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The Effects of Water and Acetone-based Dentin Adhesives on Apical Microleakage

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Abstract

In this study, the aim was to assess the *in vitro* apical microleakage of a resin-based sealer used with two different adhesives. Thirty nine freshly extracted maxillary incisors were used. The teeth were decoronated at the cemento-enamel junction with a water-cooled fissure bur. Chemo-mechanical debridement of the root canals was accomplished with the step-back technique. The smear layer was removed by 19% ethylenediamine tetra acetic acid (EDTA). The roots were then divided into three experimental groups of thirteen teeth in each. Specimens in group 1 were filled with gutta-percha, AH Plus sealer, and water-based adhesive system (Syntac Single Component). Group 2 specimens were filled with gutta-percha, AH Plus sealer, and acetone-based dentin adhesive (Prime & Bond NT). Specimens of group 3 were filled with only gutta-percha and AH Plus sealer (no adhesive was applied). The teeth were immersed into 2% methylene blue solution. Apical sealing qualities were assessed by measuring the linear dye penetration with a stereomicroscope. Dentin tubule penetration was observed under scanning electron microscopy (SEM). Results showed no statistically significant difference between the materials used, however, the leakage in group 2 was less than group 1 and 3.

Keywords: Apical leakage, water-based adhesive, acetone-based adhesive

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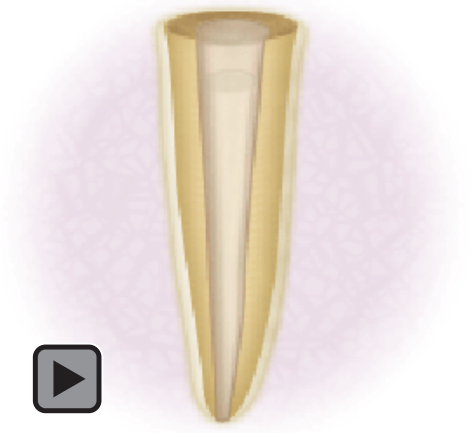
Introduction

Total obturation of the root canal system is one of the main objectives of endodontic treatment. Strindberg[1] recorded a higher proportion of failures in cases where the radiographs revealed poor adaptation and shrinkage of the root filling. Grossman[2] found the most common cause of failure in endodontically treated teeth was a poorly filled canal.



The latest generation of adhesive systems produces, by etching, demineralization of the dentin to a depth of several microns. The infiltration of hydrophilic monomers into the demineralized dentin creates a gap-free resin-collagen hybrid, the so-called hybrid layer.[3,4,5] Because a gap-free obturation of the root canal is one of the main objectives of endodontic treatment, the usage of dentin bonding systems as root canal filling materials was evaluated in several studies.[6,7] Two studies have shown by scanning electron microscopy (SEM) the characteristic hybrid layer at the resin-dentin interface of root canal fillings performed with dentin adhesives.[7,8]

The impossibility of an effective retreatment of canals filled with a resin alone and the presence of gaps between resin and dentin are among the main reasons not to use a bonding resin as an endodontic filling material itself.[7] To use laterally condensed gutta-percha with an epoxy resin based root canal sealer which has good adhesion to dentin, in combination with a dental adhesive, might have a good seal while also permitting the retreatment of canals.[9]

The purpose of this study was to evaluate the in vitro apical microleakage of fillings performed with a resin-based root canal sealer used in conjuction with water and acetone-based dentin adhesives and laterally condensed gutta-percha.

Methods and Materials

Thirty nine upper incisors with straight root canals, extracted for periodontal reasons, were selected for this study. External debris was removed with a scaler. After cutting the roots at the cemento-enamel junction with a water-cooled high speed fissure bur (Busch, Germany), the roots were stored in deionized water until the preparation of the specimens. The working length was visually established by subtracting 1 mm from the length of a size #15 file (Zipperer, Germany) when its tip appeared at the apical foramen. The teeth were then instrumented to the working length to a size #40 file. The middle and coronal thirds were enlarged using #1-3 Gates Glidden drills (Maillefer, Ballaigues, Switzerland). Irrigation with 3 ml of 2.5% NaOCl solution was performed after filing with every size throughout the cleaning and shaping of the canals. After completion of the instrumentation, 19% ethylenediamine tetra acetic acid (EDTA) (File-Eze, Ultradent, USA) was used for 1 min using a luer-lok syringe (Ultradent products) and a 27-gauge endodontic needle (Ultradent Products) in order to remove the smear layer. Canals were then flushed with 10 ml of deionized water, then dried with paper points (Roeko, Germany). The prepared teeth were randomly divided into three experimental groups with an equal number of specimens in each.

Group 1. A water-based adhesive system, Syntac Single Component (3M Dental Products, USA), was applied inside the canals with the same syringe as previously described and excess adhesive material was aspirated out with the same syringe in order to prevent a thick layer formation. They were then gently dried with paper points and polymerized for 20 sec by using a light curing unit with the diameter of 2 mm (Kerr, Germany). Resin based sealer (AH Plus Root Canal Sealer, De Trey, Germany) was prepared according to the manufacturer's instructions, and the master gutta-percha point was coated with AH Plus sealer and seated

in the canal to full working length. A finger spreader (Maillefer, Ballaigues, Switzerland) was then inserted into the canal to a level that was ~1 mm short of the working length. Lateral condensation with nonstandardized fine gutta-percha points (Diadent, Korea) was performed until the entire canal was obturated.

Group 2. An aceton-based dentin adhesive system, Prime & Bond NT (Dentsply, Germany) was applied inside the canals, dried with paper points, and then polymerized with a 2 mm tip for 20 sec by using a light curing unit. The root canal filling procedure was performed as described for the teeth in group 1.

Group 3. No adhesive system was applied and the root canal filling procedure was performed as described for the teeth in groups 1 and 2.

The access cavities of teeth in all groups were filled with Coltosol (Coltene, AG, Switzerland). The teeth were left in saline solution for 48 hours at 37°C.

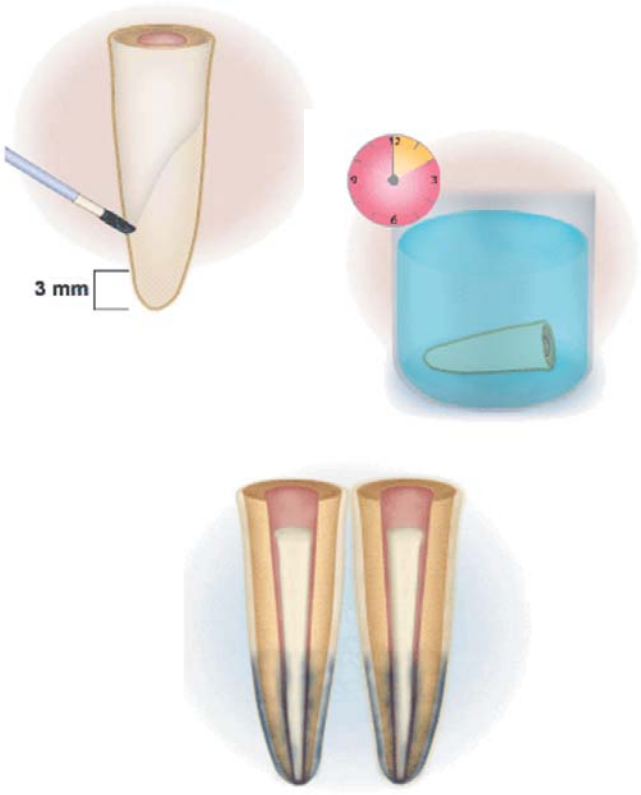
Evaluation of Microleakage by Dye Penetration

After storage, ten teeth from each group were double coated with nail polish with the exception of the apical 3 mm. Then these specimens were placed in 2% methylene blue solution (37°C, pH 7) for 48 hours. The roots were removed from the dye solution, washed, and dried with compressed air. To evaluate the depth of dye penetration, each tooth was sectioned longitudinally in a direction approximately parallel to the long axis of the tooth and through the apex. Using a millimeter grid and a stereomicroscope (Olympus SZ60, Japan) at 10x magnification, the dye penetration was measured by two different observers. The measurement was made from the apex to the point where the dye no longer penetrated the filling material, its interface with the dentinal tubules, or the dentinal tubules on both halves of each root.

Evaluation of Resin Penetration by SEM

Three specimens from each group were used for SEM examinations (Jeol, JSM-6400, Japan). Longitudinal grooves were cut at the buccal and lingual surfaces of the roots. The sections were separated from each other with a sharpened blade. The specimens were mounted on aluminum stubs and sputter-coated with gold for examinations.

The ANOVA test was used to evaluate the statistical difference between the dye penetration values of the experimental groups.



Results

All specimens demonstrated dye penetration to varying degrees. Average dye penetration results for the three experimental groups are shown in Table 1.

Group 3 (no adhesive system was applied) leaked more than the other groups (Figure 1).

The lowest dye penetration was obtained by group 2 (acetone-based dentin adhesive system - Prime & Bond NT). (Figures 2 and 3) However, no statistically significant differences were found between the experimental groups ($p>0.05$).

SEM examination revealed dentin tubule penetration was better in groups 1 and 2 than in group 3 (Figure 4).

Table 1. The statistical results of the apical leakage of tested groups.

Groups	Arithmetic Means (mm)	Standard Deviations	Sx	Min	Max
Group 1	1,286	0,731	0,276	0,300	2,000
Group 2	1,143	0,723	0,273	0,300	2,000
Group 3	1,64	0,988	0,373	0,300	2,000

Figure 1. A specimen of group 3 (control) showing dye penetration at the apex.

Figure 2. A specimen of group 2 (Prime-Bond NTI) showing less dye penetration at the apex.

Figure 3. A specimen of group 1 (Syntac Single Component) showing dye penetration at the apex.

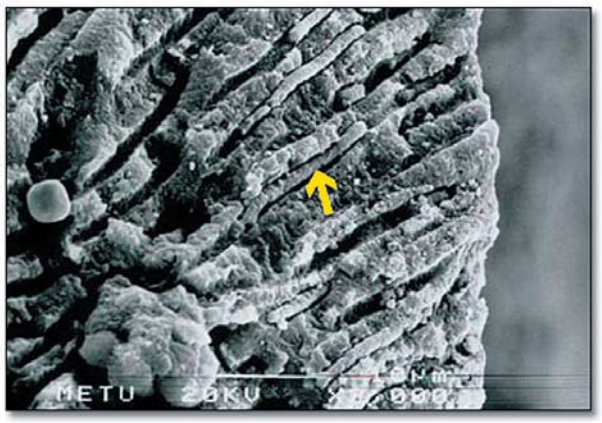


Figure 4. SEM showing the resin tags in the dentine tubules in group 2.

Discussion

The expectations from a dentin adhesive sealer/gutta-percha combination in a root canal filling is to be able to perform a tight, gap-free relation among root canal walls, dental adhesive, and gutta-percha to avoid microleakage and to maintain gutta-percha in the center of the canal. This will facilitate retreatment and post preparation. These aims can be reached only if a homogeneous distribution of the above mentioned materials can be obtained in every part of the canal. In the study of Manocci et al.[8] the use of laterally condensed gutta-percha in combination with an epoxy resin cement and two different dentin bonding agents failed to achieve this objective because with one of the adhesives (Scotchbond Multipurpose Plus) only dental adhesive remained and with the other (Allbond 2) only gutta-percha remained at the apical part of the canal.

Prime & Bond NT dissolves in acetone, which can displace water from the dentin surface and from the moist collagen network, thus promoting the infiltration of the monomers through the nano spaces of the dense collagen web and enhancing bond strengths.[10,11] The resin replaces the water of the pores among the collagen fibers. These pores could serve as diffusion channels for subsequently applied monomers, of single bottle dentin bonding systems, thus increasing the surface free energy and improving the resin impregnation of the demineralized dentin web.[12]

Syntac Single Component is an acetone and ethanol free material. It has been demonstrated the behavior of these water-based materials may be improved when the monomers are combined with acetone or when the priming time is increased.[13] In these systems, the conversion of the bonding resin and the resultant bond strengths are markedly reduced when water is added to the resin because failure to remove water could result in the dilution of water-soluble resin components.[13] While Syntac Single Component is water-based, the capillary pressure may not be sufficient for thorough penetration of the material into the moist filigree of exposed collagen fibers. These factors might explain the wide spaces within the resin-dentin area, suggesting incomplete saturation of the collagen scaffold, although there is good infiltration into the tubular openings.

In our study, both adhesives performed better than the control group (group 3). This agrees with another recent study by Manocci and Ferrari[8] in which the apical seal of roots, obturated with lateral condensation technique and dentin bonding agent, was evaluated. More leakage was seen in the control group.

In our study, adaptation of the dentin adhesive sealer/gutta-percha combination in the middle part was better then the apical and coronal parts of the roots. This is due to more lateral force applied during condensation technique. Manocci et al[8,15] have also expressed the same findings in their different studies. In the acetone-based adhesive group microleakage values were less then the other two groups. (Figure 1) However in a study performed by Perdiago et al.[14], Prime & Bond formed the shortest resin tags, whereas Syntac Single Component formed the longest resin tags. As the adhesives we have tested were single bottle type, we did not face any problems regarding the working time of dental adhesives. However, some problems encountered in a previous study[8] were also valid for our study such as the complexity of this technique which I left adhesive as a thick layer on the dentin surface. We applied the dentin adhesive with a luer-lok syringe which can reach to the apical part of the root. Excess adhesive was aspirated out with the same syringe. During this procedure it was almost impossible to aspirate out the entire amount of material. As the resin is viscous, a thick layer was formed in the apical part and it was not possible to obtain a homogenous layer on the dentin surface (Figure 5).

Therefore, the polymerization of material in the apical region is doubtful. In a similar study by Perdigao[14], empty spaces were also observed within the resin-dentin interdiffusion area when Syntac Single Component was used.

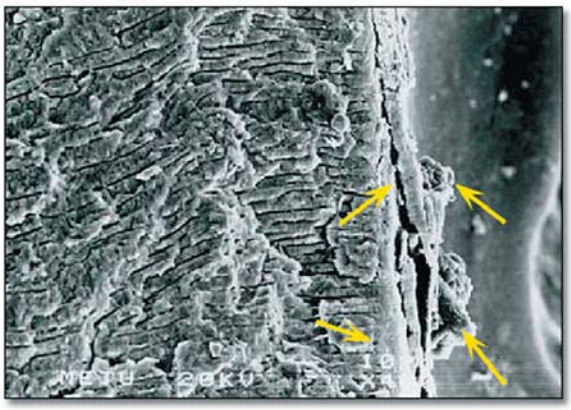


Figure 5. SEM showing the non-homogeneous layer in group 1.

Conclusion

Further studies are needed to develop simplified techniques for the use of dental adhesives in endodontics to determine the bond strengths of dentin bonding agents applied to root canal walls and to evaluate both the possibility of retreating canals filled using this technique.

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