Original Article

Apical Microleakage Assessment of Calcium Silicate-based and Resin-based Sealers by Fluid Filtration Technique

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Abstract

Introduction: The quality of root canal treatment depends on the sealing ability of root canal obturation materials. Sealers help create an impenetrable seal. This study aimed to compare the sealing ability of AH Plus and Sure-Seal Root sealers by the fluid filtration technique. **Methods:** This in-vitro study evaluated 80 extracted human mandibular second premolars. After initial preparation, the teeth were randomly divided into two experimental groups (n=35) and positive and negative control groups (n=5). The experimental groups were obturated with AH Plus sealer and Sure-Seal Root sealer. The AH Plus and the Sure-Seal Root groups were obturated with the lateral condensation technique and the single-cone technique, respectively. Apical leakage was assessed at two intervals of 1 week and 3 months, evaluated by the fluid filtration technique, and compared between the two groups using Student's t-test. **Results:** No significant differences were observed between the two groups in 7 days. However, after 90 days, the AH Plus group exhibited significantly less leakage than the Sure-Seal Root group. The microleakage of AH Plus decreased over time ($P<0.05$). **Conclusion:** In this study, AH Plus exhibited significantly better sealing ability than Sure-Seal Root in the long term.

Keywords: AH Plus; Apical microleakage; Fluid filtration; Sure-Seal Root

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Introduction

The ultimate goal of root canal filling is three-dimensional sealing of the root canal system and inhibition of leakage and proliferation of microorganisms in the root canal system and periapical region (1). Root canal sealers are necessarily required to seal the gap between the root dentinal walls and the root filling material. Sealers also fill the gaps and irregularities in the root canal wall, obstruct the accessory canals, and fill the voids and gaps between gutta-percha cones in the lateral compaction technique (2, 3).

AH Plus sealer (Dentsply, DeTrey, Konstanz, Germany) is an epoxy resin-based sealer and has been commonly used as a gold standard endodontic sealer due to its optimal flow, bond strength to dentinal walls, dimensional stability, low solubility, and adequate working time (4, 5). Sure-Seal Root is a new bioceramic sealer with an easy application for permanent root canal filling. Sure-Seal Root (Sure Dent Crop., Gyenggi-do, Republic of Korea) is a calcium silicate-based sealer that requires water for polymerization. It does not shrink during polymerization and has favorable physical properties. In addition to calcium silicate, it contains calcium sodium phosphosilicate and zirconium oxide. However, it does not contain resin or eugenol and is supplied in the form of injectable pastes with the optimal flow (6).

Lateral compaction technique is the most popular obturation technique in endodontic clinics. Simplicity, affordability, predictability, and controlled application of filling material are among the advantages of this technique (5).

The matched single-cone obturation technique using a single gutta-percha cone with the optimal taper is the most recent and popular obturation technique after the root canals' rotary instrumentation. This technique saves time, compared to the lateral compaction technique, when the root canal is enlarged with rotary instruments. However, it can also lead to void formation in irregular canal spaces (7-12).

Since bioceramics lack polymerization shrinkage and have approximately 0.002% expansion, the single-cone technique has been widely suggested in the literature (9, 13, 14).

Microleakage due to impaired apical seal is a common cause of endodontic treatment failures (9, 15). Currently, the fluid filtration technique is commonly used to evaluate the apical sealing ability of root canal sealers because this technique allows quantitative measurements to be repeatedly made over time without the root specimen destruction (2, 16-18). Furthermore, the sensitivity of the fluid filtration technique can be adjusted by altering the pressure used (17).

Therefore, because of the importance of microleakage over time, this study aimed to evaluate the apical sealing ability of a bioceramic (Sure-Seal Root) sealer and an epoxy resin-based sealer (AH Plus) at 7 days and 90 days using the fluid filtration technique.

Materials and Methods

This study was approved by the Ethics Committee of Qazvin University of Medical Sciences and there is no conflict with ethical considerations (IR.QUMS.REC.1398.026). A total of 80 single-rooted, single-canal extracted human mandibular second premolars were collected. The teeth were extracted due to periodontal disease, orthodontic treatment, or severe caries. Teeth with fractures, cracks, congenital anomalies, root curvatures, open apices, or calcified canals were excluded.

The teeth were immersed in a 5.25% sodium hypochlorite solution for 2 hours and cleaned with a Gracey curette (9). The teeth were then stored in chloramine-T solution (Merck, Darmstadt, Germany) until the experiment (19). The crowns were cut below the cementoenamel junction using a high-speed handpiece and a diamond disc (D&Z, Germany) so that 15 mm of root length remained (20). All the roots were measured with a digital caliper. Patency was ensured in all the roots using a #10 stainless steel hand file (Dentsply Maillefer, Ballaigues, Switzerland). The canal length was then measured from the cut cross-section to the apex using a #10 K-file. The working length was determined at 0.5 mm short of the measured length. All the root canals were prepared to the working length using a ProTaper universal rotary file system (Dentsply Maillefer, Ballaigues, Switzerland) up to F3 size. All the root canals were rinsed with 2 ml of 2.5% sodium hypochlorite (9) between two consecutive files and at the end of the cleaning procedure to prevent debris accumulation. For smear layer removal, the root canals were rinsed with 2 ml of 0.17% ethylenediaminetetraacetic acid (EDTA) (META-Biomed Co., Republic of Korea) (9) for 1 min, followed by 5% hypochlorite solution and a final rinse with 5 ml of 2.5% saline solution (DarouPakhsh, Tehran, Iran). The root canals were dried with paper points (Dia Dent, Cheongju-si, Republic of Korea). The teeth were randomly divided into four groups, consisting of two experimental groups (n=35) and two control groups as follows:

Group 1: The root canals were filled with ISO #30 of gutta-percha (Dia Dent, Cheongju-si, Republic of Korea) and AH Plus sealer (Dentsply Maillefer, Konstanz, Germany) using the lateral compaction technique.

Group 2: The root canals were filled with a bioceramic sealer (Sure-Seal Root, Suredent, Republic of Korea) and gutta-percha F3 size (Meta Biomed, Cheongju, Republic of Korea) using the matched single-cone technique. The needle of the Sure-Seal Root sealer was then introduced into the canal to the coronal third, and the sealer was injected according to the manufacturer's instructions. Subsequently, the master cone was gently introduced into the canal (to prevent void formation) to reach the working length. The remaining root filling material was packed by a plugger.

Group 3 (positive control): The root canals were obturated using the lateral condensation technique of gutta-percha without using any sealer.

Group 4 (negative control): The root canals were filled with gutta-percha as in groups 1 and 2 and the apical end of each root was covered with two layers of nail varnish.

All roots were incubated at 37°C and 99% humidity for 1 week.

Preparation of root canals for the fluid filtration test

The external surfaces of all roots in groups 1 and 2 were coated with two layers of nail varnish, except for the apical 1 mm. The coronal cavity was covered with light-cured glass-ionomer cement (GC Corporation, Tokyo, Japan). In the negative control group, the entire external surface, even the apical end, was coated with two layers of nail varnish. However, in the positive control group, the external apical and coronal surfaces were not coated with any material.

In the next step, Tygon tubes with an internal diameter of 0.5 cm and an approximate length of 3 cm were connected to the apex of the roots and fixed with cyanoacrylate glue to prevent any leakage in this part. The other end of the Tygon tube was connected to the fluid filtration apparatus. A nitrogen tank with a 0.5-bar (50,000 Pa) pressure was connected to the apparatus to compress the liquid column (50,000 Pa).

To assess microleakage, the Tygon tube connected to the apex was also connected to a pipette with a 0.001-ml accuracy. The other end of the pipette was connected to a hose that was connected to the nitrogen tank. The pipette was filled with distilled water containing 0.01 ml of fuchsine dye (for better visibility of the liquid column). The faucet was opened to release the pressure; 8-minutes of time was allowed for the liquid column movement. Any changes in the liquid level in the pipette indicated the magnitude of leakage and were recorded in microliters (µl). The measured value was then divided by 8 min to determine the magnitude of microleakage per minute in microliters. The longitudinal movement of the liquid column was converted into the volume of fluid passing from the samples, shown as µl/min/cm H_2O. Thus, the number of each sample represented the amount of leakage in the canal (µl/min/cm H_2O).

Data were analyzed in SPSS 23 (SPSS Inc., Chicago, III., USA) using independent t-test for comparison between two groups in each separate period and paired t-tests for comparison between 7 and 90 days ($P<0.05$).

Results

The negative control group exhibited no fluid column movement in the model, indicating zero leakage. In the positive control group, the considerable displacement of the fluid column revealed microleakage within 8 min.

The amount of microleakage at 1 week was obtained at 0.32±0.11 and 0.29±0.1 µl/min/cm H_2O in Sure-Seal Root and AH Plus groups, respectively. Inndependent t-test showed no significant difference in microleakage between the two groups at 1 week (P=0.35) (Table I).

Table I. Mean microleakage in AH Plus and Sure-Seal Root groups at 1 week

Variable	Mean	Std. deviation	Minimum microleakage	Maximum microleakage	P-value
AH Plus	0.29	0.1	0.12	0.56	0.35
Sure-Seal Root	0.32	0.11	0.12	0.56	

The microleakage at 3 months was higher in the Sure-Seal Root group than in the AH Plus group. Mean leakage was estimated at 0.25 and 0.31 µl/min/cm H_2O in the AH Plus and Sure-Seal Root groups, respectively. According to the independent t-test, microleakage was significantly different between the two groups at 90 days, and AH Plus exhibited lower microleakage than Sure-Seal Root at 90 days (Table II).

Table II. Mean microleakage in AH Plus and Sure-Seal Root groups at 3 months

Variable	Mean	Std. deviation	Minimum microleakage	Maximum microleakage	P-value
AH Plus	0.25	0.11	0.06	0.5	0.02
Sure-Seal Root	0.31	0.12	0.12	0.56	

Microleakage in the Sure-Seal Root group was not significantly different in 7 and 90 days (P=0.9). Microleakage in the AH Plus was significantly lower at 90 days (P=0.04).

Discussion

The success of endodontic treatment depends on the effective eradication of microorganisms from the root canal system; however, a complete removal is not always possible (1, 2). Proper sealing is required to prevent microorganisms from entering the root canal system from the oral cavity (21). Sealers are used as lubricants during obturation to fill the space between the dentin wall and the filler, as well as filling the irregularities and voids of the root and lateral canals (21).

The AH Plus sealer belongs to epoxy-resin sealers and is widely used to treat the root canal due to its appropriate sealing properties, low solubility, and good adhesion (22, 23). Sure-Seal Root is also a novel bioceramic sealer with an increasing usage because of its relatively high speed of canal filling (due to using the single-cone filling technique), ease of applicability by the operator, and appropriate properties of sealing.

There are different methods to measure the amount of microleakage, including dye penetration, bacterial microleakage, liquid seepage (4), and marginal matching (6). In the present study, the liquid seepage method was used to investigate the amount of microleakage because it is not associated with tooth destruction and provides the possibility for reassessments over time. Additionally, in this method, there is no need to use special markers, which obviates subsequent marker-related problems. Moreover, this method not only possesses a high accuracy, but can also detect even negligible leakage (7, 24). It also lacks the disadvantages of other methods, such as the small size of dye (the dye penetration method) (9), isotopes (the radioisotope method) (6) respective to bacteria, and the antimicrobial effects of the agent on bacteria (in the bacterial microleakage method) (10). Above all, the liquid seepage method is simply and easily applicable, compared to other methods that generally have a complicated process.

This study aimed to compare the apical sealing features of two types of sealants, namely Sure-Seal Root and AH Plus, by measuring their microleakage via the liquid seepage method. Based on the results, no significant difference was observed between Sure-Seal Root and AH Plus sealants during the first week, as evidenced by the liquid seepage method. After 1 month, however, the AH Plus sealant delivered significantly less microleakage, compared to Sure-Seal Root, indicating its superiority over time. The better matching properties of epoxy resin sealants, such as AH Plus, can be due to their capability of covalently binding with the exposed amine group of the collagen, conferring these sealants a stronger adhesion to the dentin (25).

Due to its weak acidity, the AH Plus sealer has the ability to etch the dentin surface, further exposing collagens and resulting in a more effective attachment to the dentin (26).

Remy et al. (27) compared the marginal matching of three sealers, including MTA-Fillapex (bioceramic), AH Plus, and Endofill, and showed that the highest marginal matching capacity belonged to AH Plus, followed by Endofill and MTA-Fillapex in descending order. In the present study, no significant difference was observed in microleakage from the Sure-Seal Root sealer between the first week and the first month. The reasons for lower microleakage in the AH Plus sealer than in the Sure-Seal Root can be attributed to its better marginal matching, higher tubular penetration, and weak acidity (28, 29).

In another study, Arikatla et al. (30) compared the tubular penetration of the AH Plus, Bioroot RCS, and MTA Plus sealers using confocal laser scanning microscopy and the lateral compaction technique, the results of which revealed a significantly higher tubular penetration in the AH Plus vs. bioceramic sealer. These findings show the possible role of tubular penetration in the better sealing ability of root canal sealers.

Although hydrophilic sealers, including bioceramic types, such as Sure-Seal, have the ability to expand, and this feature can boost their sealing performance over time (31), the use of EDTA during their application can change dentin surface energy, prominently compromising the wetting and bonding capacities of hydrophilic sealers, such as Sure-Seal Root, justifying the lower sealing function of this sealer observed in the present study (28, 29).

In general, various factors affect the sealing capability of sealers, including tubular penetration, void formation, and marginal matching, as well as the hydrophilicity of sealers. In a study by Abdullah et al., the tubular penetration of the Sure-Seal sealer was reported to be higher, compared to that of AH Plus (32). Furthermore, Akcay et al. (33) and Toursavadkohi et al. (34) reported that bioceramic sealers, such as iRoot SP and Sure-Seal, had higher tubular penetration than resin-based sealers, including AH Plus and AH26. This phenomenon can be attributed to the small particle size, high flow rate, low film thickness, and high viscosity of bioceramic sealers (35, 36).

In the present study, a bioceramic sealer (i.e., Sure-Seal) was used employing the single-cone technique. In addition, differences in the filling techniques can explain the differences observed between our results and those of the aforementioned studies (32-34).

According to the findings of a study by Toursavadkohi et al. (34), the tubular penetration of the Sure-Seal sealer was higher, in comparison to that of AH26 (i.e., an epoxy-resin sealer) at the 3-mm and 6-mm levels from the anatomical apex (applying the lateral compression method), which may be due to the lower film thickness of this sealer (37). In the present research, the Sure-Seal sealer was employed utilizing the single cone technique; nevertheless, the AH Plus sealer (a resin sealer) was implemented by the lateral compaction technique; therefore, the differences in the filling techniques may also explain different outcomes. Haung et al. (6) investigated and compared the void formation associated with different sealers, such as Total Bioceramic Sealer, Sure-Seal Root, and AH Plus, using the micro-computed tomography (CT) and nano-CT methods. These researchers used the single-cone filling technique and reported that the Sure-Seal Root sealer formed smaller voids than AH Plus at all root surfaces, which was inconsistent with our results. This discrepancy may be justified by different canal filling techniques employing the AH Plus sealer (in the present study, this sealer was employed along with the lateral compression technique) (6). Al-Hadlaq et al. (38) assessed the coronal sealing ability and measured microleakage by the dye penetration method. They showed that the single-cone method had more microleakage than the lateral compression method, which could be due to the more gutta-percha used in the canal and less volume of the sealer in the lateral compression technique (39). These findings highlight the role of the canal filling technique in determining the sealing capability of sealers. Mohamed El Sayed et al. (40) also compared the one-week microleakage rates of two types of sealers (i.e., EndoSequence and AH Plus) using the dye penetration method. In the recent study, the EndoSequence sealer was filled by the single-cone technique, while the AH Plus group was filled by the lateral compression method. The results showed higher microleakage in the EndoSequence than in the AH Plus sealer, which was consistent with our observation despite the fact that different microleakage assessment methods and sealers (i.e., a bioceramic sealer in our study) were utilized in the two studies. In another study, Altan et al. (41) compared the 24-hour and 180-day microleakage rates of the AH26 and MTA-fillapex sealers and reported a higher 24-hour microleakage rate in the AH26 than in the MTA-fillapex sealer, whereas after 180 days, the AH26 sealer delivered less microleakage than MTA-fillapex. Therefore, it seems that resin-based sealers deliver better sealing properties over time, compared to bioceramic sealers. In the recent study, however, the employed bioceramic sealer showed no significant difference in the microleakage rate between the two time points (i.e., 24-hour and 180-day), which was in line with our results. Further studies are required using other microleakage assessment methods to elaborate our observations. It is also recommended to compare the efficiency of these two sealers by employing different filling methods, such as vertical compression, in oval and circular root canals.

Conclusion

Within its limitation, this study revealed that obturation with Sure-Seal Root sealer with matched single-cone obturation was not superior to conventional lateral obturation GP/AH Plus sealer in terms of resistance to microleakage over time. The sealing ability of AH Plus increased in 90 days, and Sure-Seal Root exhibited no significant difference in microleakage from 7 days to 90 days. However, further long-term studies are necessary to establish the clinical application of bioceramic sealers using the matched single-cone obturation technique.

Conflicts of interest

The authors declare that there is no conflict of interest.

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