SEALING ABILITY AND MICROSCOPIC ASPECTS OF A SELF-ADHESIVE RESIN CEMENT USED FOR FIBER POST LUTING INTO ROOT CANALS

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Abstract

Objectives: The aim of the study was to assess the sealing ability and the bonding mechanism of a self-adhesive resin cement (RelyX Unicem, 3M ESPE) for luting fiber posts to root canal dentin.

Materials and Methods: Microleakage tests and a scanning electron microscope (SEM) evaluation of the material's ability to form a resin-dentin interdiffusion zone (RDIZ) and resin tags with adhesive lateral branches were performed. RelyX Unicem was used to lute RelyX Fibre Posts (3M ESPE), and was compared with control resin cement/fiber post combinations that included Multilink Automix cement (Ivoclar-Vivadent), Maxcem (Kerr) and Calibra (Dentsply) in combination with Prime & Bond NT. A total of 60 extracted teeth were tested. Ten samples were used for the leakage test and the other 5 of each group for SEM evaluation.

Results: Microleakage was universally observed, although leakage scores among the three groups were statistically significant (P>0.05) and significantly lower for RelyX Unicem. No resin tag formation could be observed from all specimens bonded by RelyX Unicem and Maxcem Groups. Conversely, resin tags with lateral branches were visible at the coronal and middle third of the root canals in Groups made with Prime & Bond NT and Calibra and Multilink in combination with its self-etching bonding system. In Calibra Group resin tags and lateral branches were present also at all the root levels.

Conclusions: Although the self-adhesive material did not show RDIZ as well as resin tags formation, the sealing ability of RelyX Unicem appeared adequate for being used routinely for luting fiber posts.

Introduction

Fiber posts have gained popularity over the past decade because of the improvements in their mechanical properties[3, 4] and dentin bonding technology[1, 2], resulting in predictable clinical performances[5-10].

New bonding systems and luting materials are continuously being introduced[14] for the luting of fiber posts. A self–adhesive resin cement (RelyX Unicem, 3M ESPE, Seefeld, Germany) has been developed for luting of crowns, bridges, inlays, onlays, posts. This dual-cure material does not require any tooth pretreatment or adhesive application, thus greatly simplifying the luting procedure.

A new type of translucent fiber posts has also been recently introduced (RelyX Fibre Post, 3M ESPE).

This study examined the use of RelyX Unicem for luting RelyX Fiber Posts to extracted endodontically-treated teeth. The morphology of the material bonded to root canal dentin, and its adaptation to the post were evaluated with scanning electron microscopy (SEM). The ability of the new resin cement to seal the root canal walls was also assessed with a microleakage test. Maxcem (Kerr), Multilink (IvoclarVivadent) and Calibra (Dentsply) are used as control materials.

The null hypothesis tested is that the adhesive cements do not differ significantly in their ability to seal canal walls and bond to root dentin.

Materials and Methods

Sixty anterior teeth extracted due to periodontal problems were selected for this study. Each tooth was 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, USA), 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, USA) and a resin sealer (AH-26, DeTrey, Zurich, Switzerland). The root canal of each tooth was enlarged with low-speed drills provided together with the post, and a 9 mm-deep post space was prepared.

The teeth were then randomly divided into four groups (n=15):

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Group 1: RelyX Fiber Posts (3M ESPE) were cemented with RelyX Unicem. As recommended by the manufacturer, RelyX Unicem was directly inserted into the root canal with the RelyX Unicem Aplicap Elongation Tip. After seating the RelyX Fiber Post and the removal of the excess cement, light-curing of the luting cement was performed for 40 seconds through the post with a light-curing unit (intensity 600 mW/cm2).

Group 2: RelyX Fiber Posts (3M ESPE) were luted with Multilink Automix cement. The root canal walls were treated with the self-etching bonding system Multilink Primer A and B. and the adhesive solution applied with a microbrush[12]. After the removal of the excess adhesive with paper points, the Multilink was brought into the root canal with a probe. The resin cement was applied onto the post surface and the post inserted into the root canal with a rotating motion. The fiber post was seated and the excess cement light-cured for 1-2 seconds for smooth removal using a scaler. The cement was then light cured for 20 seconds through the post, with the same light-curing unit used in Group 1.

Group 3: RelyX Fiber Posts (3M ESPE) were cemented with Maxcem (Kerr). The cartridge with its tip were placed on a dual syringe cartridge. The cement was dispensed onto the post and the post was seated vibrating slightly. The resin excess was removed with an explorer and the luting material was then light cured for 20 seconds.

Group 4: RelyX Fiber Posts (3M ESPE) were cemented with Calibra (Dentsply), and the bonding agent used was Prime & Bond NT. Tooth walls were etched with 36% phosphoric acid gel and then washed using a water syringe with an endodontic needle and dried with paper points. Primer adhesive solution was self-activated and then placed into the root canal using a microbrush and light cured for 20 seconds after its excess was removed with a paper point. The Calibra base and catalyst were mixed in similar amounts and then deposited into the root space using a lentulo drill. The post was placed into the root canal and the resin excess removed with a microbrush. The cement was then light cured through the post for 20 seconds using the same light source used in Group 1-3.

After water storage for one week at room temperature, ten specimens from each group were randomly selected for microleakage evaluation, and the rest for SEM evaluation.

Microleakage evaluation

Microleakage was evaluated along the interface between the resin cement and canal walls at the apical level of the root. Each experimental group consisted of ten samples. Each specimen was coated with nail varnish up to 3 mm from the apical foramen, and placed in a 2% methylene blue solution for 24 hours. The root was then rinsed with water and sectioned longitudinally for assessing the extent of dye penetration along the canal walls, according to the scoring system proposed by De Moor et al.[15]. When no leakage was detectable at the interface between apical gutta-percha and luting material, a 0 score was assigned. Scores of 1, 2, 3, and 4 were attributed when the leakage extended respectively for less than 0.5 mm, 0.5-1 mm, 1-2 mm, and more than 2 mm.

Evaluation of the resin dentin interdiffusion zone (RDIZ)

All of the five remaining teeth from each group was longitudinally sectioned into two halves with a slow speed diamond saw (Isomet, Buehler, Lake Bluff, NY, USA) under copious water cooling. One half was partially decalcified with a 30 second application of 32% phosphoric acid, and further deproteinized with 2% sodium hypochlorite for 120 seconds.

After thoroughly rinsing with water, the specimens are air-dried, sputter-coated with gold (Edwards Ltd, London, UK), and observed with SEM (Philips 515, Philips Co., Eindhoven, The Netherlands) at different magnifications. The continuity of RDIZ was assessed as the percentage ratio between the length of the RDIZ and the total length of the adhesive interface.

Table 1: The table reports the median values of the microleakage scores recorded for each group. The graph shows the mean rank of microleakage scores. The differences among the four groups were statistically significant (p>0.05).

Groups	Type of post	Adhesive	Resin Cement	Median
1.	RelyX Fiber Posts	-	RelyX Unicem	0.5
2.	RelyX Fiber Posts	Primer A and B	Multilink	1.5
3.	RelyX Fiber Posts	-	Maxcem	2.5
4.	RelyX Fiber Posts	Prime & Bond NT	Calibra	2

Resin tag formation

The other half of each tooth was completely decalcified in 30% HCl for 24 hours to examine resin tag and adhesive lateral branch formation. The samples were processed for SEM observation in the manner previously described.

Serial SEM micrographs at x500 magnification were taken of the canal walls at the 1-, 4.5- and 8- mm levels from the coronal aspect of the severed root. The micrographs from each level were arranged to form a montage. Each montage was subdivided into 8 "assessment units". The density and morphology of the resin tags were then graded between 0 and 3. A score of 0 was assigned where resin tags are not detectable. A score of 1 was recorded when few and short resin tags (resin plugs) were visible. A score of 2 was recorded where uniform resin tag formation without lateral branches was noted. A score of 3 was recorded when long resin tags with lateral branches were uniformly evident.

Results

Table 1 reports the median value of the microleakage scores for the four Groups of specimens. The differences in microleakage scores among the four tested groups were statistically significant ($p>0.05$).

The presence of bubbles within the resin cement layer was more evident in the Maxcem, Multilink and Calibra Groups (Figure 1a).

For the extension of RDIZ relative to the overall length of the interface, the highest ratio was recorded from the specimens prepared with Prime & Bond NT and Calibra, followed by the Multilink group. On the other hand, no resin-dentin interdiffusion zone could be detected from all specimens prepared with RelyX Unicem and Maxcem (Figure 1b).

No resin tag formation could be observed from all specimens bonded by RelyX Unicem and Maxcem Groups. Conversely, resin tags with lateral branches were visible at the coronal and middle third of the root canals in Groups made with Prime & Bond NT and Calibra and Multilink in combination with its self-etching bonding system. In the Calibra Group resin tags and lateral branches were present also at all the root levels (Table 3).

Discussion

In this study the self-adhesive resin cement RelyX Unicem was tested for its ability to seal the endodontic space when used to lute fiber posts. In particular, the quality of the seal produced by the luting material in the apical third was assessed. A similar experiment is currently being performed, aimed at evaluating microleakage at the interface between fiber posts luted with the same materials tested in this study and canal walls at the coronal third of the root.

Although it is unrealistic to expect a hermetic apical seal within root canals[15], RelyX Unicem nevertheless exhibited better sealing properties than those of resin cements that are routinely used for adhesive luting. Only a limited dye penetration was seen along the root canal walls. This may be related to the fact that when Rely X Unicem is applied under pressure, it seems it can have a better bonding to dentin[14], and placement of the post can result in a pressure application on the cement against the root canal walls.

From the SEM observations, in both Multilink and Calibra Groups, the specimens exhibited the typical features of micromechanical bonding to dentin. However, the same could not be observed for the RelyX Unicem and Maxcem specimens, as neither the hybrid layer nor resin tags could be detected (Fig. 1b). Therefore, the exact bonding mechanism for this new material still remains to be clarified.

The results of previous TEM observations of the interfaces created on dentin by the tested adhesive materials[16-18] correspond with the outcome of this SEM investigation. Prime & Bond NT, used in combination with Calibra, penetrated deeper into root dentin tubules than the other three materials. This could be related to the efficient action of phosphoric acid in dissolving the smear layer and opening up the tubules. In

Table 2: Scanning electron microscope evaluation of the resin dentin interdiffusion zone (RDIZ)

Group	Overall length of observed interface (in tenths of Ìm)	Length of interface with RDIZ (in tenths of Ìm)
1.	2850	No RDIZ formation was noted
2.	2500	1650 (65%)
3.	2350	No RDIZ formation was noted
4.	2650	2140 (80%)

Table 3: Median values of the resin tags formation scores recorded at 1-, 4.5-, and 8 mm levels.

Group	1mm level (Coronal third)	4.5 mm level (Middle third)	8 mm level (Apical third)
1.	0	0	0
2.	2	2	1
3.	0	0	0
4.	3	3	2

addition, the use of a microbrush as a carrier of the primer-adhesive solution in Calibra Group samples, as well as the self-activation of the solution, could have also contributed to enhancing dentin infiltration at the apical level that was found to be more evident in these specimens than that found using Multilink cement. In fact, only the Prime & Bond NT specimens showed better uniformly developed resin tags than the Multilink samples, particularly in the root canal third (Table 3). On the contrary, it appears that the action of the self-etching adhesive applied in combination with Multilink was less aggressive, and therefore limited to modifying the smear layer without completely removing it and without widening the tubular orifices.

Although the bonding mechanism of RelyX Unicem does not show a micromechanical bonding similar to using pretreatment of dentin, its results were better than the control cements in terms of microleakage, showing the lowest values for microleakage in all the tested cements. As a result, it can be speculated that resin tag and hybrid layer formation cannot contribute to the sealing of root canal space. Doubts about the role of resin tag and hybrid layer on bond strength to root canal dentin have been indicated[19-21] and it has been hypothesized that friction along root canal walls can play a key role. In order to elucidate this aspect, data on the bond strength of fiber posts luted with RelyX Unicem are currently been collected using the microtensile and the push-out method.

Another microscopic aspect of Maxcem, Multilink and Calibra is the presence of bubbles and voids within the cement in all of the observed specimens (Fig. 1a). It can be supposed that voids and bubbles are included within the luting materials during the mixing step and application into the root canal. An incomplete mixing of the paste/paste components or a cement viscosity unsuitable for luting inside the root canal can be responsible for the development of these defects. This aspect was minimized in the Unicem samples with appropriate mixing procedures and the use of the new delivering tip. In addition, it should be pointed out that the other resin cements were brought into the root canal with a lentulo drill (Calibra group) or with the post itself (Multilink and Maxcem). As a matter of fact, the use of a lentulo spiral is the method of cement application is still a controversial topic in the literature for post luting[22].

It should finally be pointed out that only Rely X Fiber Posts were tested in combination with all luting materials. Such a presumably favorable combination of materials was feasible with RelyX Unicem, as this cement's manufacturer has now developed its own specific fiber post system. However, in daily practice, a fiber post is often combined with different luting materials and the results of this study show the compatibility of RelyX Fiber Posts when used with different luting materials.

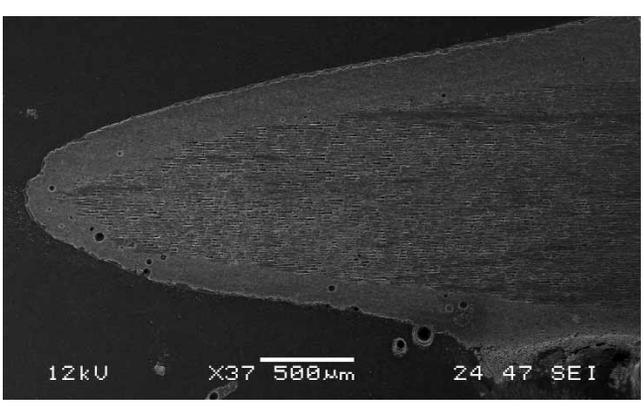

Figure 1a: SEM showing the presence of small bubbles in the luting material.

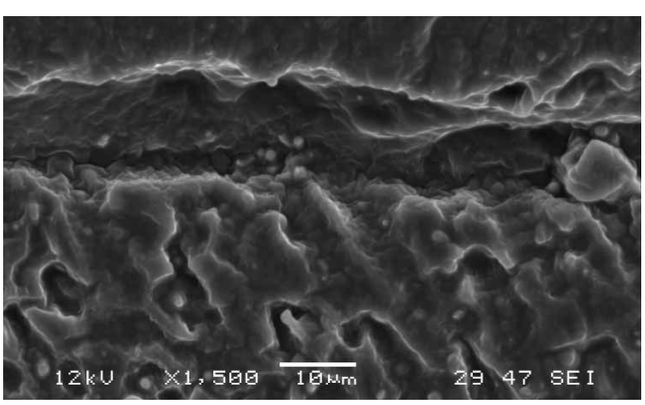

Figure 1b: SEM showing no evidence of resin tags and hybrid layer formation at the adhesive interface.

Conclusions

When used for luting fiber posts in endodontically treated roots, RelyX Unicem self-adhesive resin cement exhibited sealing properties that were better than the others. Additionally, from a morphological perspective, the RelyX Unicem presented a very low amount of bubbles and voids within the cement layer compared with the other cements. In addition, the new RelyX Unicem Aplicap Elongation Tip simplifies the complex cementation procedure in the root canal because almost no voids and bubbles were found and pretreatment of neither the tooth nor of the Rely X Fiber Post was necessary.

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