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Bacterial leakage in root canals filled with resin-based and mineral trioxide aggregate-based sealers

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ABSTRACT

Background: Sealing ability is one of the most important features of endodontic sealers. The purpose of this *in vitro* study was to compare the sealing ability of a resin-based sealer with a mineral trioxide aggregate-based sealer.

Materials and Methods: A total of 60 single-rooted extracted human teeth were randomly divided into two experimental groups (n = 25) and two control groups (n = 5). After canal preparation and smear layer removal, both groups were obturated with gutta-percha and sealer. Resin-based AH26 sealer was used in the first group and Fillapex® sealer in the second group. Two layers of nail varnish were applied on tooth surfaces except for the apical 2 mm. In the negative control group, nail varnish was applied on the entire surface. The teeth were mounted according to Lima *et al*. study and then sterilized by ethylene oxide gas. The samples were evaluated for bacterial microleakage using *Enterococcus faecalis* (ATCC 29212) for 90 days. Data were analyzed by survival test ($P < 0.05$).

Results: Control groups had either immediate leakage or no leakage. The Fillapex® showed significantly higher amounts of microleakage compared with AH26 sealer ($P < 0.05$) and both groups exhibited significant differences in comparison with control groups.

Conclusion: Both sealers had bacterial leakage. Sealing ability of AH26 was significantly higher than that of Fillapex®.

Key Words: Bacterial leakage, mineral trioxide aggregate-based sealer, resin-based sealer, root canal therapy

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INTRODUCTION

The success of endodontic therapy relies on the three-dimensional sealing of the canal after removing bacteria from the root canal to prevent microleakage and penetration of microorganisms. It is reported that the most common reason for endodontic failure is the inability to achieve a three-dimensional seal.[1,2] Strindberg[3] and Allen[4] showed that long-term endodontic failure is due to lack of complete canal seal.

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The ideal features of a root canal filling material include tissue compatibility, antibacterial properties, radiopacity, easy handling, insolubility in tissue fluids, three-dimensional seal of the canal and no coronal discoloration.[5,6] Gutta-percha, the most common root-filling material does not adhere to the canal walls and shrinks after cooling down, resulting in gaps which provide an access route for bacteria.[7] Sealers are required to fill these gaps. There are various types of sealers; zinc oxide-based sealers, resin-based sealers, silicon sealers and mineral trioxide aggregate (MTA)-based sealers.

Farhad *et al*.[8] reported that epoxy resin-based sealers, such as AH26, could adhere to dentinal walls after

removal of the smear layer. Resin-based sealers have other advantages, including setting in the presence of moisture, insolubility in tissue fluids, good setting time and antibacterial effects.[9]

MTA cement has a great sealing ability and has been used widely in endodontic treatments for sealing perforation areas,[10,11] internal and external root resorptions,[12] creating an artificial barrier for non-vital open-apex teeth,[13] root-end filling[14,15] and pulp capping.[16]

Recently, researchers have tried to use MTA cement as a sealer. One of the MTA-based sealers introduced is Fillapex® (Angelus, Londrina, PR, Brazil), which is a double-paste sealer (base and catalyst). The manufacturer claims that it has good sealing ability and biocompatibility; it can stimulate the generation of mineralized tissue and has a favorable setting time. Camilleri *et al*.[17] compared the sealing ability of Fillapex® and Pulp Canal sealer using fluid filtration technique and reported that the sealing ability of these sealers was comparable. Oliveira *et al*.[18] compared bacterial microleakage resistance of two MTA-based sealers (MTA sealer and Endo CPM sealer) with six popular sealers (AH Plus, sealer 26, Epiphany SE, Sealapex, Activ GP and Endofill). Their results showed that AH Plus and Sealapex had the highest bacterial microleakage resistance whilst Activ GP and MTA-based sealers showed the greatest microleakage. Fillapex® sealer has been introduced recently but only a limited number of studies have evaluated the bacterial microleakage of this MTA-based sealer.[18-20] The aim of this study was to evaluate the apical microleakage of Fillapex sealer compared with AH26 sealer after filling of root canals prepared with hand instrumentation.

MATERIALS AND METHODS

Sixty single-rooted extracted human teeth with mature and straight roots were included in this experimental study. The teeth were examined clinically and radiographically and those with vertical or transverse fractures, severe curvatures, internal or external resorption and pulpal calcification were excluded. All the remaining calculi and tissue remnants were removed using an ultrasonic devise (Juya Electronic Co, Tehran, Iran). Then the teeth were kept in 5.25% sodium hypochlorite (Golrang, Pakshoo Co. Tehran, Iran) for 30 min for further disinfection and dissolving of the organic tissues. The teeth were decoronated from the cementoenamel junction using a diamond disc (D and Z, Berlin, Germany) for achieving the average root length of 15 mm. The working length was established using a k-file #10 (Mani, Utsunomiya, Japan). The apical portion of the canal was prepared using the step-back technique up to k-file #30. Canal shaping was performed up to k-file #60 in the coronal portion. The canal was irrigated with 5.25% sodium hypochlorite between using each file. Finally, the smear layer was removed using 17% ethylenediaminetetraacetic acid (EDTA) (Merck, Darmstadt, Germany) for 1 min.

The teeth were randomly divided into four groups. The first group consisted of 25 teeth obturated with gutta-percha (Mani, Utsunomiya, Japan) and AH26 sealer (Dentsply, Konstanz, Germany). The second group also contained 25 teeth, which were obturated with gutta-percha (Mani, Utsunomiya, Japan) and Fillapex® sealer (Angelus, Londrina, PR, Brazil). Obturation was performed using a finger spreader (Mani, Utsunomiya, Japan) by lateral condensation technique. The third group (positive control) consisted of five teeth, which were obturated using a single gutta-percha cone without any sealer. The last group (negative control) also included five teeth, which were obturated with gutta-percha and AH26 sealer. The teeth were incubated for 48 h at 100% humidity and 37°C for complete sealer setting. Two layers of nail varnish (My Co., Tehran, Iran) were applied on the root surfaces except for the apical 2 mm. In the negative control group, nail varnish was applied on the entire root surface.

Then, the teeth were transferred to the system used in Lima *et al*.[21] study to evaluate bacterial microleakage. The roots were placed inside sixty micropipettes with removed ends. The contact surface of the teeth and the micropipettes were sealed with two layers of cyanoacrylate glue and one layer of nail varnish. This system was placed inside the hole created on the anti-serum vial lids and then sterilized for 24 h using ethylene oxide gas.[22] Afterward, this system was transferred to anti-serum vials containing 10 mL of brain heart infusion (BHI) (Merck, Darmstadt, Germany) under aseptic conditions. The samples were kept inside an incubator for 3 days to ensure non-contamination.

A total volume of 1 mL of the solution containing 10^9 *E. faecalis* (ATCC 29212) was injected from the upper part of the system and bacterial microleakage

was evaluated by observing turbidity in BHI solution. The samples were checked every day for 90 days, bacterial injection was performed every 3 days and the turbidity of the medium was recorded every day. The results were analyzed by survival test ($P < 0.05$).

RESULTS

All specimens in positive control group had turbidity of the medium within 24 h, while none in the negative control group became turbid. During the experimental period, 26 specimens had bacterial leakage [Table 1]. The survival analysis showed that the Fillapex® group had more microleakage (mean: 77.92; standard deviation (SD): 5.48) than the AH26 sealer group (mean: 41.84; SD: 7.74). The difference was significant ($P = 0.04$) [Figure 1]. Both experimental groups had significant differences with control groups, showing the validity of the experiment ($P < 0.05$).

DISCUSSION

The most important factor for endodontic success is the three-dimensional canal seal. Gutta-percha and sealers are the most commonly used materials for canal obturation. Gutta-percha is rigid and cannot completely fill the inside of the canal; therefore, sealers are needed to complete the canal seal.[23]

Table 1: Number of specimens with bacterial leakage during the experimental period

Periods (weeks)	1st week	2nd week	3rd week	4th week	5th week	6th week
AH26	3	—	—	—	2	—
MTA Fillapex®	11	3	—	1	1	—
Positive control	5	—	—	—	—	—
Negative control	—	—	—	—	—	—

MTA: Mineral trioxide aggregate

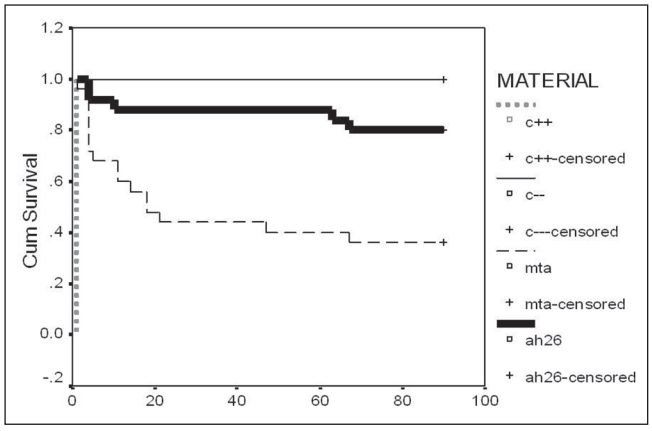

Figure 1: Survival function for both groups

All the procedures of this study were done by the same operator to avoid intra-operator discrepancies. Only teeth with single straight root canals were included because they can offer a more standardized method for evaluation of apical leakage.

The culture medium of positive control group became turbid within the first 24 h, confirming the importance of endodontic sealers when filling root canals.[20] In the present study, evaluation was carried out for 90 days in which the majority of the specimens showed bacterial leakage. Within the first 30 days, bacterial leakage was detected in 6% of the specimens filled with AH26 and 28% of the specimens filled with MTA Fillapex®. The first medium turbidity was seen in two specimens of AH26 group at day 4th. Oliveira *et al*.[18] observed bacterial leakage in 33% of the AH plus group 61% of MTA sealer group after 1 month. This divergence in bacterial leakage percentages may be due to the number of samples and anatomical complexity of the root canal systems.

Gomes-Filho *et al*.[19] compared the sealing ability of two MTA-based sealers (Fillapex® and Endo CPM sealer) with a calcium hydroxide-based sealer (Sealapex), using dye penetration technique. The results showed that Fillapex® and Sealapex had significantly lower microleakage than Endo CPM sealer.

Yegin and Keser[20] evaluated the sealing ability of MTA Fillapex, Sealapex and AH Plus using fluid movement technique. They reported that during the first 24 h Fillapex® showed the least microleakage, but after 180 days AH Plus and Sealapex had the least microleakage.

AH26 sealer was more resistant against bacterial leakage, which may be related to its flowability and dimensional stability, which led to a reduction in marginal leakage.[24-27] Oliveira *et al*.[18] also verified that AH Plus had good resistance to leakage, which suggests better adaptation of this material to dentine walls. Farhad *et al*.[8] and Saleh *et al*.[28] reported that AH26 had less leakage when the smear layer was removed, highlighting the importance of using EDTA.

Fillapex® is based on MTA with additional substances to obtain a consistency suitable to be used as a sealer in root canal treatment. MTA can form calcium

ions and hydroxyl ions important for stimulation of hard tissue deposition.[22] The presence of MTA also suggests a possibility of setting expansion, which might have favored the sealability. Most of the dental materials have a tendency to shrink away from their interfacial margins, exposing a gap through which contaminating elements can penetrate. MTA setting results in the hydration of anhydrous mineral oxide compounds to produce calcium silicate hydrate and calcium hydroxide phases[6,7,22] which produces expansion against its confining margins, enhancing the seal and minimizing leakage.[5,16,25]

The results of this study showed that AH26 was more resistant to bacterial microleakage compared with MTA Fillapex®. This finding was similar to those of Oliveira *et al*.[18] but contrary to the findings reported by Camilleri *et al*.[17] and Gomes-Filho *et al*.[12] This difference might be attributed to the selected sealers and microleakage evaluation techniques.

In the present study, microleakage of Fillapex® increased over time, which is similar to the results of a study by Yegin and Keser.[20] This proves the decreasing sealing ability of this sealer. Fillapex® had lower sealing ability compared with AH26, but resulted in a significantly higher sealing ability than the positive control group, demonstrating that it can improve the root canal seal. Various factors affect the sealing ability of sealers, including moisture, removal of the smear layer and penetration of sealer into inaccessible regions, dimensional stability and sealer setting time. All these factors can affect the sealing ability of MTA Fillapex®. The difference between the chemical composition of MTA-based materials can lead to differences in sealing ability, which was shown in a study by Gomes-Filho *et al*.[19] Further studies are necessary, particularly animal studies, to evaluate the sealing ability of MTA-based sealers.

CONCLUSION

According to the results of this *in vitro* study, the sealing ability of gutta-percha and AH26 sealer is higher than that of gutta-percha and MTA Fillapex®.

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