A study into application of fiber technology for endo posts
Vichi, A.

Citation for published version (APA):
Vichi, A. (2002). A study into application of fiber technology for endo posts

General rights
It is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), other than for strictly personal, individual use, unless the work is under an open content license (like Creative Commons).

Disclaimer/Complaints regulations
If you believe that digital publication of certain material infringes any of your rights or (privacy) interests, please let the Library know, stating your reasons. In case of a legitimate complaint, the Library will make the material inaccessible and/or remove it from the website. Please Ask the Library: http://uba.uva.nl/en/contact, or a letter to: Library of the University of Amsterdam, Secretariat, Singel 425, 1012 WP Amsterdam, The Netherlands. You will be contacted as soon as possible.

UvA-DARE is a service provided by the library of the University of Amsterdam (http://dare.uva.nl)
Chapter 4  Application

“Brushes” versus “Microbrushes”

Introduction

Endodontically-treated teeth with defective coronal aspects very often need to be restored with a post and core as a foundation for the final restoration\(^1,2\). In the last few decades, cast posts have been the most commonly used form of restoration for these teeth. Unfortunately, several disadvantages associated with conventional cast post-and-cores have been reported such as loss of retention of the post or of the crown, a potential for post and root fracture, and a risk of corrosion when different metals were used in the system\(^1\). Although several factors are involved, some of these failures can be related to the mechanical properties of the posts\(^5\)\(^-\)\(^7\). In particular, root fractures have been mainly correlated to the shape and length of the post\(^1,2,4\).

Thus, the use of the frictionless-bonded post technique in combination with fiber posts has been advocated to reduce the risk of root fracture from the wedging effect of metallic posts\(^7,8\). Recently, the use of adhesive systems for luting fiber posts has increased in popularity and resin cement materials have been proposed for use in combination with an acid etching technique and adhesive system, and a luting resin cement and fiber posts\(^7,9,10\).

The fiber post offers several favorable characteristics: 1. The modulus of elasticity of a fiber post is similar to that of dentin\(^7,9\), 2. The post can be cemented with an adhesive technique avoiding the development of friction between the post and root canal walls\(^7,9,10\), 3. Fiber translucent posts exhibit high fatigue and tensile strength, and have a modulus of elasticity (stiffness) comparable to that of carbon and quartz fiber posts\(^7\) 4. Their chemical nature is compatible with the Bis-GMA resins commonly used in bonding procedures.
Use of the latest generation of adhesive systems involves etching, removal of the smear layer, demineralization of the dentin, and exposure of a fine network of collagen fibrils. Infiltration of this network with resin permits formation of a hybrid layer, resin tags and adhesive lateral branches, thus creating a micromechanical retention of the resin to the demineralized substrate.

Although bonding into root canals might be difficult because of the handling characteristics of the adhesive system, the anatomy of the root, tooth position, presence of residual coronal tissues, light curing technique, clinical experience of the operator, etc, recent clinical studies have shown efficacy of fiber posts when luted with adhesive materials.

The aim of this clinical report was to evaluate 1. The effectiveness of the SB1 adhesive system in combination with Rely X ARC resin cement in formation of resin tags, adhesive lateral branches and a hybrid layer when used to lute esthetic fiber posts under clinical and laboratory conditions, and 2. to test the null hypothesis that the type of carrier of primer-adhesive solution can not affect bonding mechanism to root etched dentin.

Materials and Methods

Twenty monoradicular endodontically treated teeth, extracted because of periodontal problems, were selected for this study. The coronal part of the samples was removed at the cementum-enamel junction. Then the teeth were endodontically instrumented at a working length 1 mm from the apex to a #35 master apical file. A step-back technique was used with stainless-steel K-files (Union Broach, New York, NY), gates Glidden drills #2 to #4 (Union Broach), and 2.5% sodium hypochlorite irrigation. The prepared teeth were obturated with thermoplasticized, injectable gutta-percha (Obtura, Texceed Corp., Costa Mesa, CA) and resin sealer (AH-26, DeTrey, Zurich,
Switzerland). The samples were randomly divided in two groups of ten samples each and luting procedures were performed (Table 1).

Table 1: Bonding-luting procedures

<table>
<thead>
<tr>
<th>Group</th>
<th>Bonding system group</th>
<th>Clinical steps</th>
<th>Resin cement</th>
<th>Clinical steps</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SB1M</td>
<td>a,b,d</td>
<td>RelyX ARC</td>
<td>e,f,g,h</td>
</tr>
<tr>
<td>2</td>
<td>SB1</td>
<td>a,c,d</td>
<td>RelyX ARC</td>
<td>e,f,g,h</td>
</tr>
</tbody>
</table>

a. Dentin conditioning with phosphoric acid  
b. Primer-adhesive application with a microbrush  
c. Primer-adhesive application with a plastic brush (3M)  
d. Light-curing  
e. Mixing resin cement  
f. Cement application into root canal with a lentulo spiral  
g. Removing resin excess with a small brush  
h. Light-curing through the translucent fiber post.

Legends: SB1M: Scotchbond 1 applied using a microbrush. SB1: Scotchbond 1 applied using a brush.

Group 1 (SB1M): The root canal walls were enlarged with low-speed burs provided by the manufacturer of the posts, the depth of the post space preparation was 9 mm. The root canal walls were etched with 35% phosphoric acid for 15 seconds, washed with water spray and gently air-dried. The excess water was removed from the post space using paper points. SB1 primer-adhesive was then applied with a microbrush tip (Fig. 1), air-dried and the pooled primer remaining in the post space was removed using a paper point. The adhesive was light-cured for 20 seconds placing the light source at the top of the root canal, followed by placement of Rely X ARC according to manufacturer’s instructions. The diameter of the (esthetic) translucent fiber post (RTD) used was 1.1 mm. The cement was applied into the root canal space by means of a lentulo, and onto the post surface, the post was then inserted into the canal. The cement was allowed to set by
light-curing for 20 seconds through the post following which crown build-up was performed with Z250 resin composite (3M).

**Fig 1.** The thin microbrush can penetrate into the root canal preparation.

Group 2 (SB1): A similar procedure to that described in Group 1 was carried out. The primer-adhesive solution was applied into the root canal preparation using the small plastic brush (Fig. 2) provided by the manufacturer of the adhesive materials (3M).

After being restored, the sample teeth from both groups were stored in water for not more than 10 days and then processed for microscopic investigation.
**RDIZ observations**

The root samples were split-fractured along the long axis of the tooth, in a mesial-distal direction, and one section of each root was gently decalcified (35% phosphoric acid was applied for 60 seconds and the sample was then washed and gently air-dried), and deproteinized (the sample was immersed in a 2% sodium hypochlorite solution for 120 seconds) in order to evaluate hybrid layer formation. The other section was kept in a solution of 30% HCl for 24 hours in order to completely dissolve the dental substrate and to detect resin tag and adhesive lateral branch formation. After being extensively rinsed with water, the two specimens were gently air-dried, sputter-coated with gold (Edwards Ltd, London, UK) and observed with a scanning electron microscope (Philips 515, Philips Co., Eindhoven, The Netherlands) at different magnifications, so that the extent, morphology and the thickness of the acid- and NaOCl-resistant resin-infiltrated layer and morphology of the resin tags could be examined and documented.

The following aspects were evaluated by scanning electron microscope:
1. The formation and uniformity of the RDIZ along the entire length of the adhesive interface (Fig. 3);
2. The presence or absence of gaps: a. Inside the adhesive layer, b. Between the adhesive and resin cement layer, c. Inside the resin cement layer, d. Between the adhesive and post.

**Evaluation of resin tag formation**

The second section of each sample was stored in 30% HCl for 24 hours in order to completely dissolve the dental substrate and to detect resin tag and adhesive lateral branch formation (Fig. 4). The samples were then processed for SEM observation as already described.
Serial SEM photomicrographs at x500 original magnification were taken of the canal walls at the 1-, 4.5- and 8- mm levels. The serial photomicrographs were aligned to form a continuous horizontal examination strip at the 3 levels. Irrespective of the number of photomicrographs needed to form a complete strip, each strip was subdivided into 8 “assessment units”. The density and morphology of the resin tags were then assessed. The density and morphology of resin tags present at x500 magnifications were graded between 0 and 3. A score of 0.0 was assigned where resin tags were not detectable. A score of 1.0 was recorded when a few short resin tags (resin plugs) were visible. A score of 2.0 was recorded where uniform resin tag formation without lateral branches was noted. A score of 3.0 was recorded when long resin tags with lateral branches were uniformly evident.
Results

The number of samples showing voids/bubbles within the resin cement and/or at the interface between resin cement and root walls are summarized in Table 2. The cement thickness varied in relation to the root canal shape for each individual tooth (Fig. 3). Between 40% and 50% of samples showed bubbles/voids within the cement. The adhesive-composite cement and composite cement-fiber post interfaces were substantially free of voids.

Table 2:
Presence of voids/bubble within resin cements of the two experimental groups.

<table>
<thead>
<tr>
<th></th>
<th>Within resin cement</th>
<th>Post / cement</th>
<th>Adhesive / cement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Group 2</td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

RDIZ observations
The results obtained regarding the presence of RDIZ under the SEM microscope are shown in Table 3. The ratio between the length of the RDIZ and the length of the observed interfaces is reported.

Table 3:
Scanning electron microscope observation of the resin dentin interdiffusion zone (RDIZ) (Different letter show statistical significant difference).

<table>
<thead>
<tr>
<th>Group</th>
<th>Overall length of observed interface (in µm)</th>
<th>Length of interface with RDIZ (in µm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 SB1M</td>
<td>2650</td>
<td>2330 (88%)\textsuperscript{a}</td>
</tr>
<tr>
<td>2 SB1</td>
<td>2820</td>
<td>2256 (80%)\textsuperscript{b}</td>
</tr>
</tbody>
</table>

Legends: SB1M: Scotchbond 1 applied using a microbrush. SB1: Scotchbond 1 applied using a brush.
The samples of Group 1 showed an uniform RDIZ formation (Fig. 5), also apically. In two samples, a discontinuous gap between the RDIZ and resin cement was observed (Fig. 6).

The samples in Group 2 showed a less uniform RDIZ formation, particularly at the apical third. A gap between RDIZ and resin cement was seldom noted.

---

Fig 5. Microphotograph shows resin dentin interdiffusion zone formed at the apical level of Group 1 sample: No gap between conditioned dentin and adhesive resin is present. Original magnification: (SEM x 3100).
Evaluation of resin tag formation

The results obtained regarding morphology and density of resin tags are summarized in Table 4.

Table 4:
Mean and median resin tag formation scores recorded at 1-, 4.5-, and 8 mm levels of bonded posts (Group with the same letter did not show any statistical significant difference).

<table>
<thead>
<tr>
<th></th>
<th>1mm level (Coronal third)</th>
<th>4.5mm level (Medium third)</th>
<th>8mm level (Apical third)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean</td>
<td>median</td>
<td>mean</td>
</tr>
<tr>
<td>Group</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.SB1M</td>
<td>2.905 a</td>
<td>2.9</td>
<td>2.492 a</td>
</tr>
<tr>
<td>2. SB1</td>
<td>2.921 a</td>
<td>2.9</td>
<td>2.653 a</td>
</tr>
</tbody>
</table>

Legends: SB1M: Scotchbond 1 applied using a microbrush. SB1: Scotchbond 1 applied using a brush.
In the samples from Group 1, the resin tags formed in the coronal and/or middle areas of the roots showed a similar morphology to those in the apical areas. The density of resin tags was also similar in the three areas (coronal, mid and apical).

Adhesive lateral branch formation was also observed throughout the length of the roots and the resin tags showed a characteristic reverse-cone shape (Fig. 7).

The surface of resin tags reproducing demineralized tubular dentin was very rough and depicted the appearance of tubular dentin dissolved by the acid (Fig. 7).

In the samples from Group 2, the resin tags formed in the coronal (Fig. 8) and/or middle areas (Fig. 9), and of the roots, were much longer than those in the apical areas (Fig. 10). Also, the density of resin tags was higher in the coronal and mid areas than in the apical region (Figs. 8-10). In the coronal two thirds of the roots adhesive lateral branch formation was also observed. In the coronal and middle third the resin tags showed a characteristic reverse-cone shape (Fig. 11), while in the apical third this morphology was seen only occasionally. In the apical third the resin tags were often seen to only plug the tubules or were absent (Fig. 10).

The interface between translucent posts, resin cement and Rely X ARC resin cement did not demonstrate discontinuity, showing a good adaptation of Rely X ARC and Z250 to RTD posts.
Fig 7. Microphotograph of apical third (Group 1 sample); Reverse-cone shape resin tags and adhesive lateral branches are visible (original magnification: SEM x2500).

Fig 8. Microphotograph of coronal third (Group 2 sample); Long and uniformly formed resin tags are visible (original magnification: SEM x503).
Fig 9. Microphotograph of middle third (Group 2 sample): Uniform resin tags are noted (original magnification: SEM x503).

Fig 10. Microphotograph of apical third (Group 2 sample): resin plugs are visible (original magnification: SEM x1010). No characteristic resin tags are detectable.
Discussion

Recently, scanning electron microscopic studies have clearly shown that the bonding mechanism of adhesive systems to root dentin substrate is essentially of a micromechanical nature, based on infiltration of the demineralized surface, and formation of resin tags and adhesive lateral branches\textsuperscript{11-13}. Unfortunately, SEM evaluation did not permit collection of numeric data and consequently any statistical analysis. Only a few studies have reported the quantitative evaluation of morphological observations of root canals\textsuperscript{10,17,18}. In one study\textsuperscript{10}, RDIZ formation was evaluated by calculating the length of RDIZ formed immediately apical and immediately coronal to three notches made by a scalpel 2, 5 and 8 mm apically to the dentin-core junction. In this study, a similar evaluation of RDIZ formation was performed but along the entire adhesive interface of each sample and the data evaluated statistically. Also the resin tags were recorded at horizontal bands around
the posts, 1-, 4.5- and 8- mm from the apices of the root canal preparations. In this manner it was possible to score and statistically analyze the data obtained from samples of 2 different groups.

The resin tag network can be considered to result from an increase in the surface area made available for bonding by the effect of etching the dentin but not all areas exhibited an equal response to the etching procedure. In Group 2 samples, different resin tag densities were noted at the three horizontal bands while Group 1 specimens showed a more uniform resin tag formation. This could be due to the fact that pressure during the bonding application would be maximal in the cervical region, and in the apical third the pressure might be reduced, resulting in resin penetrating less deeply into the tubules leaving the lateral branches unfilled. Another explanation of the differing densities and morphology of resin tags and adhesive lateral branches at the different regions of the root could be related to the shape of the short brush used for carrying the primer and/or primer-adhesive solutions into the root canal space: The length of the bristles was around 4-5 mm which may not have reached to the apical third (Fig. 2). The primer-adhesive solution may have penetrated the opened dentinal tubules due to its wettability but it might not have been enough to properly infiltrate the apical substrate. The use of a very thin microbrush, as in Group 1, able to penetrate deeply into a root canal preparation was more predictable and useful (Fig. 1).

After light curing the bonding system from the coronal end of the canal, the dentin bonding system tested could form a RDIZ that did not interfere with the post placement into the root canal. This is likely due to the fact that the ‘one-step’ bonding system tested in this study produces a very low film thickness, and has sufficient reactivity to the curing light that it can be polymerized by a light source placed at the access to the root canal.

The presence of voids/bubbles within the resin cement might be mainly related to the cement characteristics and to the anatomy of the root samples. The anatomical variatiability of the root, and consequently the variable amount of resin cement and its three dimensional distribution into the
prepared canal space, could determine void formation. Another reason of the voids/bubbles presence within the resin cement might be the need for mixing base and catalyst, incorporating air. Also viscosity of the cement and placement technique might determine void and/or bubble formation.

Recently, a retrospective study of the clinical performance of fiber posts has been reported\(^2^0\). Three types of fiber posts and 4 adhesive systems in combination with proprietary resin cements were tested including Scotchbond MultiPurpose Plus in combination with Opal luting composite, and Scotchbond 1 (Single Bond) in combination with Rely X ARC resin cement. The latter combination of adhesive materials showed only 9 failures out of 252 luted posts. All the failures consisted of debonding of the post without any irreversible damage to the root. In these instances the debonded posts were either reluted into the root canal or replaced by a new preparation. All the posts were luted using a brush to carry the adhesive into the root canal. It might be speculated that by using a microbrush, the bonding mechanism can be improved and consequently clinical debonding of the posts consistently reduced.

**Conclusion**

It can be concluded that resin tag and hybrid layer formation produced by SB1 in combination with Rely X ARC was evident, and it created a micromechanical interlocking with root canal dentin. The null hypothesis of this study was rejected. Microbrush are indicated for bonding fiber posts into the root canal. When microbrush were used, the bonding mechanism created between root canal dentin and 'one-bottle' system was uniform along canal walls of root canal preparation.
References

18. Ferrari M, Vichi A, Grandini S, Davidson CL. ‘One-bottle’ and three step adhesive systems used for bonding fiber posts into root canals under clinical conditions: An SEM investigation. Proceedings of VII Congress of Italian Academy of Conservative Dentistry, Bologna, May 2000, pag. 27 (Abstract n.16)