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Original

Evaluation of microleakage following application of a dentin bonding agent as root canal sealer in the presence or absence of smear layer

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Abstract: The aim of this study was to compare the apical leakage of roots obturated with gutta-percha using either an epoxy resin sealer (AH26) or a dual cure dentin binding agent (Excite DSC) as sealer in the presence or absence of smear layer with fluid filtration method. The canals of eighty-six, single-rooted premolars were instrumented until a #40 K-file fit at working length and then randomly divided into four groups (n = 20) with the remaining six used as controls. Groups 1 and 2 were filled with gutta-percha using AH26 as sealer; groups 3 and 4 were filled with gutta-percha and Excite DSC as sealer. Groups 1 and 3 were smear layer-positive, while group 2 and 4 were designated as smear layer-negative. After 3 days and 3 months, the samples were connected to a fluid filtration system. Analysis of data with the paired t-test showed that microleakage in AH26 groups (with and without smear layer) decreased significantly at 3 months compared to 3 days; however, in the DBA groups, the amount of microleakage at 3 days and 3 months was not significantly different. According to the results of this study, DBA (Excite DSC) had better apical sealing ability and could be applied clinically. (J Oral Sci 51, 207-213, 2009)

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Introduction

Microleakage, whether apical or coronal, is a clinical problem which may cause failure of endodontic therapy (1,2). Therefore, an endodontic sealer should have good sealing ability (3) and firmly adhere to both dentin and gutta-percha. This is important in both static and dynamic situations, because it eliminates any space that allows penetration of fluid between the filling and the wall, and resists dislodgment of fillings during subsequent manipulations (4).

As described by McComb and Smith, the smear layer is a combination of organic and inorganic debris present on the root canal wall after instrumentation (5). Its presence may act as a path for the ingress and growth of bacteria (6). If filling materials leak out of the root canal and the smear layer is not removed, it may be eliminated by bacterial byproducts such as acids and enzymes or it may slowly disintegrate and dissolve (7). Considering the technical aspect, the smear layer may interfere with the adhesion and penetration of root canal sealers into dentinal tubules. Many studies have reported reduction of apical leakage after removal of the smear layer (8).

Epoxy-resin based sealers (AH26) are characterized by a reactive epoxide ring and are polymerized by the breaking of this ring (9).

According to Tidmarsh (10) and Goldman et al. (11), adhesive systems can be used in endodontics for two purposes: as a root canal filling material and as a luting agent for posts in combination with a proper resin cement. However, Rowlinsin has contraindicated the use of resins as obturation materials because the method of delivery into the canal is different and unpredictable and retreatment of the canal is impossible. Furthermore, most of the conventional bonding systems require light polymerization, which is not practical in root canal systems (12). Using advanced resin systems as sealers in conjunction with gutta-percha may limit these problems, and at the same time, increase sealing ability.

Excite® DSC (Ivoclar Vivadent AG, Liechtenstein) is a dual-curing adhesive for enamel and dentin and contains HEMA, dimethacrylates, phosphonic acid acrylate, highly dispersed silicon dioxide, initiators and stabilizers in an alcohol solution. It is a single-component adhesive offered in a single-dose vessel. Its applicators are available in two different sizes: regular (green) for cavities, crown preparations etc.; and small/endo (blue) for root canals and micropreparations.

This product involves a dual curing system that includes self-polymerizing initiators placed on the brush and light-curable initiators in the bottle liquid, producing both auto- and photo-polymerization when mixed and thus ensuring improved polymerization in areas where light penetration proves to be difficult. In the root canal, it was frequently used as a luting agent for posts. To the best of our knowledge, there is little information about the application of this new material as root canal sealer in conjunction with gutta-percha.

Leakage along root fillings may increase or decrease with time. Dissolution of the sealer may increase leakage (13), whereas swelling of gutta-percha may decrease leakage (14) in the root canal. Physical and chemical properties of the sealer, such as the thickness of the sealer layer, may also play an important role in sealing of the root canal (15) because 50% of the root canal surface is covered by sealer after lateral condensation of gutta-percha (16).

In 1986, Derkson described an *in vitro* system for measuring the sealing ability of the dentin-pulp complex before and after obturation with different materials (17). In this method, the permeability is measured by the amount of fluid that comes through the area studied per unit time. This experimental system has been applied in endodontics.

This investigation compared the apical leakage of roots obturated with gutta-percha using either an epoxy resin sealer (AH26) or a dual cure dentin binding agent (Excite DSC) as sealer in the presence or absence of smear layer with fluid filtration method.

Materials and Methods

Sample preparation

Eighty-six single-rooted lower premolars were obtained for the study. Any excess calculus and soft tissue was removed with scalers. All roots were cross-sectioned at the CEJ (cemento-enamel junction) with a carborundum disk (Brasseler USA, Savannah, GA) except three roots that served as negative controls. A #10 K-file (Dentsply Maillefer, Ballaigues, Switzerland) was placed in the canal until visible at the apex and pulled back 1 mm to determine the working length. Instrumentation of all teeth was performed using Ni-Ti rotary files (FKG, EasyRace, La Chaux-de-Fonds, Switzerland) size #40 0.10 taper, size #35 0.08 taper, and size #25 0.06 taper in a crown-down sequence until a #40 K-file was fit at working length. Irrigation was performed using 1 ml of 5.25% NaOCl between each file. A #15 file was used to maintain a patent apex. On completion of instrumentation, the specimens were randomly divided into four groups of 20 each with the remaining three used as positive controls:

In groups 1 and 3, the canal was finally irrigated with 5 ml normal saline only. These groups were designated as smear layer not removed. In groups 2 and 4, the smear layer was removed with 1 ml 17% EDTA (ARIADENT, Asia Chemi Teb, Tehran, Iran) for 1 min, followed by 3 ml of 5.25% NaOCl and the canals were finally flushed with 5 ml normal saline (Table 1). The root canals were completely dried with paper points before obturation. Groups 1 and 2 were filled with gutta-percha using AH26 (Dentsply, DeTrey, Konstanz, Germany) as a sealer cement with the lateral condensation technique according to the manufacturer's instructions. Groups 3 and 4 were filled with gutta-percha and Excite DSC (Ivoclar Vivadent AG, Liechtenstein) as sealer by lateral condensation technique (Table 1). As previously mentioned, Excite DSC is a dual-curing dentin bonding agent and its small applicator (blue)

Table 1 Description of the groups

groups	Final irrigation	Smear layer	Sealer
G_1	Normal Saline	+	AH_{26}
G_2	EDTA, NaOCl, Normal Saline	-	AH_{26}
G_3	Normal Saline	+	Excite DSC
G_4	EDTA, NaOCl, Normal Saline	-	Excite DSC

was used in the root canals of these groups. According to the manufacturer's instructions, the root canal was etched by 37% phosphoric acid gel for 10 – 15 s, washed vigorously with water and dried with paper points before applying the applicator.

In all groups, the coronal seal was achieved by 2 – 3 mm of Cavit (Premier Dental, King of Prussia, PA, USA). Canals in the positive control group were not filled. To allow the material to set, all roots were stored at 100% humidity and 37°C for the next 72 h.

Measurement of microleakage

This system is based on the evaluation of fluid transport in the specimen, calculated from the bubble movement. It is necessary to apply pressure to the fluid to move through the specimen and move the bubble. Therefore, an oxygen tank equipped with a manometer (for precise adjustment of pressure) was used. A specific plastic tube was connected to the oxygen source and the end part was connected to an erlen. Two holes were made on the lid, one for oxygen input and the other for emersion of fluid (Fig. 1a). The other side of this cylinder was connected to a micropipette (0.1 cc) by a plastic tube. This micropipette was fixed on a vertical plate and its other side was connected to a three-valve tube by a latex pipe 0.5 cm in diameter and approximately 2 cm in length. The three-valve tube was equipped with a bilateral control faucet; when the faucet was turned, only two directions were connected (Fig. 1b).

The upper side of the three-valve tube was connected to a syringe, which was used to create an air bubble through the micropipette (Fig. 1b). Its lower side was the connection side for the specimens discussed above. All of the connections of this system were smeared with cyanoacrylate glue (Inter Lock, Japan) and covered by multiple layers of Parafilm strips (Parafilm "M"; Laboratory Film, Chicago, IL). This strip seals the connections in experimental tubes and ensures an impervious connection.

This system had two parts:

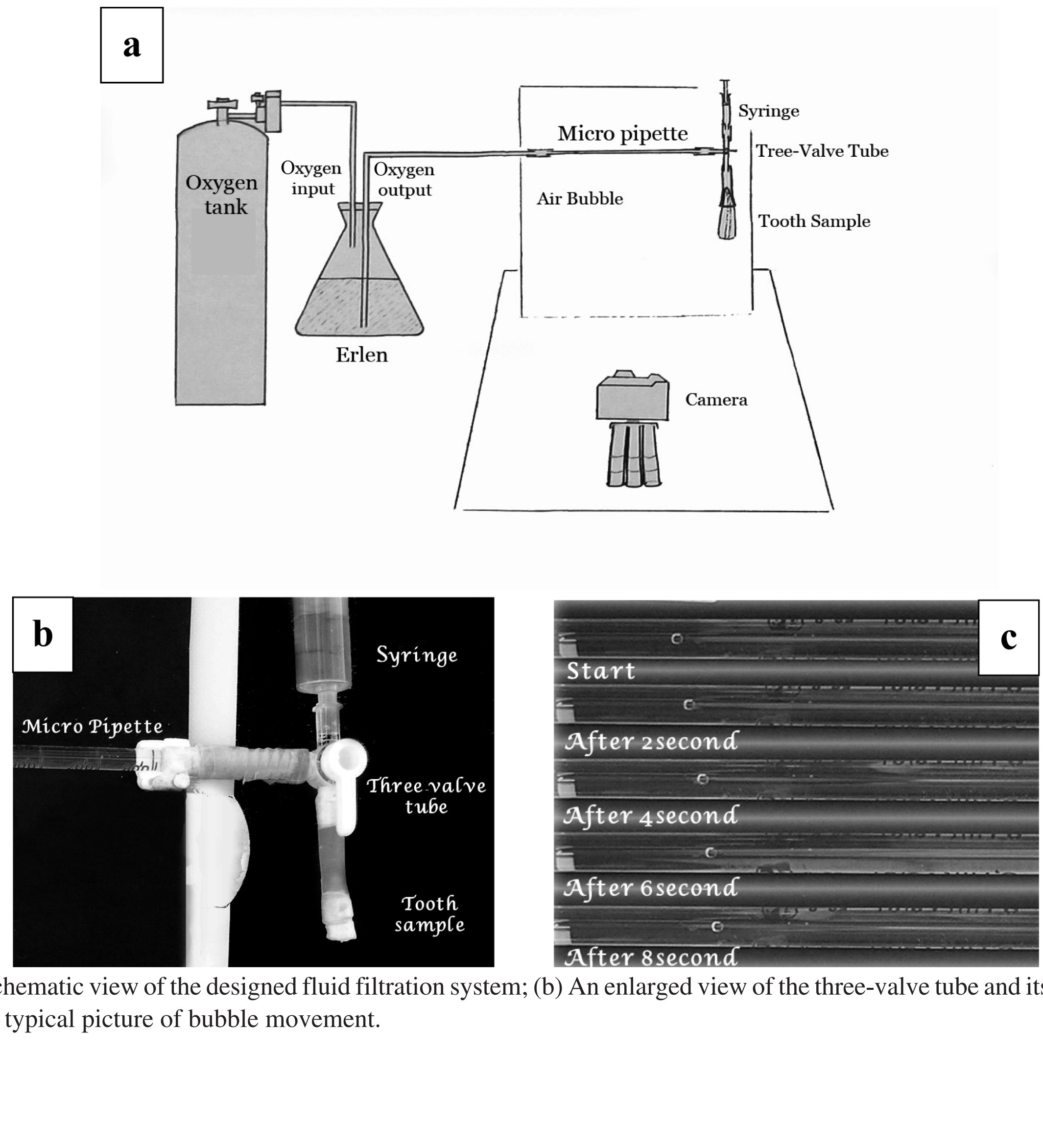

Fig. 1 (a) Schematic view of the designed fluid filtration system; (b) An enlarged view of the three-valve tube and its connections; (c) A typical picture of bubble movement.

Part 1: tubes, micropipette, pipes and tooth sample that transfer pressure to the specimen.

Part 2: recorder of fluid transport. We used a digital camera (C765, 5 megapixel; Olympus, Tokyo, Japan) and professional software (AutoCAD, 2006, Autodesk, Inc) in this system to record and measure the amount of bubble displacement.

The apical end of the root (excluding apical foramen) was covered by cyanoacrylate glue and inserted in a latex pipe (Guihua Co., Zhangdian, China) with a 0.5-cm internal diameter and 5-cm length. The free end of the pipe was connected to the only free end of the three-valve tube (the lower end). This junction was sealed completely by a Parafilm strip. We used the syringe to insert an appropriate air bubble to the micropipette. The sample was then ready for the experiment. Its relevant number was written near the micropipette. The camera was adjusted in the macrograph to take a precise picture from a short distance. The control faucet was opened to the tooth and the syringe was removed from the pass. Now only the tooth and the fluid filtration system were connected. The major faucet of the oxygen tank was then opened. The pressure was previously adjusted, since it should be constant during all steps of the experiments. We waited 30 s to attain a balance in the system, and then the first picture of the bubble position in the micropipette was taken. Four subsequent pictures were taken at 2-min intervals (2, 4, 6 and 8 min after the first picture) (Fig. 1c). The same steps were repeated for the next samples. The samples were then returned to their storage box for the next 3 months, after which the same steps were repeated for all of them. All pictures of the samples (5 for each tooth) were transferred to the computer. The bubble position in each picture was determined by professional software (Auto CAD 2006). These numbers (5 numbers for each sample) were introduced to custom-made software designed for performing the calculation. This software calculates the mean displacement of the bubble per minute and then with a specific quotient converts the longitudinal displacement of the bubble into the volume of fluid passing from the samples, showing it as µl/min/cm H_2O. As a result, we had one number for each sample that represented the amount of leakage in its canal as µl/min/cm H_2O.

Results

The mean microleakage in µl/min/cm H_2O is presented in Table 2. The preliminary analysis with the Kolmogrof-Smirnov test confirmed normal distribution of the data. In the first evaluation of microleakage (3 days after obturation), analysis of results with the Student's *t*-test showed that:

Group 1 (AH26 with smear layer) had significantly more leakage than group 3 (DBA with smear layer) ($P < 0.05$) (Fig. 2a); however, in the groups without smear layer (groups 2 and 4) the difference in microleakage was not significant ($P < 0.05$). There was significantly less leakage in group 1 compared to group 2 ($P < 0.05$) (Fig. 2b), but there was no significant difference between group 3 and 4 ($P < 0.05$) (Fig. 2c).

In the second evaluation of microleakage (3 months after obturation):

Analysis showed that there were no significant differences between groups 1 and 3 (smear layer-positive groups) (Fig. 2a) and groups 2 and 4 (smear layer-negative groups). Also, the same results were observed between groups 1 and 2 (AH26 groups) (Fig. 2b) and 3 and 4 (DBA groups) (Fig. 2c). Analysis of data with the paired t-test showed that the microleakage in group 1 (AH26 with smear layer) decreased significantly at 3 months compared to 3 days (Fig. 2d); however, in groups 2 (AH26 without smear layer) (Fig. 2d), 3 and 4 (DBA with and without smear layer) the amount of microleakage at 3 days and 3 months was not significantly different.

Discussion

Methods that have been used to measure leakage around filling materials include bacterial penetration, dye penetration, radioisotopes, light microscopic methods or SEM. These methods have some disadvantages, the most important one being their qualitative, rather than quantitative information – they can reveal the presence or absence of leakage, but not the amount (18). The use of fluid filtration systems has been recommended to enhance reliability,

Table 2 The mean microleakage of four groups in two periods of time (µl/min/cm H_2O)

		3 days after obturation (FT)		3 months after obturation (ST)	
Sub groups	N	Mean	Std. Deviation	Mean	Std. Deviation
G1	20	0.01852	0.01257	0.00108	0.00124
G2	20	0.00375	0.00209	0.00184	0.00254
G3	20	0.00202	0.00072	0.00150	0.00084
G4	20	0.00257	0.00159	0.00188	0.00100

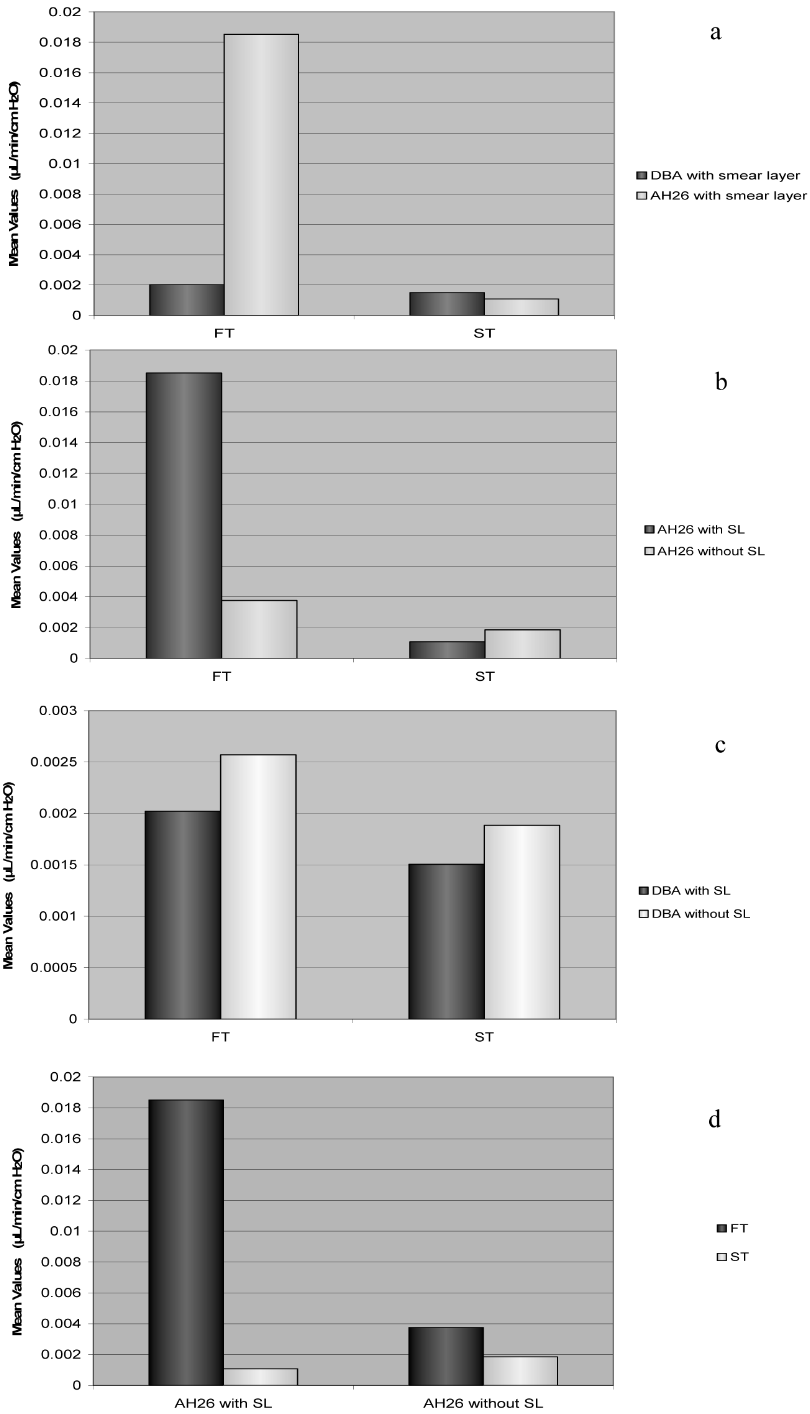

Fig. 2 Mean microleakage in different groups in μl/min/cm H_2O.
(a) Comparison between group 1 and group 3 at first time (FT) and second time (ST). At FT, group1 had more leakage than group 3 ($P < 0.05$), but at ST the difference between the two groups was not significant.
(b) Comparison between groups 1 and 2 in FT and ST. At FT, group 1 had more leakage than group 2 ($P < 0.05$), but at ST the difference between two groups was not significant.
(c) Comparison between groups 3 and 4 in FT and ST. At both times, the difference between the two groups was not significant.
(d) Comparison between FT and ST in group 1 and group 2. In group 1, the mean microleakage in FT was significantly more than ST, but in group 2 the difference between FT and ST was not significant.

reproducibility and comparability (18). In several studies, the change of leakage values with increasing period of time showed that longitudinal leakage studies are important in determining leakage values of materials.

This study evaluated the sealing ability of a dentin bonding agent (Excite DSC) used as root canal sealer and compared it with a common resin-based root canal sealer (AH26). Excite DSC is a dual-curing dentin bonding agent and has a small applicator that facilitates its application in the root canals. According to the manufacturer, Excite DSC may be used on slightly moist canals because of its hydrophilic properties. As it is not possible to obtain a completely dry surface within the root canal, this characteristic may be advantageous for the sealer. In several studies, different dentin bonding agents have been used as root canal sealers and their sealing abilities have been compared with common sealers. However, all bonding agent studies have had problems in working properties, radiopacity, and lack of removability when used for endodontic purposes (12,19-21). This was expected because the materials studied were not manufactured with the intention of using them within the root canal system (22).

In the comparison between one type of DBA as sealer and a ZOE-based sealer with Thermafill method of obturation, the sealing ability of ZOE sealer proved to be better (23). Also, AH Plus (an epoxy resin sealer) exhibited less leakage than Panavia F (a DBA) with dye penetration method (24), whereas Scotchbond (another type of DBA) had better sealing properties than Tubliseal (19). Researchers indicated that the use of Panavia F is contraindicated as root canal sealer. The disparity in results could possibly be explained by the differences in the materials and methods, such as obturation method, the method for measuring leakage, or the type of DBA.

No difference in the sealing ability of DBA in the first and second evaluation was detected in this study, whereas AH26 had less leakage after 3 months. Some studies have shown polymerization shrinkage of resin materials after setting (25,26). This undesirable property may be responsible for high leakage on first evaluation; however, the hygroscopic expansion due to immersion of the materials in water or saline may cause significant reduction in the dimension of marginal gaps. This may explain why higher leakage values have been observed after setting and the absorption of water by the materials over the following time periods expanded the materials slightly, increasing the sealing integrity (18). In this study, the presence or absence of smear layer had no effect on the sealing ability of DBA. Britto et al. reported similar results with Panavia F (24). In concurrence with previous studies, in this study, removal of smeared layer increased the sealing ability of AH26 (8,27-29). According to the results of this study, DBA (Excite DSC) had better apical sealing ability and could be applied clinically as well. However, further studies using different sealers and techniques are warranted before Excite DSC can be recommended for clinical application.

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