsply Maillefer, Ballaigues, Switzerland), according to the manufacturer’s guidelines. Cleaning and shaping of the root canals were performed with Protaper Ni-Ti rotatory instruments (size S1, S2, S3; Dentsply Maillefer, Ballaigues, Switzerland) following the crown-down technique. After every instrument, 3 mL of 5.25% sodium hypochlorite (NaOCl) was introduced into the canals using a 10-mL syringe with a 27-gauge tip. The root canals were obturated with laterally condensed gutta-percha (Kerr/Sybron Corp. Romulus, MI, USA) and an epoxy resin root canal sealer containing no eugenol (AH26, Dentsply DeTrey GmbH, Konstanz, Germany).

Specimens were divided into two groups (36 each) according to the different times of post space preparation and cementation. Group 1: the teeth were stored for 24 hours after obturation; Group 2: the teeth were stored for 2 weeks after obturation. Gutta-percha was removed and post spaces were prepared using a number 5 Peeso reamer (Pulpdent Corporation, Watertown, MA, USA), at low speed, to a depth of 8 mm with a minimum allowed distance of 5 mm gutta-percha plug for all samples followed by a number 6 parallel-sided Parapost twist drill (Parapost Black P-42, Whaledent International, NY, USA) at low speed. Post spaces were prepared to a diameter of 1.5 mm and a depth of 8 mm. NaOCl irrigation was performed to all post spaces.

Parallel-sided, prefabricated fiber posts (Parapost Fiber Lux, Coltene/Whaledent, Altstatten, Switzerland) were used. The Parapost posts were fitted passively in their respective canals before luting. To maintain moistness, teeth were held in a gauze sponge soaked in saline throughout all root canal therapy and post space preparations. To increase the retention of the roots in the acrylic block during pull-out test, each root was notched on the buccal and lingual surfaces with a carbide bur. Specimens were then mounted with autopolymerizing resin (Ortho Resin, Dentsply DeTrey, Konstanz, Germany), in a short length of polyvinyl chloride pipe, by using a dental surveyor (J.M. Ney Co., Bloomfield, CT, USA) to orientate the post space to the vertical axis of the tooth.

Conclusion: There was no influence of time interval between canal obturation and post cementation after 24 hours and 2 weeks on the retentive strength of posts luted with ParaCore or Unicem cements.

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After canal irrigation with NaOCl and drying with absorbent paper points, the posts were luted with one of three different luting agents:

1. ParaCore (Parapost, Coltene Whaledent, Altstätten, Switzerland) dual-polymerized resin cement. The ParaBond non-rinse conditioner (Parapost, Coltene Whaledent) was applied to the canal using a thin microbrush and massaged in for 30 seconds. The excess of conditioner was removed by paper points and dried with a light jet of air for 2 seconds. A mix of ParaBond Adhesive A/B (Parapost, Coltene Whaledent) was applied to the canal using a thin microbrush and massaged in for 30 seconds. The excess of adhesive was removed by paper points and dried with a light jet of air for 2 seconds. Finally, the cement material was applied directly from the tip of syringe into the prepared post space in the root canal. Fiber post was also coated with the cement and then inserted into the canal using slight pressure. Excess cement was removed and then light polymerized (XL 2500, 3M ESPE, St Paul, MN, USA) for 40 seconds.

2. Variolink II (Ivoclar Vivadent, Schaan, Liechtenstein) dual-polymerizing resin cement. Acid etch (phosphoric acid gel 37%, Ivoclar Vivadent) was applied to the tooth for 15 seconds. The canal was rinsed immediately with water and dried with paper points. The adhesive (Excite DSC, Ivoclar Vivadent) was applied to the canal using microbrush and excess adhesive was removed using paper points. The cement mixed in a 1:1 ratio on a mixing pad for 10 seconds. The cement was applied to the bonding surface of the canal. The posts were also coated with the cement and inserted to the prepared canals with finger pressure, and excess cement was removed flush with the top of the tooth. The light activation was performed for 40 seconds.

3. RelyX Unicem (3M ESPE, St Paul, MN, USA) dual-polymerizing self-adhesive resin cement. The cement capsule was activated for 2 seconds and mixed automatically in a high-speed triturator for 10 seconds. Afterwards, the resin cement was applied into the root canals by means of Elongation Tip (3M ESPE). The posts were also coated with the cement and inserted to the prepared canals with finger pressure, and excess cement was removed flush with the top of the tooth. The light activation was performed for 40 seconds.

Specimens were stored in 100% relative humidity at room temperature for 24 hours before testing. Each tooth specimen was vertically secured in the universal testing machine (Instron, Model 8500 Plus Dynamic Testing System, Instron Corp., High Wycombe, UK). The force required to dislodge the post was determined using pneumatic grips that grasped the post head along its long axis (Fig. 1). A constant loading rate of 0.5 mm/minute was applied until cement failure was achieved. The peak force 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).

Statistical analyses

Statistical analyses of the data were performed by using a statistical software package (SPSS v16.0, SPSS Corp., Chicago, IL, USA). A two-way analysis of variance (ANOVA) was applied to the mean retentive strengths of time interval, cement materials, and combinations. When a significant cross-product interaction was found, one-way ANOVA and t test were applied to the combinations. A Tukey multiple comparison test was performed to determine which groups were significantly different. All statistical analyses were performed at 0.05 level of significance (\( \alpha = 0.05 \)).

Results

The tensile forces (N) required for post dislodgment after different periods between canal obturation and post cementation with the three cements are shown in Table 1. Statistical analysis revealed statistically significant differences in mean post retention among the three cement types (\( P < 0.001 \)), and among the means of the different time intervals investigated (\( P = 0.009 \)). Moreover, two-way ANOVA indicated no interaction between cement type and time interval (\( P = 0.952 \)) (Table 2). A Tukey multiple comparison test indicated that the mean post bond strength in the ParaCore and Unicem groups was significantly higher than that in the Variolink II group (\( P < 0.001 \)), but no significant difference between the means of post bond strength in the two groups was found (\( P = 0.538 \)). Furthermore, a Student t test revealed that post bond strength values achieved with early cementation after 24 hours were significantly lower than those achieved with
showed the least degree of conversion, probably because of both the physical and mechanical properties of the bonds into polymeric C expressed as degree of conversion of monomeric C area. The extent of polymerization in resin composites is explained by the incomplete polymerization at the apical and cementation between 24 hours and 2 weeks.

were affected by a time interval of post space preparation only posts cemented with Variolink II among other cements hypothesis of the study was partially disproven, because with posts cemented after 24 hours. Therefore the a significant increase in post bond strength in comparison space preparation and post cementation with Variolink II luted using ParaCore and Unicem. In addition, when post Unicem resin cements. Fiber posts cemented with Variolink II showed reduced post bond strength compared with posts cemented with Variolink II, Paracore and RelyX Unicem. The present study reported a significant difference in retention of posts cemented with Variolink II, Paracore and Unicem resin cements. Fiber posts cemented with Variolink II showed reduced post bond strength compared with posts luted using Paracore and Unicem. In addition, when post space preparation and post cementation with Variolink II were performed 2 weeks after the canals were filled with gutta-percha and AH26 sealer (Dentsply DeTrey) there was a significant increase in post bond strength in comparison with posts cemented after 24 hours. Therefore the hypothesis of the study was partially disproven, because only posts cemented with Variolink II among other cements were affected by a time interval of post space preparation and cementation between 24 hours and 2 weeks.

The lower values for Variolink II after 24 hours may be explained by the incomplete polymerization at the apical area. The extent of polymerization in resin composites is expressed as degree of conversion of monomeric C=C bonds into polymeric C–C bonds. Conversion extent affects both the physical and mechanical properties of the polymer.

It has been shown that in the apical third Variolink II showed the least degree of conversion, probably because of decreased transmission of light as the depth increases. It would seem that the amine in the base paste and peroxide in the catalyst paste were unable to react effectively in the self-curing mode. Several studies have shown that light activation is still required for some dual-cured resin cements to increase the degree of conversion, even though the self-curing and light-curing modes of activation are independent. Thus, the decrease in degree of conversion when increasing the distance from the curing tip was probably because of a significant reduction in light intensity within the root canal.

After 2 weeks, Variolink II showed significantly higher bond strength. This may be explained by the increased degree of conversion and thus more polymerization of the cement. According to Schwartz and Robbins, resin luting cements have been found to be more technique sensitive and required more steps as compared with other conventional luting cements. Predictable delivery of etchants and adhesive materials deep into the post space can be very challenging. Inability to produce a good etching surface of the intra-canal dentine wall in addition to limited access for the adhesive materials to reach the most apical part of the post space can affect the bond strength of such cements.

It had been speculated that primer/adhesive application with standard brush tips that were supplied together with the respective adhesive systems probably resulted in solution accumulation into the post space at the apical region; thus limiting solvent volatilization and this could interfere with the polymerization process and create additional difficulty for the light activation process; thus making this region predisposed to post displacement prior to complete cement setting. The inappropriate shape and dimension of disposable bristle brush tips were also known to restrict the homogeneous application of the adhesive solution into constricted root apical areas.

Clinically, the order of post space preparation and cementation with respect to obturation proved to be a significant factor in post retention. It is desirable when luting fiber posts to have a clean dentine surface with a high number of open dentinal tubules which could be infiltrated by the adhesive resin. Post space preparation and cementation may be delayed beyond 1 week after obturation and this may affect the retentive strength values of post. A previous study reported lower mean retentive strength values of posts when post spaces were prepared before obturation than after obturation.

AH26 Sealer (Dentsply, De Trey, Konstanz, Germany) has a setting time of 6–8 hours. Therefore, when immediate post space preparation and cementation are performed, the sealer in the apical part of the canal is not fully set. As a consequence, both the paper points and the microbrush used in the luting procedure may contaminate the post space with the unset sealer just before post insertion. On the contrary, a delayed post space preparation and cementation allows the sealer to set properly thus the contamination of the post space is avoided.

The use of resin cement etch and rinse adhesives has been shown to achieve higher interfacial strengths in post spaces when compared with those that utilize mild self-etching adhesives or a self-etching resin cement. Because the acidic monomers incorporated in these systems are not

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Mean tensile forces (N) required for post dislodgment after different periods between canal obturation and post cementation with the three cements (n = 12).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>Cement</td>
</tr>
<tr>
<td>---------</td>
<td>------------------</td>
</tr>
<tr>
<td>24 h</td>
<td>137.4 ± 50.2</td>
</tr>
<tr>
<td>2 wk</td>
<td>190 ± 76.7</td>
</tr>
</tbody>
</table>

Values are expressed as mean ± standard deviation followed by upper case and lower case superscripts (repeated measures of analysis of variance followed by Tukey multiple comparisons test, P < 0.05). Upper case superscripts compare means across time rows. Lower case superscripts compare means along cement columns for each time period. Means with the same superscript are not significantly different (P > 0.05).

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Two-way analysis of variance test for investigated parameters (cement types and time interval).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source</td>
<td>Type III sum of squares</td>
</tr>
<tr>
<td>Cement</td>
<td>171,031.128</td>
</tr>
<tr>
<td>Time</td>
<td>36,909.539</td>
</tr>
<tr>
<td>Cement</td>
<td>500.198</td>
</tr>
<tr>
<td>× time</td>
<td>336,342.523</td>
</tr>
</tbody>
</table>

The present study reported a significant difference in retention of posts cemented with Variolink II, Paracore and Unicem resin cements. Fiber posts cemented with Variolink II showed reduced post bond strength compared with posts luted using Paracore and Unicem. In addition, when post space preparation and post cementation with Variolink II were performed 2 weeks after the canals were filled with gutta-percha and AH26 sealer (Dentsply DeTrey) there was a significant increase in post bond strength in comparison with posts cemented after 24 hours. Therefore the hypothesis of the study was partially disproven, because only posts cemented with Variolink II among other cements were affected by a time interval of post space preparation and cementation between 24 hours and 2 weeks.

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strong enough to etch through thick smear layers to form hybrid layers along the walls of the post spaces.

Self-adhesive cements were designed with the purpose of overcoming some of the limits of both conventional and resin cements. Self-adhesive cements require no pretreatment of the tooth substrate; once the cement is mixed, application is accomplished through a single clinical step. RelyX Unicem cement was the first product from the class of self-adhesive cements to be introduced to the market. Its multifunctional monomers with phosphoric acid groups simultaneously demineralize and infiltrate enamel and dentine. The dominant setting reaction is the radical polymerization that can be initiated by light exposure or through the self-cure mechanism. This results in extensive cross-linking of cement monomers and the creation of high-molecular-weight polymers. 25

Phosphoric acid groups also react with the tooth apatite. Water that is formed in these neutralization processes is claimed to contribute to cement’s initial hydrophylicity, which provides improved adaptation to the tooth structure and moisture tolerance. Subsequently, water is expected to be reused by reaction with acidic functional groups and during the cement reaction with ion-releasing basic filler particles. Such a reaction would finally result in an intelligent switch to a hydrophobic matrix. The adhesion obtained is claimed to rely on micromechanical retention and chemical interaction between monomer acidic groups and hydroxyapatite. 26 In addition, RelyX Unicem was inserted into the root canal utilizing an elongation tip, resulting in less chance of bubble formation and air entrapment, which would lead to an improvement in the marginal adaptation of the material, both to the dental substrate and to the fiber post. This may explain the higher retentive strength for fiber posts in the present investigation. 27

The self-adhesive composite cement RelyX Unicem (3M ESPE) was found to be significantly more effective than the multi-step composite cements Variolink II (Ivoclar-Vivadent). The bonding mechanism of the self-adhesive cement RelyX Unicem is claimed to be based on micro-mechanical retention and chemical adhesion. 28

ParaCore is a dual-polymerized, glass-reinforced composite resin cement with an integrated bond and cement system. The ParaBond consists of a non-rinse conditioner and a chemical cured adhesive, which is ideal for situations where light might not penetrate, such as for post cementation. In addition, ParaCore’s syringe delivery system ensures optimal mixing properties. Its long, narrow-shaped root canal mixing tip allows the material to be applied directly into the root canal for efficient post cementation. 29

The differences in the results may be caused by factors such as the handling characteristics of the adhesive system, root anatomy, tooth position, presence of coronal residual tissues, light curing technique, and experience and skill of the operators. In addition, the difference in film thickness of the luting cements may contribute to the present results although all possible measures were taken for standardization in post space preparation. 30

Within the limits of this study, the results showed that there was no influence of time interval between canal obturation and post cementation after 24 hours and 2 weeks on the retentive strength of posts luted with ParaCore or Unicem cements.

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