Resin cement thickness in oval-shaped canals: Oval vs. circular fiber posts in combination with different tips/drills for post space preparation

IVANOVIC CONIGLIO, DDS, MSC, FRANKLIN GARCIA-GODOY, DDS, MS, ELISA MAGNI, DDS, MSC, CARLOS AUGUSTO CARVALHO, DDS, MSC & MARCO FERRARI, MD, DDS, PhD

ABSTRACT: Purpose: To evaluate the cement thickness around oval and circular posts luted in oval post spaces prepared with different drills/tips. Methods: Extracted premolars were endodontically treated and obturated, then randomly divided into three groups (n=5) according to the tips/drills used for post-space preparation and to the type of fiber post luted: medium grit oval tip + oval posts, fine grit oval tip + oval posts, Mtwo Post File drill + circular posts. The specimens were sectioned in horizontal slices; one slice per canal third was chosen for each post-space, resulting in three slices for each specimen. The distances between the canal wall and the post perimeter were measured on SEM images of each slice. Results: The fine grit tip + oval post group obtained statistically significant lower cement thicknesses than the other groups (P< 0.05), in particular in the apical third. The MtwoPF + circular post group showed the highest cement thickness, comparable to that of the medium tip + oval post group. A good post fitting in oval-shaped canals can be obtained using a fine grit oval tip combined with oval posts. (Am J Dent 2009;22:290-294).

CLINICAL SIGNIFICANCE: When luting a fiber post in oval-shaped canals, the use of oval fiber posts instead of circular posts may reduce the cement thickness around the post.

Introduction

An excessively thick layer of resin cement around a fiber post has been reported to be an unfavorable factor for long-term success of post-retained restorations in vivo, as it might be correlated to higher frequencies of post debonding. The thickness of the resin cement may represent a critical factor in the clinical performance of fiber posts. Many in vitro studies investigated the influence of different resin cement thicknesses on the bond strength of fiber posts. On the contrary, D’Arcangelo et al reported that the cement thickness influenced the pull-out strengths of fiber posts. The cement thickness is correlated to the post fitting into post space: the more the post is adapted to the canal walls, the less is the cement thickness.

In oval-shaped canals, circular posts do not present a good post fitting due to the discrepancy between the post’s circular shape and canal’s anatomy. Thus, to fit the post, preformed drills used for post-space preparation alter the anatomy of oval canals, sacrificing dentin tissue. To reduce this alteration, a more conservative drill suitable for all canals and a medium grit ultrasonic oval tip (Ellipson tip) designed for oval-shaped canals were investigated and proposed. The latter respected the canal shape but appeared quite aggressive on dentin walls; therefore a finer grit tip was advocated.

Recently, preformed posts with oval tips (Ellipson posts) have been proposed for oval-shaped post-spaces, aiming to achieve a better fiber post adaptation to the post space walls, as they reproduce the oval form of this type of canals.

This study evaluated the cement thickness around oval and circular posts luted into oval post-spaces prepared with different drills/tips. The null hypothesis tested was that similar cement thicknesses are achieved by luting oval or circular posts combined with different drills/tips for post-space preparation in oval-shaped canals.

Materials and Methods

Specimen selection - Extracted human single-rooted premolars, stored in 1% T-chloramine solution at 4°C for less than 1 month, were used. Mesio-distal and bucco-lingual radiographs of each tooth were taken. The teeth with the ratio between the long and short canal diameter at 5 mm from the apex ≥ 2 could be assumed to have an oval-shaped canal, as reported by Wu et al, and were therefore selected.

Endodontic treatment of specimens - The teeth were endodontically treated by the same operator. The working length was set at 1 mm shorter than the canal length measured with a K-file #10 placed into the canals until the apical foramen. Only teeth with comparable canals’ diameters and shapes were selected: they had to present a canal sufficiently patent to allow a K-file #10 to penetrate beyond the apical foramen, but not to allow a K-file #15 to reach the full working length without resistance. All the teeth were cut to standardize the working length at 14 mm using a low-speed diamond saw.

The 14 mm-working length was measured from its apical limit, which was determined as described above. The canals were instrumented up to a #25.06 file with NiTi rotary instruments (MTwo files) mounted in a 16:1 gear reduction handpiece, while irrigating with 5.25% NaOCl (Nicolor 5%). Each set of MTwo files was used for five teeth. The canals were finally dried with paper points (Mynol).

The teeth were obturated with the lateral gutta-percha condensation; the master cone (#25.02) was covered with sealer (CRCS) and placed into the canal. Additional gutta-percha cones (fine points) were added and compacted using a spreader (#25NT SE Root Canal Spreader) until complete canal filling. The coronal portion of the cones was removed.
with a warm plugger. Each treatment was checked radiographically. The teeth were coronally sealed with a glass-ionomer cement (GC Fuji II™) and stored in saline solution for 24 hours at 37°C.

Post space preparation - After storage, the coronal seal was removed and 8 mm deep post spaces were prepared. Three different tips/drills were used for removing the filling material and for post-space preparation:

1. A medium grit (76 µm) diamond-coated ultrasonic tip with oval section, mounted in a Suprasson handpiece, set at medium power;
2. A fine grit (46 µm) diamond-coated ultrasonic tip with oval section mounted in a Suprasson handpiece, at medium power;

The tips/drills were used for 1 minute while rinsing with 10 ml of 17% EDTA solution using an endodontic needle. The removal of gutta-percha and the post space morphology was checked radiographically. Each drill/tip was used for 5 specimens.

Luting procedure of fiber posts - Afterwards, two types of fiber posts were luted:

1. New fiber posts with oval section similar in shape to the oval tips employed.
2. Fiber posts (DT Light Post™) with circular section.

The posts were tried into the post spaces before luting to check their fitting; if necessary, they were cut apically for 2 mm maximum to improve the fit.

The post-spaces were rinsed with distilled water, dried, etched with 36% phosphoric acid (Conditioner 36™) for 30 seconds, rinsed with water and dried with paper points. The same light-curing unit (VIP™) was used throughout the study with an output of 600 mW/cm² measured with a radiometer (Optilux Radiometer™). The adhesive system (Prime&BondNT + Self Activator Dual™) was applied onto post space walls with a microbrush, gently air-dried and light-cured for 20 seconds. A resin material (Fluorocore 2™) suitable for both cementation and with an output of 600 mW/cm² with the dedicated software (G*3 PowerS), showed that 120 measurements for each experimental group was enough in order to assure a power of 95% for finding the statistical significance with a Kruskal-Wallis ANOVA on ranks design, at a 0.05 value of type I error. An effect size of 0.5 was assumed for comparing the means of the cement thickness

Cement thickness measurement - The specimens were sectioned in a coronal-apical direction to obtain 1 mm-thick horizontal slices of the post spaces, using a low-speed diamond saw under water-cooling. Three slices were chosen for each post-space, one slice per third: the most coronal (the first slice obtained), the middle and the most apical (the last slice), in order to assess the cement thickness along the entire post’s length. Each slice was immersed in 90% alcohol, air-dried, mounted on a metallic stub, gold-sputtered (K550™) and observed under scanning electron microscope (JSM 6060 LV™) (SEM).

A x40 magnification SEM image was recorded of each slice. Virtual tangent lines were traced on the canal walls and on the fiber post’s section at eight standardized points; the cement thicknesses were measured on the perpendicular lines to the tangents as the minimum distances between the canal wall and the post perimeter (Fig. 1). The measurements were performed with dedicated software provided by the manufacturer of the SEM.

Statistical analysis - A preliminary power analysis handled with the dedicated software (G*3 Power™), showed that 120 measurements for each experimental group was enough in order to assure a power of 95% for finding the statistical significance with a Kruskal-Wallis ANOVA on ranks design, at a 0.05 value of type I error. An effect size of 0.5 was assumed as relevant for this study, according to the results of an unpublished pilot study of the authors.

Two separate Kruskal-Wallis ANOVA on ranks were applied for comparing the means of the cement thickness among the groups in the entire post-space length and in each canal third. The post hoc analyses were performed with a series of U Mann-Whitney tests for pairwise comparisons with Bonferroni’s correction. A one-way ANOVA followed by the Tukey’s test was applied to compare the cement thicknesses measured in each point within each canal third in each group. In all the analyses, the level of significance was set at P< 0.05. The data were analyzed with SPSS 12.0™ software for Windows.

Results

All cement measurements (µm) are reported in Tables 1-3. The statistical analysis detected significant differences among the three experimental groups. The randomization was performed by numbering the roots from 1 to 15 and by generating random numbers comprised between 1 and 15 with the software Microsoft Excel 2003. The first series of five random numbers generated by the software was used to select the roots to be included in Group A, the second series of five numbers corresponded to the roots selected for Group B, the remaining five roots were assigned to Group C.
Table 1. Means, standard deviations, minimum and maximum values of the cement thickness (µm) measured in each experimental group. Different uppercase letters indicate statistically significant differences.

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean</th>
<th>SD</th>
<th>Min-Max</th>
<th>Statistical difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium grit tip + oval posts</td>
<td>280.2</td>
<td>241.8</td>
<td>16-1150</td>
<td>B</td>
</tr>
<tr>
<td>Fine grit tip + oval posts</td>
<td>117.4</td>
<td>88.4</td>
<td>10-395</td>
<td>A</td>
</tr>
<tr>
<td>MTtwoPF + circular posts</td>
<td>363.1</td>
<td>356.5</td>
<td>33-2000</td>
<td>B</td>
</tr>
</tbody>
</table>

Table 2. Means, standard deviations, minimum and maximum values of the cement thickness (µm) measured in each canal third of each experimental group. Different lowercase letters indicate statistically significant differences.

<table>
<thead>
<tr>
<th>Group</th>
<th>Canal third</th>
<th>Mean</th>
<th>SD</th>
<th>Min-Max</th>
<th>Statistical difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium grit tip + oval posts</td>
<td>Apical</td>
<td>292.70</td>
<td>221.97</td>
<td>16-970</td>
<td>c</td>
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<tr>
<td></td>
<td>Middle</td>
<td>253.35</td>
<td>232.97</td>
<td>25-1030</td>
<td>bc</td>
</tr>
<tr>
<td></td>
<td>Coronal</td>
<td>294.65</td>
<td>271.45</td>
<td>38-1150</td>
<td>bc</td>
</tr>
<tr>
<td>Fine grit tip + oval posts</td>
<td>Apical</td>
<td>91.50</td>
<td>58.17</td>
<td>14-220</td>
<td>a</td>
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<tr>
<td></td>
<td>Middle</td>
<td>122.15</td>
<td>90.40</td>
<td>10-280</td>
<td>ab</td>
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<tr>
<td></td>
<td>Coronal</td>
<td>138.65</td>
<td>105.43</td>
<td>15-395</td>
<td>ab</td>
</tr>
<tr>
<td>MTtwoPF + circular posts</td>
<td>Apical</td>
<td>266.00</td>
<td>254.67</td>
<td>36-1120</td>
<td>bc</td>
</tr>
<tr>
<td></td>
<td>Middle</td>
<td>367.25</td>
<td>340.65</td>
<td>33-1390</td>
<td>c</td>
</tr>
<tr>
<td></td>
<td>Coronal</td>
<td>456.10</td>
<td>433.89</td>
<td>43-2000</td>
<td>c</td>
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</table>

Table 3. Means of the cement thickness (µm) measured in each measurement point of each canal third in each experimental group. Different letters indicate statistically significant differences.

<table>
<thead>
<tr>
<th>Groups (posts)</th>
<th>Canal third</th>
<th>L</th>
<th>ML</th>
<th>M</th>
<th>MB</th>
<th>B</th>
<th>DB</th>
<th>D</th>
<th>DL</th>
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</thead>
<tbody>
<tr>
<td>Medium grit tip + oval posts</td>
<td>Apical</td>
<td>621.0</td>
<td>354.0</td>
<td>223.4</td>
<td>268.8</td>
<td>481.2</td>
<td>133.4</td>
<td>76.6</td>
<td>186.2</td>
</tr>
<tr>
<td></td>
<td>Middle</td>
<td>509.0</td>
<td>78.0</td>
<td>133.2</td>
<td>168.8</td>
<td>620.0</td>
<td>232.8</td>
<td>113.4</td>
<td>168.6</td>
</tr>
<tr>
<td></td>
<td>Coronal</td>
<td>554.0</td>
<td>227.6</td>
<td>177.6</td>
<td>313.0</td>
<td>655.0</td>
<td>224.2</td>
<td>89.2</td>
<td>106.6</td>
</tr>
<tr>
<td>Fine grit tip + oval posts</td>
<td>Apical</td>
<td>99.4</td>
<td>51.8</td>
<td>110.0</td>
<td>63.2</td>
<td>84.6</td>
<td>76.4</td>
<td>89.2</td>
<td>157.4</td>
</tr>
<tr>
<td></td>
<td>Middle</td>
<td>189.6</td>
<td>109.8</td>
<td>77.2</td>
<td>104.2</td>
<td>178.6</td>
<td>93.0</td>
<td>76.8</td>
<td>148.0</td>
</tr>
<tr>
<td></td>
<td>Coronal</td>
<td>198.4</td>
<td>91.4</td>
<td>77.8</td>
<td>153.2</td>
<td>229.8</td>
<td>124.8</td>
<td>48.8</td>
<td>185.0</td>
</tr>
<tr>
<td>MTtwoPF + circular posts</td>
<td>Apical</td>
<td>461.2</td>
<td>175.0</td>
<td>138.0</td>
<td>266.8</td>
<td>601.0</td>
<td>206.0</td>
<td>79.0</td>
<td>201.0</td>
</tr>
<tr>
<td></td>
<td>Middle</td>
<td>664.6</td>
<td>225.2</td>
<td>103.8</td>
<td>414.4</td>
<td>896.0</td>
<td>283.4</td>
<td>97.8</td>
<td>222.8</td>
</tr>
<tr>
<td></td>
<td>Coronal</td>
<td>1014.0</td>
<td>306.0</td>
<td>156.2</td>
<td>381.0</td>
<td>907.6</td>
<td>282.2</td>
<td>157.2</td>
<td>444.6</td>
</tr>
</tbody>
</table>

L= lingual; ML= Mesio-lingual; M= Mesial; MB= Mesio-buccal; B= Buccal; DB= Disto-buccal; D= Distal; DL= Disto-lingual.

The groups both in the entire post-space length and in each canal third (P < 0.05). Analyzing the cement thickness means along the entire post space length, the fine grit tip + oval post group obtained statistically significant lower values than the other groups (P < 0.05). As for post space regions, the fine grit tip + oval post group showed the lowest cement thicknesses in the apical third and lower, but statistically comparable with medium grit tip + oval post group, cement thicknesses in the middle and coronal thirds (Fig. 2). The MTtwo PF + circular post group showed the highest cement thickness values comparable to those of the medium tip + oval post group (Figs. 3, 4).

The one-way ANOVA showed that in the fine grit tip + oval post group the cement thicknesses measured in each point were comparable among them, regardless of the post space third.
Means, standard deviations, maximum and minimum values of cement thickness and statistically significant differences among the groups in the entire post-space length (uppercase letters) and in each post-space third (lowercase letters) are reported respectively in Tables 1 and 2. The outcome of the one-way ANOVA is reported in Table 3.

Discussion

Luting a fiber post into an oval-shaped canal presents some problems related to the particular canal configuration. The oval shape does not permit complete instrumentation and cleanliness of the canal wall during the endodontic treatment, as well as during post-space preparation, as Ni-Ti instrumentation tends to maintain a self-centered position while rotating, leaving non-instrumented areas of the canals and of post-spaces. Moreover, the placement of a post with a different section compared to that of the post-space, implies the sacrifice of sound dental tissue in order to adapt the canal shape for achieving a good post fitting.  

To overcome the incomplete post-space debridement in oval-shaped canals, the medium grit ultrasonic oval tip was chosen, as it resulted in a better debridement than a circular tip, not altering the oval canal's shape. Since the latter was reported to be quite aggressive on post-space walls, probably because of its grain, a fine grit tip was also tested to avoid this negative effect. The fine grit tip enlarged the post-space less than the medium grit one: the cement thickness means in the fine grit tip group was significantly inferior to the medium grit group. Since the same working time and the same oval posts were used in both groups, it could be hypothesized that the fine grit tip exerted a more conservative action on dentin walls. Thus, the sacrifice of sound dentin, which is often determined by preformed drills in an oval canal in order to fit the post, could be reduced by using this fine grit tip, representing an advantage for a long-term outcome.  

The difficulty of achieving a good post fitting in canals with different shape compared to the post's round shape, such as oval-shaped canals, was previously investigated. When preformed circular posts, which do not fit in oval post-spaces, were used, a modification of the oval canal's shape was necessary. On the contrary, when undersized posts were chosen for preserving tooth structure, an increase of resin cement's volume around the posts occurred. Chairside techniques with the aim of creating more anatomically shaped posts for solving these difficulties were also proposed, such as the combination of a fiber post with a dual-curing resin cement in order to create an anatomical post, or the lateral compaction of two or more small fiber posts to fill the post-space, or the modification of a cylindrical fiber post with a diamond-coated bur to give the post a shape as close as possible to the canal's anatomy by using as a guide a cast previously created through post space resin impression. These techniques were effective in improving post fitting, respecting the canal's anatomy and not increasing the resin cement, but required clinical ability and were more time-consuming, factors that could represent disadvantages during clinical procedures.

The preformed oval posts and the oval tips investigated in the present study are analogous in shape. When oval posts and oval tips were used in combination, a better fit to oval post-spaces was achieved than that obtained with circular posts. Moreover, the use of preformed oval posts in oval-shaped canals is easier and more time-saving than the above mentioned chairside techniques to adapt the shape of the post to the canal’s anatomy. In the present investigation, the better adaptation of the posts was obtained by using the fine-grit oval tip for post-space preparation (Fig. 2). In fact, in the fine grit tip + oval post group, the mean cement thickness around the post resulted significantly lower than in the other tested groups. Furthermore, the one-way ANOVA showed that in this group the measured cement thicknesses were homogeneous around all the sides of the posts and, subsequently, the discrepancy between the maximum and minimum values recorded was less than the other groups. On the contrary, a higher and irregular cement thickness was observed in the medium grit tip + oval post group, resulting in an inferior post fitting. The latter finding could be ascribed to an extensive enlargement of the post-space created by the medium grit tip, which removed an excessive dentin layer from the post-space walls, without altering the oval configuration (Fig. 3). The MtwoPF + circular posts group showed the poorest fitting into the oval post-space, though statistically comparable to the medium grit tip + oval post group. The MtwoPF drill slightly modified the oval shape of the canal, creating a circular bulge where it acted, in order to match the shape of circular posts. Subsequently, an excessive amount of resin cement was measured around the circular posts along the larger diameter of the canal (Fig. 4). Since the cement thicknesses statistically differed among the investigated groups, the tested null hypothesis was rejected.

Within the limitations of this in vitro study, it may be concluded that a good post fitting in oval-shaped canals can be obtained using a fine grit oval tip combined with oval posts.
References


