Evaluation of microleakage of three different endodontic sealers in the presence and absence of moisture

Hamid Razavian1, Kimia Hanjani2, Kiana Hanjani3, Hesam Mirmohammadi4, Alireza Shabanian Boroujeni5

1Department of Endodontics, Dental Materials Research Center, Dental Research Institute, School of Dentistry, Isfahan University of Medical Sciences, Isfahan, Iran
2Dental Student, School of Dentistry, Isfahan University of Medical Sciences, Isfahan, Iran
3Post Graduate Student, Department of Pediatric Dentistry, School of Dentistry, Shahid Beheshti University of Medical Science, Tehran, Iran
4Department of Endodontontology and Preventive Dentistry, Academic Center for Dentistry Amsterdam, Amsterdam, the Netherlands

*Corresponding Author: Kimia Hanjani, Dentistry Student; 3rd floor, 25th Building, Bagh Zereshak Alley, Chaharbagh-Bala Street, Isfahan, Iran. Tel: +989134096938, Email: Hanjanikimia@gmail.com

Abstract

Background and aims: AH26, Master-Dent, and Endoseal mineral trioxide aggregate (MTA) are three different types of sealers. The purpose of this study was to assess and compare the apical seal of the root canal-treated teeth with the above-mentioned sealers in the presence and absence of moisture using the fluid filtration method.

Methods: To this end, 54 freshly extracted single root canal human canines were selected for this study. The canals were prepared using rotary instruments, and then sodium hypochlorite was applied as an irrigation solution in this protocol. The specimens were randomly divided into three groups of 18. One group was obturated with the gutta-percha by the cold lateral compaction technique. Half of one of the aforementioned sealers belonged to the group of moistened teeth and the other half to the group of the dried teeth. Microleakage in all groups was assessed 3 months after the obturation of canals by the fluid filtration method. The data were analyzed using ANOVA and Tukey’s post hoc tests, and the level of significance was set at P<0.05.

Results: The results showed that the minimum and maximum micro-leakage belonged to Masterdent dry (mean leakage = 1.7778 μL/min/Cm20) and Endoseal-MTA dry (mean leakage = 3.5000 μL/min/Cm20), respectively. All three groups of sealers exhibited a significant difference in apical micro-leakage between dry and moist conditions (P<0.001, P=0.002, and P=0.007), respectively. The findings of this experimental study demonstrated that Masterdent provided the least apical micro-leakage under dry conditions while Endoseal-MTA had the highest micro-leakage under these conditions. There was a significant difference between dry and moist conditions in all groups.

Keywords: Microleakage, Fluid filtration, Root canal obturation, Moisture, Sealer

Introduction

Endodontic obturation includes complete three-dimensional filling of the dental root canal with materials that present satisfactory physical and biological properties (1-3). Ideally, the filling material should sufficiently seal the root canal and simultaneously prevent fluid penetration into the root canal space, stimulate the resolution of periapical pathologies, and encourage the deposition of cementum to obtain a biological seal (3).

An inappropriate apical seal has been reported as the most important cause of root treatment failure (4). It was suggested to dry the root canal before obturation since it increases the adherence of the filling material to the dentin walls of the canal before the appearance of mineral trioxide aggregate (MTA)-based sealers (5, 6).

Resin-based endodontic sealers such as AH26 have received considerable attention from endodontists because of their good physical-chemical and biological properties (7). Other sealers, especially those that are based on zinc oxide eugenol (ZOE) or MTA (8), could have better biological properties.

Nowadays, one of the most commonly used sealers in root canal treatment is the ZOE-based sealer, which has been qualified for endodontic purposes. The powder of this sealer contains zinc oxide (ZnO), which is the valuable component of this sealer and blends with a liquid, generally eugenol (9).

Resin-based sealers have good physical features, sealing ability, adequate biologic function, and micromechanical retention to root dentin. Sealers such as AH-26 are routinely employed as control materials in endodontic research because of their low solubility, long-lasting stability, and adequate retention to dentin (10).

Bioceramic-based materials containing calcium silicate and/or calcium phosphate have been considerably noticed due to their physical and biological properties such as their biocompatibility, alkaline pH, chemical stability in the biological environment, and the lack of shrinkage.

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Evaluation of the microleakage of endodontic sealers

For example, a premixed bioceramic endodontic sealer, EndoSequence BC Sealer, and an experimental MTA-based root canal sealer showed optimal physicochemical properties for the root canal sealer (11).

Although MTA is remarkably biocompatible when employed in pulpotomies (12), root perforations (13), and retrograde obturations (14), as well as an account of its difficult handling and insertion, it is not commonly applied as a root canal filling material (15). However, more recently, some manufacturers have added specific elements to MTA-based cements such as ProRoot Endo Sealer, CPM. Sealer, and MTA-Obtura in order to integrate the favorable biological properties of MTA into an easy to handle and to insert material (1).

Various studies have investigated the sealing ability of different sealers (16), and different amounts of the remaining moisture in the root canal have been shown to change the sealing properties of conventional and resin-based sealers (17). Contrarily, some studies have focused on apical micro-leakage using Masterdent and Endoseal MTA sealers in comparison with other routinely used sealers, or the effect of the moisture on the apical microleakage of these sealers (18-20). Many studies have suggested that apical microleakage happens due to delayed bleeding, interstitial fluid, or irrigation solution remnants, particularly sodium hypochlorite (21,22). These all have certainly happened out of the sight of the operator, but recent research has also claimed that residual moisture does not alter the mean value of microleakage (20). Based on these observations, the present study aimed to analyze the apical seal of AH26, Masterdent, and Endoseal MTA in the presence and absence of residual moisture within the canal by the fluid filtration method at the observation period of 90 days.

Materials and Methods

According to the sample size calculation formula (23), this experimental study included 54 extracted teeth collected within one month from dental clinics in Isfahan, Iran. This research process was performed by two endodontists, two dentistry students, and one pediatric dentistry resident. The inclusion criteria were maxillary or mandibular canine, no restoration or decay lower down the cemento-enamel junction (CEJ), complete root formation without any sign of external resorption, straight cone-shaped root with curvature less than 30° in the apical third, no fracture or crack in the root, and no calcification in the root canal. On the other hand, the exclusion criteria included K files #10 and #15 not passing beyond 14 mm from CEJ into the root canal (22).

\[
\begin{align*}
\alpha &= 0.05, \quad z = 1.96 \\
1 - \beta &= 0.80Z_{\alpha/2} = 0.8 \\
\end{align*}
\]

\[
\begin{align*}
\sigma_1, \sigma_2 &\approx 0.0036 \\
d &= 0.00336
\end{align*}
\]

With 18 samples for dry and wet conditions (9 samples in each group), it is 0.80 probable that the difference will be at least equal to \(d = 0.00336\) between the average microleakage of sealers at the 0.05 significant level.

Preparation of the teeth

Initially, the teeth were debrided by eliminating all attached hard and soft tissues and immersing in 1000 mL of 5.25% sodium hypochlorite (Golrang Company, Tehran, Iran) for 24 hours. Then, the teeth were stored in the container with a lid containing 0.9% sterile saline (Iran transfusion product Company, Tehran, Iran) at room temperature until the following processing. Out of 160 extracted teeth in the recent month, 54 human maxillary canine teeth with acceptable appearance meeting the inclusion criteria were selected before starting the study. The sampling method was based on the simple random sampling method. These 54 acceptable samples were numbered, and then 9 teeth were selected for each of the 6 groups using a computer-based random number generator which almost always uses a pseudo-random number generation method (24). Their crowns were cut near the CEJ by a diamond disc (Tizkavan, Tehran, Iran) and a high-speed handpiece (NSK, Tokyo, Japan) with water coolant, which is perpendicular to the long axis, to achieve a 15 mm root length for all samples measured by a digital caliper (Goanjigo SR 44, China). All prepared teeth were again held in 0.9% sterile saline at room temperature until the test time. The working length was confirmed using a #10 K-file (Dentsply Maillefer, Ballaigues, Switzerland) by decreasing 1 mm from the file length after appearing through the apical foramen. Following apical patency verification using a #10 K-file, the teeth were instrumented by the Denco rotary instrument (Shenzhen Denco Medical Company, Guangdong, China) and shaped to file #80, establishing a #40 master apical cone for all the samples. In this protocol, sodium hypochlorite was used as an irrigation solution. After shaping all the canals, the smear layer was removed by root canal irrigation with hypochlorite for 1 minute and then 17% EDTA for 1 minute (10) and preferably normal saline in between to prevent any unpredictable interaction. Subsequently, all the canals were flushed with normal saline. All the teeth were evenly prepared by this time. Afterward, the groups were organized to have 18 teeth for each sealer, half of which belonged to the group of moistened teeth and the other half was related to the group of the dried teeth. Masterdent, Endoseal MTA, and AH26 were applied in this study. To prepare the dry group, the canals were dried by paper points with a similar size and length as the master apical file until the thorough elimination of the moisture. In the moistened group, however, the canals were not completely dried after flushing with normal saline, as only the moisture of the
pulp chamber and the coronal two-thirds of the canal would be displaced using a paper point with a greater size compared to the master apical file. Next, in each group, the sealers were mixed according to manufacturers’ instructions and inserted into the root canals coating all the walls by a spreader (MANI, Japan) with the size and length of the master apical cone introduced 0.5 mm short of the working length and always with the same amount of sealer. Afterward, the gutta-percha point reached the working length; the extruded sealer throughout the foramen was gently removed from the root surface with gauze. The root canals were filled and obturated by (Diatent, Korea) gutta-percha cones by applying cold lateral condensation. The excess gutta-percha and sealer were removed by alcohol-soaked cotton. After the radiography procedure to ensure proper obturation, the teeth were incubated at 37°C and 100% humidity for setting the sealers (8, 19, 10).

After 90 days, the roots were connected to 54 plastic tubes (Guihaa, China), and the interface between the teeth and plastic tubes was sealed with two layers of cyanoacrylate glue (Osaka, Japan) at the apical side and then sealed with Parafilm (Parafilm, Laboratory films, Chicago) as well. Before mounting the roots, except for an area of 2.0 mm around the root apex, the rest of the root surfaces were covered with two layers of nail polish to eliminate the effect of lateral canals (18, 25-27).

Leakage was evaluated by the fluid filtration method using a pressure equivalent to 10 psi as reported by Derksen et al (28) and adjusted for Endodontics by Wu and Wesselink (26). Four measurements were performed for each sample at 2-minute intervals for a total of 8 minutes at 90 days after filling. The amount of leakage was presented as μL/min.1.10 psi. Finally, the designed device was used for assessing bubble movements, and the data were quantified in μL/min/CmH2O and analyzed by one-way ANOVA and Tukey’s post-hoc tests.

Results
The results showed microleakage in all samples over 90 days. Table 1 presents the mean leakage values and standard deviations for different sealers under wet and dry conditions. Further, the leakage of all the sealers was compared two by two, and their P values are mentioned in Table 2.

The lowest amount of micro-leakage was observed in the Masterdent sealer under dry conditions while the highest micro-leakage was related to the Endoseal-MTA sealer under dry conditions. At the 3-month period, ANOVA test results revealed statistically significant differences in the amount of micro-leakage between almost all the studied groups of sealers (P<0.05). The mean micro-leakage in all sealers was significantly lower on dry canal conditions compared with moist canal conditions except for the Endoseal-MTA sealer (Table 1). In the presence of moisture, the type of the sealer had no meaningful effect on the amount of the micro-leakages of the sealers but in dry condition, there was a remarkable difference between the Endoseal-MTA and Masterdent groups (P<0.001) and the Endoseal MTA and AH26 groups (P<0.001).

Discussion
Based on the results of the present study, the lowest amount of micro-leakage belonged to the Masterdent group in dry conditions whereas the highest amount was found in the Endoseal-MTA group in dry conditions. In AH26, Masterdent, and Endoseal-MTA group, there was a statistically notable difference in micro-leakage between dry and wet conditions. MTA Fillapex was previously demonstrated to have a better apical seal compared to AH26 (29). However, in the present study, Endoseal-MTA had the highest rate of micro-leakage in the presence and absence of moisture. This divergence may be explained by the hydrophilic properties of MTA in the Endoseal-MTA group among these three types of sealer.

Sealers containing MTA have hydrophilic characteristics, and some recent studies have concluded that moisture is needed for setting MTA-based sealers. They even claim that if MTA plays the role of a sealer, complete drying of the canal before placing the sealer might even prevent complete setting. It is also accepted that it may be favorable to leave the canals with a bit of moisture before root canal obturation with such sealers (6). The individual difference in handling and employing the sealers can be
Conclusion
On apical seals may reveal useful findings (4).

of different percentages of residual moisture in root canals
serum or blood in the prepared root canals).

circumstances (e.g., in the presence of the remaining
suggested that similar research be conducted in different
groups in the MTA-based sealer
was reported to be significant in our study contrary to
Ehsani and colleagues’ study, the amount of the residual
was reported to be significant in our study contrary to
Ehsani et al (31) and Goldman et al (5) suggested totally dried root
canals be maintained in a wet status to take advantage
of the hydrophilic properties of their sealers without
specific clinical instructions to reach the optimal degree
of residual moisture (17). Nagas et al (17) concluded
that the amount of residual moisture can notably have
an effect on the adhesion of sealers to root canal dentin.
For the mentioned sealers in their article, including AH
Plus and MTA Fillapex, it may be favorable to leave the
canals quite wet before filling (17). Similarly, Roggendorff
et al (30) showed that humidity resulted in lower micro-
leakage for Apexit, RoekoSeal, and Tubli-Seal while
higher values for AH Plus and Ketac-Endo, stating that
the remnant moist may act as a lubricant for previously
named sealers allowing a better adhesion to the root canal
walls, therefore, thorough drying of the root canal dentin
may have unfavorably affected linear dye penetration (30).

On the other hand, some other researchers such as Jang
et al (31) and Goldman et al (5) suggested totally dried root
canals before the obturation process because they believed
it may increase the adherence of the filling material to the
dentin walls of the canal.

According to Ehsani et al, experiments under moist and
dry conditions represented that the AH26 sealer owned
the lowest micro-leakage, and the matter of moisture
(blood or 5.25% hypochlorite) had no remarkable effect
on the amount of sealer micro-leakage (4).

To recreate the clinical situation more specifically, it is
suggested that similar research be conducted in different
circumstances (e.g., in the presence of the remaining
serum or blood in the prepared root canals).

Supplementary research concentrating on the outcomes
different percentages of residual moisture in root canals
on apical seals may reveal useful findings (4).

Evaluation of the microleakage of endodontic sealers
of three types of endodontic sealers in the presence and
absence of moisture in order to find the appropriate sealer
for when moisture involuntarily remains inside root
channels during root canal treatment. Based on our findings,
Masterdent represented the least amount of micro-leakage
in dry conditions while the Endoseal-MTA group had
the highest micro-leakage again under dry conditions.

There was a notable difference between dry and moist
conditions in all groups. Eventually, the current study
had some limitations including the use of only single-rooted
teeth, limitations of the fluid filtration method, sample
size, duration of observation, and different individual
manipulation techniques. More importantly, this was an
in vitro study, which may have affected the results.

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Authors’ Contribution
HR, KH (Kimia Hanjani), and KH (Kiana Hanjani) conducted
the experiment. KH wrote the manuscript and HR supervised the
project. HR conceived the study and was in charge of the overall
direction and planning. In addition, KH, and KH, as well as HR, and
KH, contributed to the preparation of samples and interpretation of
the results, respectively. All authors provided critical feedback and
helped shape the research, analysis, and manuscript. HR and KH,
designed the experiments, derived the models, and analyzed the
data. KH assisted with measurements and helped in performing the
simulations. Further, KH wrote the manuscript in consultation with
HM and AS. HR verified the analytical methods. HR encouraged
KH to investigate and supervise the findings of this work. All authors
discussed the results and contributed to the final manuscript.
HM devised the project, the main conceptual ideas, and the proof
outline. KH and AS worked out almost all the technical details
and performed the numerical calculations for the suggested
experiment. Similarly, KH processed the experimental data,
performed the analysis, drafted the manuscript, and designed the
figures with the help of other authors. HR aided in interpreting the
results and worked on the manuscript. All authors discussed the
results and commented on the manuscript. Finally, both AS and
KH, contributed to the final version of the manuscript, and HM
supervised the project.

Conflict of Interests
The authors declared no conflict of interests.

Ethical Approval
Ethical considerations in this study included obtaining permission
from the Ethics Committee of Isfahan University of Medical Sciences
(Approval ID: IR.MUI.RESEARCH.REC.1400.148).

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