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

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Download date: 30 Dec 2018
Chapter 5  Curing

"One shot polymerization technique"

Introduction

Over the last years, fiber posts became more popular and used because of their favorable physical properties and biocompatibility. Simultaneously, the use of adhesive systems for post cementation have increased in popularity and resin materials have been proposed to be used in combination with an acid etching technique, adhesive system, luting resin cement and fiber posts\(^1\). Recently several clinical studies showed the efficacy of fiber posts when luted with adhesive materials\(^5\)\(^-\)\(^7\).

Originally, a carbon fiber post developed in France and introduced in the U.S. (Composipost, RTD, St. Egreve, France) was proposed. Because of esthetic appearance, white fiber posts were proposed\(^8\). Recently, translucent fiber posts were made: these posts can transmit the light through the post permitting light curing of adhesive materials into the root canal. The translucent fiber post exhibits high fatigue and tensile strength, and has a modulus of elasticity (stiffness) comparable with that of dentin and of other fiber posts\(^3\). Its chemical nature is compatible with the Bis-GMA resin commonly used in bonding procedures. This post can be bonded within root canal space with polymer dentin bonding agents and resin cement of similar flexibility, and effectively transmit stresses between the post and the root structure, reducing stress concentration and preventing fracture\(^3\).

Recently, the so called 'one-bottle' adhesive systems were introduced to simplify the clinical bonding procedure in direct restorative dentistry. The clinical indications of 'one-bottle' systems might be now increasing and also were proposed for bonding fiber posts\(^8\). However, bonding into root canals might be difficult because handling characteristics of the adhesive system,
anatomy of roots, tooth position, presence of coronal residual tissues, light curing technique, experience and skill of the operators, etc.\textsuperscript{9,10}.

The latest generation of adhesive systems produce, by means of an etch technique, removal of the smear layer and demineralization of the dentin exposing a fine network of collagen fibrils\textsuperscript{11}. The infiltration of this network with resin permits formation of a resin dentin interdiffusion zone (RDIZ) with resin tags and adhesive lateral branches, thus creating micromechanical retention of the resin to the demineralized substrate\textsuperscript{12,13}. The efficacy of a dentin bonding system can be evaluated by observing uniformity and quality of the RDIZ, resin tag and adhesive lateral branch formation and presence of voids/bubbles within the luting material or at the interface between it and the cavity walls and the post\textsuperscript{14,15}.

RDIZ and resin tag formation might be also related to application technique of primer-adhesive material. The apical third of root canal preparation usually shows a not uniform resin tag and RDIZ formation with a consequent decrease of retention\textsuperscript{4,9,16,17}.

The aim of this study was to evaluate 1. The bonding mechanism of a ‘one-bottle’ adhesive system in root canal dentin when applied with three different clinical procedures and used in combination with proprietary resin cements, 2. The efficacy of translucent posts on light curing adhesive/resin cement materials, 3. The efficacy of microbrush on carrying priming/adhesive solution to the apical third of root canal preparation, 4. The null hypothesis that different clinical procedures can not affect directly the bonding mechanism of adhesive systems into the root canal preparations.

\textbf{Materials and Methods}

Fifty anterior teeth, extracted for periodontal reasons were selected for this study. The teeth were endodontically instrumented at a working length of 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 Copr., Costa Mesa, CA) and resin sealer (AH-26, DeTrey, Zurich, Switzerland).

The root canal walls of each sample were enlarged with a low-speed drills provided by the manufacture (RTD), and the depth of the post space preparation was 9 mm. The samples were randomly divided into four groups of ten samples each (Table 1).

Table 1:
Bonding-luting procedures

<table>
<thead>
<tr>
<th>Group</th>
<th>Bonding system</th>
<th>Clinical steps</th>
<th>Resin cement</th>
<th>Clinical steps</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>OS</td>
<td>a,e,g</td>
<td>Dual Resin Cement</td>
<td>j,k,l,m,n</td>
</tr>
<tr>
<td>2</td>
<td>OS/MB</td>
<td>a,f,g</td>
<td>Dual Resin Cement</td>
<td>j,k,l,m,n</td>
</tr>
<tr>
<td>3</td>
<td>OS/NLC</td>
<td>a,e</td>
<td>Dual Resin Cement</td>
<td>j,k,l,m,n</td>
</tr>
<tr>
<td>4</td>
<td>OS/NLC</td>
<td>a,f</td>
<td>Dual Resin Cement</td>
<td>j,k,l,m,n</td>
</tr>
<tr>
<td>5</td>
<td>AB2</td>
<td>a,b,c,d</td>
<td>C &amp; B</td>
<td>h,i,k,l,m</td>
</tr>
</tbody>
</table>

a. Dentin conditioning with phosphoric acid
b. Primer application with small brush
c. Pre-bonding resin application with a small brush
d. Adhesive application with a small brush
e. Primer-adhesive application with a small brush
f. Primer-adhesive application with a microbrush
g. Light-curing
h. Activator
i. Post treated with Primer B
j. Post treated with the Primer-adhesive solution
k. Mixing resin cement
l. Cement application into root canal with a lentulo drill
m. Removing resin excess with a small brush
n. Light-curing through the translucent fiber post.
Group 1: The first ten samples were treated with One Step bonding system (Bisco) following manufacturer’s instructions. The root canal walls were etched with 32% phosphoric acid (Bisco) for 15 seconds, washed with water syringe and then gently air-dried. Excess water was removed from the post space using paper points. 4-5 coats of primer-adhesive material were applied into the root canals with a small brush provided by the manufacturer. Excess primer adhesive solution was removed with a paper point, gently air-dried and then light-cured for 20 seconds. Dual Link resin cement catalyst and base were mixed and used following manufacturer's instructions. The resin cement was applied into the root canal space with a lentulo drill, the fiber post was seated and the excess of resin removed and light-cured for 20 seconds through the post.

Group 2: Other ten roots were treated in Group 2. The root canal walls were etched with 32% phosphoric acid for 15 seconds, washed with water syringe and then gently air-dried. Excess water was removed from the post space using paper points. The primer adhesive solution was applied in 4-5 coats with a thin microbrush Plus (Microbrush Co., USA), gently air-dried and light-cured for 20 seconds. Finally, Dual Link Composite base and catalyst were mixed and a layer of it was introduced into the root canal space with a lentulo drill and finally the fiber post was inserted. After removing excess of resin, the resin cement was light cured for 20 seconds through the post.

Group 3: The sample roots were treated as described in Group 1 samples. After application with a brush, the One Step primer/adhesive solution, it was not light-cured. After applying the dual resin cement with a lentulo drill and placing the post into the root canal preparation, the dual curing resin cement and the adhesive material were light-cured simultaneously through the post.
Group 4: These 10 samples were treated as described in Group 1. The only difference consisted that the bonding system and resin cement were light cured once through the transmittent post after setting it into the root canal space.

Group 5: The last ten roots were treated with All Bond 2 and C & B resin cement, as control. The adhesive luting materials were used strictly following manufacturer’s instructions. Aestheti-Plus posts (translucent fiber posts, RTD, France) were used. The diameter of the fiber post (RTD) used was 1.3 or 1.8 mm depending the size and shape of the roots. After complete setting of the cement, crown build-up was performed with proprietary resin composite (Biscore, Bisco).

The sample teeth were stored in a water solution at room temperature. A week later, the root samples were sectioned parallel to the long axis of the tooth using a diamond saw (Isomet, Buhler, Lake Bluff, NY, USA) at slow speed under water.

RDIZ observations
One section of each root was gently decalcified (32% phosphoric acid was applied for 30 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 RDIZ formation. After being extensively rinsed with water, the 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.

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. 1);
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 adhesive and post.

A chi-square test and a Kruskal-Wallis analysis at the 0.05 level of significance were used to statistically evaluate the results obtained in the various groups regarding the presence of RDIZ.

Evaluation of resin tag formation
The other 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. 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 (Fig. 2).
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 few and 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. The mean scores of resin tags found at 1-, 4.5- and 8-mm levels were statistically analyzed using the Scheffer and Fischer tests to test for significance between and within the groups at 0.05 level of significance.

Results

The number of samples showing voids/bubbles within the resin cement or/and at the interface between resin cement and root walls are summarized in Table 2. Voids were present in the composite cement layers of all groups. The cement layer was substantially similar in all groups. The cement thickness varied in relation to the root canal shape for each individual tooth. Between 20% (Group 2) and 40% (Group 1 and 5) 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.

<table>
<thead>
<tr>
<th>Group</th>
<th>Within resin cement</th>
<th>Post/cement</th>
<th>Adhesive/cement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td>1</td>
<td>/</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>/</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>2</td>
<td>/</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>1</td>
<td>/</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
<td>/</td>
<td>/</td>
</tr>
</tbody>
</table>

RDIZ observations
The results obtained regarding the presence of RDIZ in the various groups under the SEM microscope are shown in Table 3.

Table 3:
Scanning electron microscope observation of the resin dentin interdiffusion zone (RDIZ).

<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 OS</td>
<td>2800</td>
<td>2120 (75%)\textsuperscript{b}</td>
</tr>
<tr>
<td>2 OS/MB</td>
<td>2550</td>
<td>2270 (89%)\textsuperscript{a}</td>
</tr>
<tr>
<td>3 OS/NLC</td>
<td>2750</td>
<td>1920 (65%)\textsuperscript{c}</td>
</tr>
<tr>
<td>4 OS/NLCM</td>
<td>2900</td>
<td>2720 (94%)\textsuperscript{a}</td>
</tr>
<tr>
<td>5 AB2</td>
<td>2820</td>
<td>2256 (80%)\textsuperscript{b}</td>
</tr>
</tbody>
</table>

The ratio between the length of the RDIZ and the length of the observed interfaces was statistically significant different between Groups 2 and 4 and the other three groups. Group 2 and 4 samples showed an uniform RDIZ formation (Fig. 3), while in the other groups RDIZ was less represented apically (Fig. 4). In two samples of Group 3 and of one of Group 1, a discontinuous gap between the RDIZ and resin cement was observed; this gap might probably be an artifact due to vacuum pressure of the sputtering device and SEM chamber. The RDIZ formation of Group 3 samples was significantly less evident than in other three Groups.
Fig 3. Microphotograph shows resin dentin interdiffusion zone (RDIZ) formed at coronal level of Group 2 sample: No gap between conditioned dentin and adhesive resin is present original magnification: (SEM x 1310).

Fig 4. Microphotograph shows resin dentin interdiffusion zone (RDIZ) at apical level: a gap is clearly visible in a Group 1 sample (original magnification: SEM x625).
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.

<table>
<thead>
<tr>
<th>Group</th>
<th>1 mm level (Coronal third)</th>
<th>4.5 mm level (Medium third)</th>
<th>8 mm level (Apical third)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Median</td>
<td>Mean</td>
</tr>
<tr>
<td>1. OS</td>
<td>2.905</td>
<td>2.9</td>
<td>2.492</td>
</tr>
<tr>
<td>2. OS/MB</td>
<td>2.957</td>
<td>2.9</td>
<td>2.891</td>
</tr>
<tr>
<td>3. OS/NC</td>
<td>2.712</td>
<td>2.7</td>
<td>2.229</td>
</tr>
<tr>
<td>4. OS/NCM</td>
<td>2.945</td>
<td>2.9</td>
<td>2.723</td>
</tr>
<tr>
<td>4. AB2</td>
<td>2.921</td>
<td>2.9</td>
<td>2.653</td>
</tr>
</tbody>
</table>

Group 1, 3 and 5: The resin tags formed in the coronal and/or middle areas of the roots were much longer than those in the apical areas (Figs. 5-7). Also, the density of resin tags was higher in the coronal and mid areas than in the apical areas (Figs. 5-7). In the coronal two thirds of the roots adhesive lateral branch formation was also observed (Fig. 8). In the coronal and mid third the resin tags showed a characteristic reverse-cone shape, 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 (Fig. 7) or were absent.

Group 2: Resin tag and lateral branch formation was more uniform than in other groups. Although the length of resin tags was more evident at the coronal third, the morphology of resin tags was similar in all three thirds (Fig. 9). The surface of resin tags reproducing demineralized tubular dentin was very rough and depicted the appearance of tubular dentin dissolved by the acid.

Group 4: Resin tag and lateral branch formation and density were very uniform. The length of resin tags was evident and similar at the three thirds, and the morphology of resin tags was similar in all three thirds. The surface of resin tags reproducing demineralized tubular dentin was very rough and
depicted the appearance of tubular dentin dissolved by the acid. Globule formation were diffusely noted along the resin tags mainly located in the apical third of the root canals. Statistically significant differences were noted (P<0.05) between Groups 2 and 4 and the other three groups.

Fig 5. Microphotograph of coronal third (Group 3 sample); Long and uniformly formed resin tags are visible (original magnification: SEM x503).
Fig 6. High magnification of microphotograph 5: Adhesive lateral branches are visible (original magnification: SEM x2020).

Fig 7. Microphotograph of apical third (Group 3 sample): resin plugs are visible (original magnification: SEM x2300). No characteristic resin tags are detectable.
Fig 8. Microphotograph of coronal third: Adhesive lateral branch formation is evident (original magnification: SEM x4580).

Fig 9. Microphotograph shows resin tag and adhesive lateral branch formation at apical third (Group 2 sample)(original magnification: SEM x2500).
Discussion

Thank to microscopic investigations, it is well accepted that bonding mechanism of adhesive systems to root dentin substrate is essentially of a micromechanical nature, based on infiltration of the demineralized surface, and on formation of RDIZ, resin tags and adhesive lateral branches\(^4,8,13,14\). Unfortunately, microscopic investigations did not permit collection of numeric data and consequently any statistical analysis. Recently several studies have reported on quantitative evaluation of morphological observations of root canals\(^4,16-18\). In this study, RDIZ formation was evaluated calculating the entire length of RDIZ formed along the interface between conditioned dentin and the adhesive resin. Also the amount of resin tags was recorded from horizontal bands around the post, 1-, 4.5- and 8- mm from the apices of the root canal preparations. In this manner it was possible to analyze statistically the data obtained from SEM observations of 4 different groups.

Based on Bachicha et al.\(^19\) and Mannocci et al.\(^16\) data, dentin-bonding cements forming RDIZ (eg, All Bond 2) have less microleakage than the traditional cements (eg, Zinc phosphate) or adhesive systems which develop a less uniform hybrid layer (eg, Panavia F). This can be due to the sealing effect of the RDIZ at the restoration margin\(^7,20\).

The resin tag network and RDIZ formation can be considered to be the result of an increase in the surface area made available for bonding by the effect of etching the dentin\(^10\) but not all areas exhibited an equal response to the etching procedure. A different density and morphology of resin tags and adhesive lateral branches at the three horizontal bands could be found in Groups 2 and 4 when compared to that of Group 1, 3 and 5 samples. The findings of this study can be related to the thin thickness of the microbrush used in Groups 2 and 4 for carrying the primer-adhesive solution into the root canal apically. Otherwise, the length of the bristles used in Group 1, 2 and 5 was around 4-5 mm which may not have reached to the apical third: In these samples, the primer-adhesive solution may have penetrated the
opened dentinal tubules thank 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 Groups 2 and 4, able to penetrate deeply into a root canal preparation, could be very useful clinically. Also, the less evident and uniform resin tag and RDIZ formation at apical third of Group 1, 3 and 5 might be due to the fact that pressure by which the primer-adhesive solution is applied during the bonding procedure with the brush would be maximal in the cervical region whereas in the apical third the pressure might be reduced, resulting in resin penetrating less deeply into the tubules and lateral branches remaining unfilled. It can be speculated that, using microbrush technique as described in Group 2 samples, those of Group 1, 2 and 5 might improve RDIZ and resin tag formation.

Presence of globule formations was noted along the resin tags of Group 4 samples, mainly at apical third. These globules might be due an uncomplete polymerization of resin monomers; in this group of samples the adhesive material and resin cement were polymerized simultaneously through the transmittent post: the bonding system was not light cured properly probably because of the light energy, the distance of the light source from the apex of the post, the capability of the traslucent post to transmit the light and the interposition of resin cement between the post and the adhesive system.

After light curing the bonding system from coronal end of the canal (Group 1 and 2), 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 produce a very low film thickness, the bonding system is light sensitive and can be polymerized by a light source placed at the access to the root canal.

In Group 3, One Step was not light cured before applying the resin cement and the post but adhesive materials were light-cured through the post simultaneously, shortening the clinical procedure. In the apical third of Group 3 root preparations, RDIZ and resin tags were seldom found: This can be due to the fact that the not light-cured primer-adhesive solution might be spread off before light-curing by placement of resin cement and of the post
because of their pressure. Another explanation may be that light-curing only through the translucent post determines an incomplete polymerization of the adhesive material.

Self-curing bonding/luting system, used as control, (Group 5) confirmed to be an useful system/technique for cementing fiber posts. Absence of voids/bubbles at fiber post/resin cement interface could result from the good bond between the resin matrix of the post and of the resin cement whereas the presence of voids/bubbles with resin cements might be mainly related to the viscosity degree of resin cement and to the anatomy of the root samples. In fact, anatomical variations of roots, the consequent variable amount of resin cement and its tridimensional distribution into a prepared canal space could be another possible cause of void formation. It can be concluded that quality, uniformity and predictability of bonding mechanism obtained with the adhesive system applied as in Group 2 samples were superior to the other groups and clinical procedure performed in Group 2 might be more reliable for daily practice.

The null hypothesis tested in this study was not confirmed by the results: there was a direct correlation between each clinical bonding procedure and resin tag, adhesive lateral branch and RDIZ formation. Further prospective clinical study will determine efficacy of "one-bottle" bonding system for luting fiber posts and what bonding procedure can be more useful for practitioners.

References

Self-Curing adhesive system

a. Lab investigation

Introduction

The use of carbon fiber posts\textsuperscript{1}, preformed metallic posts and/or custom-cast metallic posts in the anterior region has been reported to result in unsatisfactory aesthetics\textsuperscript{2,3}. As a result, aesthetic fiber posts have become more popular. They are also well accepted because of their favorable physical properties and their biocompatibility\textsuperscript{4-10}. The aesthetic fiber posts can be bonded within root canal space with polymer dentin bonding agents and resin cements of similar flexibility, and effectively transmit stresses between the post and the root structure, thus reducing stress concentration and preventing the occurrence of fracture\textsuperscript{5}.

The clinical indications of 'one-bottle' adhesive systems have rapidly increased to include the bonding of fiber posts and of indirect esthetic restorations. Clinical studies have proved that 'one-bottle' adhesive materials to be effective in retaining aesthetic fiber posts\textsuperscript{2,11}.

The efficacy of an enamel-dentin bonding system in combination with a resin cement can be evaluated by observing the extent of Resin Dentin Interdiffusion Zone (RDIZ), resin tag and adhesive lateral branch formation\textsuperscript{12,13-15} and presence of voids/bubbles within the luting material or at its interface with the cavity walls and the post\textsuperscript{16}.

Bonding into root canals might be difficult because of the handling characteristics of the adhesive system, root anatomy, tooth position, presence of coronal residual tissues, light curing technique, experience and skill of operators, etc.\textsuperscript{17,18}
Recently, combinations of light cured 'one-bottle' bonding systems and dual-cure resin cements were proposed for luting fiber posts\textsuperscript{16}. A lack of micromechanical bonding mechanism was often observed in the apical third of the canal preparation\textsuperscript{9,16}. The RDIZ and resin tag formation was shown to increase if the primer-adhesive solution was carried with a thin microbrush to reach the most apical third of root canal preparation\textsuperscript{16}.

In order to improve the reliability of clinical bonding procedure of indirect restorations, such as inlays, crowns and fiber posts, the use of a dual-cure 'one-bottle' bonding system (Excite Dual-Self-Cure, Vivadent, Schaan, Liechtenstein) was suggested. Attributed to small particles of catalyst incorporated into the bristles of a very thin microbrush included in the system, the primer-adhesive solution can be carried into the deepest area of canal preparation and simultaneously he self-activated (Fig 1). This combination of self-cure materials is proposed to be used with experimental fiber posts made using Vectris fiber reinforced technology (Ivoclar, Schaan, Liechtenstein).

The aim of this study was to evaluate the efficacy of a new bonding/luting system in resin tag, adhesive lateral branch and hybrid layer formation when used in combination with experimental fiber post.

**Method and Materials**

Thirty anterior teeth, extracted for periodontal problems, were selected for this study. The teeth were endodontically instrumented at a working length of 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 burs #2 to #4 (Union Broach), and 2.5\% sodium hypochlorite irrigation. The prepared teeth were obturated with thermoplasticized, injectable gutta-percha (Obtura, Texceed Copr., Costa Mesa, CA) and resin sealer (AH-26, DeTrey, Zurich, Switzerland).
The samples were randomly divided into three groups of ten samples each (Table 1).

Gutta-percha was removed using Largo drills and then root canal walls of each sample were enlarged with a low-speed burs provided by the manufacture (Ivoclar and RTD, St. Egreve, France, respectively). The depth of the post space preparation was 9-10 mm measured from cementum-enamel junction.

Table 1:
Bonding Lutin Procedures used

<table>
<thead>
<tr>
<th>Group</th>
<th>Bonding system</th>
<th>Clinical steps</th>
<th>Resin cement</th>
<th>Clinical steps</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>EX/LC</td>
<td>a,b,d</td>
<td>Variolink II</td>
<td>e,f,g,h</td>
</tr>
<tr>
<td>2</td>
<td>EX/DSC</td>
<td>a,c</td>
<td>MultiLink Resin Cement</td>
<td>e,f,g</td>
</tr>
<tr>
<td>3</td>
<td>OS</td>
<td>a,c</td>
<td>Dual Resin Cement</td>
<td>e,f,g,h</td>
</tr>
</tbody>
</table>

a: Dentin conditioning with phosphoric acid
b: Primer-adhesive application with a small brush
c: Primer-adhesive application with a self-activating microbrush
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.

OS: One-Step (Bisco, Schaumburg, IL);
EX/LC: Excite light-cured (Vivadent, Schaan, Liechtenstein);

Group 1: Ten samples were treated with Excite bonding system in combination with VarioLink II dual-curing resin cement (Vivadent) following manufacturer’s instructions. The root canal walls were etched with 37% phosphoric acid for 15 seconds, rinsed and then gently air-dried with air-water syringe. Excess water was removed from the post space using paper
points. 2-3 coats of primer-adhesive material were applied into the root canals with a small brush provided by the manufacturer. The excess of the primer adhesive solution was gently blown with the air-syringe and adsorbed with a paper point. Then the residual adhesive material was light-cured for 20 seconds. Variolink II resin cement catalyst and base were then mixed and used according to the manufacturer's instructions. The resin cement was applied into the root canal space with a lentulo spiral, the experimental Vectris fiber post was seated, excess resin was removed with a small brush and the cement was light-cured through the post for 40 seconds.

Group 2: Another ten teeth were restored with experimental Vectris fiber posts, Excite DSC (Dual-self-curing) and MultiLink self-curing resin cement (Vivadent). The root canal walls were etched with 37% phosphoric acid for 15 seconds, rinsed and then gently air-dried with a air-water syringe. Excess water was removed from the post space using paper points. The Excite primer/adhesive solution was applied with a 'self-activating' microbrush, which was able to activate the Excite inside root canal. The adhesive solution was gently air-dried. MultiLink base and catalyst resin cement were mixed and a layer of it was applied into the root canal space with a lentulo spiral and finally the Vectris fiber post was seated. After removing excess of resin with a brush, the resin cement was left undisturbed for 60 seconds.

Group 3: The last group of ten teeth were treated with One-Step bonding system in combination with Dual Link resin cement (Bisco, Schaumburg, IL), and served as control. Manufacturer's instructions were strictly followed. The primer/adhesive solution was applied in several coats, gently air-dried, and light cured for 20 seconds. The resin cement was introduced into the canal using a lentulo spiral and the post was inserted into the canal (EndoAesthetic fiber posts, RTD). Finally, the dual curing resin cement was light cured through the post for 40 seconds.

Fiber post 1.3 or 1.8 mm in diameter (Ivoclár and RTD) were used, depending on the size and the shape of the root. After complete setting of the cement, crown build-up of Group 1, 2 and 3 samples was performed with proprietary resin composite (Tetric Ceram, Vivadent and Aeliteflo, Bisco).
The sample teeth were stored in water at room temperature. A week later, the root samples were sectioned parallel to the long axis of the tooth using a diamond saw (Isomet, Buhler, Lake Bluff, NY, USA) at a slow speed under water.

**RDIZ observations**

One section of each root was gently decalcified (32% phosphoric acid was applied for 30 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 RDIZ formation. After being extensively rinsed with water, the 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.

The following aspects were evaluated under the scanning electron microscope:

1. The formation and uniformity of the RDIZ along the entire length of the adhesive interface.
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 adhesive and post.

A chi-square test and a Kruskal-Wallis analysis at the $P=0.05$ level of significance were performed to statistically evaluate the results obtained in the various groups regarding the presence of RDIZ.

**Evaluation of resin tag formation**

The other 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. The samples were then processed for SEM observation as described earlier.

Serial SEM photomicrographs at x500 original magnification were taken of the canal walls at the 1-, 4.5- and 8- mm levels (Fig 1). 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.

![Composite picture shows the three levels of observation (arrows) (original magnification SEM x 242). Root canal preparation was 9 mm in length; The level of observations was 1 mm from the most apical part of the preparation (apical level), at 4.5 mm from the apical and/or coronal level (medium level) and 8 mm from the apical level and/or 1 mm from the most coronal part of the preparation (coronal level).](image)

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 few and 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.

The mean scores of resin tags found at 1-, 4.5- and 8-mm levels of each sample were statistically analyzed in order to assess the significance of differences between and within the groups. The Kruskal-Wallis non-parametric analysis was performed and the level of significance was set at $P<0.05$.

SEM evaluations were performed in double blind by two different operators. In case of discrepancy between the two readers, the lower score was recorded.
Results

No voids/bubbles were noted at the interface between translucent posts and resin cements in all samples. The cement layer was similar in all groups. The cement thickness varied in relation to the root canal shape for each individual tooth. Between 20% (Group 2) and 40% (Group 1 and 3) of samples showed bubbles/voids within the cement. Also, the adhesive-composite cement interface was almost free of voids: only one sample in each group showed voids.

RDIZ observations

The ratio between the length of the RDIZ and the length of the observed interfaces was statistically significantly different between Group 2 and the other two groups (Table 2).

Table 2:
Scanning Electron Microscope Observation of the Resin Dentin Interdiffusion Zone (RDIZ). Group with Different Letter Showed Statistically Significant Differences.

<table>
<thead>
<tr>
<th>Group</th>
<th>Overall length of observed interface (mm)</th>
<th>RDIZ length (mm)</th>
<th>Ratio RDIZ/overall length (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EX/LC</td>
<td>28.5</td>
<td>23.6</td>
<td>80% b</td>
</tr>
<tr>
<td>EX/DCS</td>
<td>25.8</td>
<td>23.2</td>
<td>90% a</td>
</tr>
<tr>
<td>OS</td>
<td>23.5</td>
<td>16.5</td>
<td>72% c</td>
</tr>
</tbody>
</table>

EX/LC: Excite light-curing;  
EX/DCS: Excite self-activated;  
OS: One Step.

In all samples, RDIZ formation was evident along the interface between adhesive material and etched dentin (Figs 2,3). In Group 1 and 3 the uniformity of the hybrid layer was apparent in the coronal two thirds but less evident at the apical third of the canal (Fig 3). In the samples of Group 2,
hybrid layer formation was noted in all thirds (Fig 2). In one sample of each group, a discontinuous gap between the hybrid layer and resin cement was observed.

Fig 2. Photomicrograph shows resin dentin interdiffusion zone at apical level of a Group 2 sample: resin tag and hybrid layer formation is clearly detectable (original magnification: SEM x1310).

Fig 3. Photomicrograph of coronal third (Group 3 sample); Uniformly formed resin tags (T) and hybrid layer (H) are visible (original magnification: SEM x1310).
Evaluation of resin tag formation

The density of resin tags in Groups 1 and 3 was higher in the coronal and middle thirds than in the apical third (Fig 4) and they were longer than those seen apically (Fig 5); (Table 3).

Table 3:
Mean and Standard Deviation (SD) of Resin Tag Formation Scores Recorded at 1-, 4.5-, and 8 mm Levels. (Group with Different Character Showed Statistically Significant Differences).

<table>
<thead>
<tr>
<th>Group</th>
<th>1 mm level (Coronal third)</th>
<th>4.5 mm level (Middle third)</th>
<th>8 mm level (Apical third)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean SD</td>
<td>Mean SD</td>
<td>Mean SD</td>
</tr>
<tr>
<td>EX/LC</td>
<td>2.9 a 0.3</td>
<td>2.4 b 0.2</td>
<td>1.3 c 0.3</td>
</tr>
<tr>
<td>EX/DSC</td>
<td>2.9 a 0.2</td>
<td>2.9 a 0.4</td>
<td>2.6 ab 0.5</td>
</tr>
<tr>
<td>EX/LC</td>
<td>2.8 a 0.4</td>
<td>2.3 b 0.3</td>
<td>1.2 c 0.5</td>
</tr>
</tbody>
</table>

EX/LC: Excite light-curing;
EX/DSC: Excite self-activated;
OS: One Step.

In the coronal two thirds of the roots adhesive lateral branch formation was also observed. In the coronal and middle thirds the resin tags showed a characteristic reverse-cone shape, whereas 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 (Fig 5).

Resin tag and lateral branch formation in Group 2 was more uniform than in Group 1 and 3. The morphology of resin tags was similar in all three thirds and characteristic reverse-cone shape was observed also apically (Figs 6, 7). Adhesive lateral branches were evident also apically (Fig 8).

In all groups, the area of resin tags reproducing demineralized tubular dentin was rough and replaced the tubular dentin dissolved by the acid.
Statistically significant differences were noted \((P<0.05)\) between Group 2 and the other two groups at medium and apical thirds (Table 3).

Fig 4. Photomicrograph of Group 1 sample: Long resin tags are visible coronally (original magnification: SEM x2020).

Fig 5. Photomicrograph of apical third (Group 1 sample): resin plugs are visible (original magnification: SEM x1550). No characteristic morphology of resin tags is noted.
Fig 6. Photomicrograph of middle third (Group 2): at low magnification the uniform resin tag formation is evident (original magnification: SEM x655).

Fig 7. Photomicrograph of coronal third (Group 2): Adhesive lateral branch formation is evident (original magnification: SEM x2020).
Fig 8. Photomicrograph shows resin tag and adhesive lateral branch formation at apical third (Group 2 sample) (original magnification: SEM x2020).

Discussion

Recently, scanning electron microscopic investigations have been performed for evaluating the bonding mechanism of adhesive systems in root canals\textsuperscript{10}. Based on the infiltration of the demineralized surface and on formation of resin tags and adhesive lateral branches\textsuperscript{4,16,17}, these studies clearly showed that the bonding mechanism of the tested adhesive systems to root dentin substrate is essentially of the same micromechanical nature. Based on a recent study\textsuperscript{16}, RDIZ formation was evaluated by calculating the entire length of RDIZ formed along the interface between conditioned dentin and the adhesive resin. Also the amount of resin tags was recorded from horizontal bands around the post at 1-, 4.5- and 8- mm from the apices of the root canal preparations\textsuperscript{16}. In this manner it was possible to statistically analyze the data obtained from samples of 3 different groups.

The results of this study can be correlated to those of another study recently performed following the same methods\textsuperscript{16}: the use of thin microbrush as
carrier of primer-adhesive solution always resulted in more uniform and predictable RDIZ and resin tag formation, which also was evident in the apical third of root canal preparations.

The self-activated bonding system, Excite dual-curing adhesive in combination with self-curing resin cement showed the most uniform RDIZ and resin tag formation along root canal walls. Therefore, it seems that the combination of a thin microbrush with self-activating particles is the most predictable procedure for bonding/luting fiber posts.

In the samples of Group 1 and 3, different resin tag densities were noted at the three horizontal bands, whereas Group 2 specimens showed a more uniform formation of resin tags. This could be related to the size of the microbrush used for carrying the primer and/or primer-adhesive solutions into the root canal space: The length of the bristles used in Group 1 and 3 was approximately 4-5 mm, which might have been inadequate to reach to the apical third. In this case, the primer-adhesive solution might have been able to penetrate the opened dentinal tubules due to its wettability, but not enough to properly infiltrate the apical substrate. The use of a very thin microbrush, as in Group 2, allowed to carry the primer-adhesive solution deeply into a root canal. The more uniform resin tag formation on the apical third of Group 2 samples might as well be due to the ability of the microbrush to locally activate the self-curing step of the priming-adhesive solution, thus ensuring a proper polymerization of the bonding.

After light curing the bonding system (Group 1 and 3) from coronal end of the canal, the dentin bonding system tested was able to 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 systems tested in this study produce a very low film thickness, the bonding systems are light sensitive and can be polymerized by a light source placed at the access to the root canal.

The two types of translucent posts tested in this study showed good adaptation to proprietary resin cement. In this study, absence of voids/bubbles at the fiber post/resin cement interface was noted. This finding could result from the good bond between the resin matrix of the post and of
the resin cement. The posts have an endodontic shape and were developed in order to reduce the removal of root dentin with burs to a minimum amount of substrate.

The variability of root anatomy, the consequent variability in the amount of resin cement and its tridimensional distribution into a prepared canal space might cause void formation within resin cement.

In the light of the results of this study, a direct correlation between each clinical bonding procedure and resin tag, adhesive lateral branch and RDIZ formation was found. The combination of a self-curing bonding/resin cement system with experimental Vectris fiber posts showed the most uniform resin tag, adhesive lateral branch and RDIZ formation and, therefore might be proposed as reliable clinical procedure.

References

Self-Curing adhesive system

b. Clinical experience.

Introduction

Endodontically treated teeth often require a post and core for being restored. For a long period of time, metal post-and-core systems were selected and used. More recently, fibre posts have been proposed for restoring endodontically treated teeth. Fibre posts are luted with a bonding technique and are passive. The modulus of elasticity of fibre posts is similar to that of dentin and, therefore the risk of root fracture is excluded. Recently, the clinical efficacy and predictability of fibre posts have been demonstrated.

Different resin cement-bonding system combinations have been proposed. Originally, carbon fibre posts (RTD, St. Egreve, France) were used in combination with a three-step bonding system (All Bond 2, Bisco Co., Schonerburg, Illinois, USA), and a self-curing resin cement (C & B, Bisco Co). Successively, several ‘one-bottle’ bonding systems have been proposed in combination with proprietary self-curing and/or with dual resin cements. Also, other bonding systems (such as SBMMP and SB1, 3M, St. Paul, USA, Excite, Vivadent, Schaan, Liechtenstein, Panavia Ex and F, Morita, Tokyo, Japan) have been used for bonding/luting fibre posts in combination with proprietary resin cements.

Several types of fibre posts have appeared in the market: Carbon, quartz, hybrid fibre posts. More recently, translucent fibre posts have been proposed.

The use of translucent posts, able to permit to the light to pass through it and to arrive at the bottom of the root canal preparation, has opened the
possibility of using an esthetic post, simplifying the clinical luting procedure and reduce the working time\textsuperscript{16}.

The clinical use of translucent posts can essentially look for two different goals: 1. an improvement of the polymerisation rate of resin composite used for core build up and resin cement and 2. a polymerisation in one ‘shot’ of all the adhesive materials.

It is not proven yet if the light intensity passing through the post can be sufficient to polymerise the resin cement and bonding system completely and simultaneously. If a practitioner does not anticipate a complete polymerisation in one ‘shot’ through the translucent post, he has two options: the bonding system can be polymerised separately, light-curing it immediately after its application into the root canal\textsuperscript{8} or a self-activating bonding system can be used, as shown in this case report.

A self-activating bonding system has been proposed\textsuperscript{3}. Thanks to small particles of catalyst placed into the bristles of a very thin microbrush (Fig. 1), the dual-cure ‘one-bottle’ bonding system (Excite DC, Vivadent) can polymerise also in the area where the light can not arrive effectively; the primer-adhesive solution can be carried into the deepest area of canal preparation and simultaneously self-activated (Fig. 2). This new adhesive material is combined with a self-curing luting material (MultiLink, Vivadent) and Vectris fibre posts (Ivoclar, Schaan, Liechtenstein), which are based on fibre reinforced technology. This technique may be simple and predictable for the practitioner.

Efficacy of a bonding system is based on resin dentin interdiffusion zone (RDIZ), resin tag and adhesive lateral branch formation\textsuperscript{13,14}.

The aims of this report were 1. to document the clinical luting procedures of a Vectris fibre post bonded with a self-activating bonding system and self-curing resin cement and 2. to evaluate the bonding mechanism of Excite DC in luting fibre posts under clinical conditions.
Fig 1. The thin microbrush can penetrate deeply into the root canal preparation.

Fig 2. Microphotograph shows bristles of a microbrush with self-activating particles (SEM x16).
Materials and Methods

Five patients were selected for this study to document clinical procedure and to evaluate bonding mechanism under clinical conditions.

Case report
A 39-year-old female presented with secondary caries in a maxillary canine that had been restored with an amalgam restoration 12 years previously (Fig. 3). The clinical examination demonstrated the need for treating the tooth endodontically. The teeth were endodontically instrumented at a working length of 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 tooth was obturated with gutta-percha and resin sealer (AH-26, DeTrey, Zurich, Switzerland) using the lateral condensation technique. The patient was informed of the possibility of covering the tooth with a crown, but because she had to travel the day after for her business, she preferred to postpone this decision. It was decided to restore the tooth with a fibre post immediately after endodontic treatment at the same appointment. Guttapercha was removed by a hot hand instrument and then the root canal was slightly enlarged with a pre-formed low-speed bur provided by the manufacturer (Ivoclar) to a depth of 9-10 mm. The post was tried in and cut at a convenient length (Fig 4). The root canal walls were etched with 37% phosphoric acid for 15 s, washed with an endodontic water syringe and then gently air-dried. The excess water was removed from the post space using paper points. Subsequently, Exite DC (Vivadent) was applied with a thin self-activating microbrush (Fig. 5), left undisturbed for 30 s, gently air-dried and the remaining puddled adhesive solution was removed from the post space using a paper point. In the mean time the adhesive solution started to self-cure, MultiLink self-curing resin cement base and catalyst (Vivadent) were mixed according to the manufacturer’s instructions. The diameter of the Vectris post used was 1.1 mm. The cement was applied on the post surface and also carried into
the root canal space using a lentulo drill and the post was inserted into the canal. The cement was allowed to set and crown build up was completed with Tetric Ceram resin composite (Vivadent, Shade A3)(Figs. 6-7).

Fig 3. The radiograph of the tooth shows the old amalgam restoration located very close to the pulp.

Fig 4. After the endodontic treatment is performed and the root canal space prepared, the translucent post is tried into the canal space and then cemented.
Fig 5. The thin microbrush is used for carrying the adhesive solution into the root canal space and to self-activating it simultaneously.

Fig 6. The radiograph shows the canine after placement of the post.
SEM evaluation

Four other patients presented an anterior single root, endodontically treated teeth, already scheduled for extraction because of endodontic or periodontal problems. Clinical and radiographic examination demonstrated the need for extraction of these teeth. The patients were informed and their written consent was obtained to postpone the extraction for one week. Approval by the ethics committee was obtained. The teeth were restored as described above, using Excite DC, Multilink resin cement and Vectris posts.

A week later, the root samples were extracted and then sectioned parallel to the long axis of the tooth using a diamond saw (Isomet, Buhler, Lake Bluff, NY, USA) at slow speed under water.

RDIZ formation

One section of each root was gently decalcified (32% phosphoric acid was applied for 30 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 RDIZ formation.
After being extensively rinsed with water, the specimens were submitted to an ascending alcohol series, 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. The following aspects were evaluated by scanning electron microscope:

1. The formation and uniformity of the RDIZ related to the entire length of the observed interfaces;
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 adhesive and post.

**Resin tag formation**
The other 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. 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 (Fig. 8). The serial photomicrographs were aligned to form a continuous horizontal examination strip at the 3 levels. Then, SEM photomicrographs at higher magnification (x1000, x2000, x5000) were taken to document morphology of resin tags and adhesive lateral branches at the same three levels described above.

SEM evaluation was performed in double blind by two different operators.

**Fig 8.** Composite picture shows the three levels of observation (arrows) (Original magnification x20). Root canal preparation was 9-10 mm in length. The level of observations was 1 mm from the most apical part of the preparation (apical third, AT), at 4.5 mm from the apical and/or coronal level (medium third, MT) and 8 mm from the apical level and/or 1 mm from the most coronal part of the preparation (coronal third, CT).
Results

No voids/bubbles were noted at the interface between Vectris posts and experimental resin cement. The cement thickness varied in relation of root anatomy of each individual tooth and it was similar in all samples. The adhesive-dentin interface was free from voids/bubbles. Voids/bubbles were found within the resin cement in all samples.

RDIZ observations

In all samples, RDIZ formation was evident along the interface between adhesive material and etched dentin. The uniformity of the hybrid layer was observed also apically (Fig. 9).

![Fig 9. Photomicrograph shows the resin-dentin interdiffusion zone at apical level. The resin-dentin interdiffusion zone is clearly detectable (Original SEM x 1010).](image)

Resin tag observations

The resin tags formed in the coronal, middle and apical areas of the roots showed same morphology and similar length (Figs. 10-12). Resin tags
showed characteristic reverse-cone shape (Fig. 13). Also the density of resin tags was similar in the three areas (Figs. 10-12). In all samples, the area of resin tags reproducing demineralized tubular dentin was rough and reflected the aspect of tubular dentin dissolved by the acid.

Fig 10. Photomicrograph at coronal level. An uniform resin tag formation is detectable (SEM x 156).

Fig 11. Photomicrograph at middle level. Resin tag formation is evident (SEM x 160).
Fig 12. Photomicrograph at apical level. Also in the most apical part of the root canal space resin tag formation is clearly visible (SEM x 503).

Fig 13. Photomicrograph at apical level. High magnification of Fig. 12. Adhesive lateral branch formation is evident and characteristic resin tag morphology is noted (SEM x 5000)
Discussion

The adhesive systems of the latest generation are able to effect, as a result of an etching technique, the complete removal of the smear layer, as well as the demineralization of the dentin, so as to expose a fine network of collagen fibrils. The infiltration of this network with resin allows the formation of a RDIZ with resin tags and adhesive lateral branches, thus producing a micromechanical retention of the resin to the demineralized substrate. Recently, the capability of Excite DC bonding system to form RDIZ, resin tags and adhesive lateral branches has been demonstrated in Class V and root canal walls.

In order to carry the adhesive solution into the root canal preparation and determine RDIZ and resin tag formation apically, a thin microbrush was used: the use of a microbrush allows to reach the most apical part of the root preparation and the form, an effective micromechanical bonding mechanism with demineralized dentin under laboratory conditions.

Therefore it seems that the combination of a thin microbrush and a self-activated bonding system may be a predictable procedure for bonding/luting fiber posts also under clinical conditions.

The Vectris translucent post used in this study has an endodontic shape which was designed to reduce the removal of root dentin with drills to a minimum. This type of post, like the other available on the market, has a limitation: it is not radiopaque. This is due to the fact that fibre technology does not permit to manufacturer radiopaque fibre posts without alter their mechanical properties. The Vectris post, described in this report, may be combined not only with proprietary adhesive/luting materials but also with all other adhesive materials already available on the market and indicated for luting posts.

Presence of voids/bubbles noted within resin cement in all samples may be related to different factors, such as root anatomy, the consequent variability in the amount of resin cement, the carrier used for placing the
cement into root canal and its tridimensional distribution into a root canal space and the mixing step in which air bubbles can be included.

An important factor in determining the success of luting procedures for fiber posts is the knowledge and experience of the practitioner and the predictability of the clinical technique. From a clinical point of view, the use of a self-activating bonding system in combination with a self curing resin cement resulted in easy, quick and predictable clinical procedure.

The final conclusions on the use of translucent fiber posts will depend on the results of ongoing prospective multicentre studies.

References