Evaluation of coronal microleakage of mineral trioxide aggregate plug-in teeth with short roots prepared for post placement using bacterial penetration technique

Khademi AA, Shekarchizade N

ABSTRACT

Context: Two of the problems of the placement of posts in teeth with short roots are to determine the minimum length of the canal obturating material at the apical third of the root canal and removal of all the canal obturating material from the root canal during post space preparation.

Aim: The aim of the present study was to compare the coronal microleakage of mineral trioxide aggregate (MTA) plug and gutta-percha in short roots prepared for post placement using the bacterial penetration technique.

Materials and Methods: In the present in vitro study, 40 extracted single-rooted anterior teeth measuring 13 mm in root length were selected. Since the roots were short, 3 mm of the root length was allocated to the root canal obturation material and 10 mm of the root length was allocated to post placement. After preparation of the root canals, post spaces were prepared and the samples were randomly divided into two groups of gutta-percha and MTA. Fifteen root canals were obturated with gutta-percha and the post space was immediately prepared, with 3 mm of gutta-percha remaining in the apical end of the root canal. In 15 teeth, MTA plugs were placed, which measured 3 mm in length. The samples were placed in the Enterococcus faecalis bacterial microleakage system for 120 days. The time for the turbidity of each sample was recorded. Data were analyzed with Fisher’s exact test.

Results: During the study period, turbidity was observed in all the gutta-percha samples and in only four MTA samples, with statistically significant differences between the two groups ($P < 0.001$).

Conclusion: Based on the results, MTA exhibited much better sealing ability compared to gutta-percha as a root canal obturation material in teeth with short roots.

Key words: Dental Leakage, gutta-percha, mineral trioxide aggregate

The aim of root canal therapy is to preserve tooth function through the elimination of inflammation and infection from the pulp and periradicular tissues. In this context, significant progresses have been made in the preparation and obturation of root canals. Several factors are involved in the failure of root canal treatment, including inadequate debridement, unidentified root canals, improper root canal obturation, over-filling and over-instrumentation, operator errors, and inadequate apical and coronal seal. Coronal seal prevents the penetration of bacteria and their toxins via saliva into the root canal space and the subsequent inflammation in the periradicular tissues. Coronal seal might be compromised through the loss of temporary restoration, fracture in the tooth structure or the restorative material, microleakage of temporary restorations and recurrent caries. Preparation of post space has a negative effect on the coronal seal of

Received: 30-08-14
Review completed: 08-10-14
Accepted: 24-05-16
root canal obturation materials. Post space preparation and creation of an empty space in the coronal third of the root canal creates conditions for the penetration of bacteria and their endotoxins because under these conditions, there is an inadequate root canal obturation material in the root canal space to prevent bacterial penetration. The sealing ability of gutta-percha measuring 3, 5, and 7 mm in length is less than that of gutta-percha which has obturated the root canal up to the canal orifice. Coronal seal depends on the length of the root-end filling material after post space preparation. Mineral trioxide aggregate (MTA) was introduced to dentistry in the early 1990s and has found many applications in the dental field since then. The sealing ability of MTA has been studied extensively. MTA, as a root-end filing material, is the most efficacious material to prevent microleakage compared to amalgam, IRM, and super-EBA.

Vizgirda et al. carried out a study on extracted bovine teeth to compare the microleakage of gutta-percha and MTA as root canal obturation materials. They reported that microleakage of gutta-percha was significantly less than that of MTA. Al Hezami et al. showed that root canals obturated with MTA exhibited less microleakage compared to root canals obturated with gutta-percha and sealer using the vertical compaction technique. It is difficult to remove gutta-percha from short root canals that need a post because the whole gutta-percha might be accidently removed or inadequate length of gutta-percha might remain in the root canal; therefore, one useful technique is to place an MTA plug after root canal preparations and to prepare the necessary space for the post. To date, no studies have compared the coronal leakage of MTA plugs and gutta-percha in teeth with short roots that need a post. Therefore, the aim of this study was to evaluate and compare the coronal leakage of MTA plugs and gutta-percha in short roots prepared for post using the bacterial penetration technique.

**MATERIALS AND METHODS**

Forty extracted single-rooted anterior teeth with mature apices and straight roots were selected. The teeth had no carries and cracks. All the teeth were similar from an anatomic point of view. The tooth surfaces were cleaned with curettes to remove any contaminants and residual tissues, including periodontal ligament fibers, from the root surfaces. The teeth were immersed in 2.5% NaOCl solution overnight and then stored in normal saline solution during the study period. The teeth crowns were removed with a diamond disk to leave a root length of 13 mm. The root canal patency was confirmed by placing a #15 K-file in the root canal. The samples without root end patency were excluded from the study and replaced by other samples. The working length was determined by a patency file and the root canal was prepared up to the root end. Filing was carried out up to #50 K-file using the step-back technique. A composition of 5.25% NaOCl was used as a root canal irrigation solution. To enlarge the coronal thirds of the root canals for post placement, Gates-Glidden drills #4, #3 and #2 were used. At the end of root canal preparation to remove of smear layer, 5 mL of 17% ethylenediaminetetraacetic acid (pH = 7.8) was used in each root canal for 1 min, followed by 5 mL of 5.25% NaOCl. Distilled water was used as the final rinse.

To sterilize the open dentinal tubules after removal of the smear layer, ethylene oxide gas was used and then the samples were randomly divided into two experimental groups and two control groups: 15 samples in the experimental Group 1, 15 samples in the experimental Group 2, five samples in the positive control group, and five samples in the negative control group.

In Group 1, the root canals were obturated with gutta-percha (GAPA Dent, Germany) and AH<sub>26</sub> sealer (Dentsply, Konstanz, Germany) using the lateral compaction technique, followed by immediate removal of gutta-percha from the root canal by a heat carrier to leave 3 mm of gutta-percha in the apical end of the root canal. The residual root canal filling material was condensed with a cold plugger. The samples were kept in a moist environment for 24 h to allow for the setting of AH<sub>26</sub> sealer.

In Group 2, a 3 mm long MTA plug (ProRoot MTA; Dentsply Tulsa Dental Specialties, Tulsa, OK, USA) was placed in the apical end of the root canal. To this end, a plugger was used that could penetrate up to 1 mm from the root canal apical end. MTA was mixed with distilled water according to manufacturer’s instructions and placed in the root canal using a messy gun-type syringe (CK Dental Specialties Inc., Orange, CA, USA) and moved to the root canal apical end with a plugger. The process continued to leave 3 mm of MTA at the root canal apical end. Then, a moist cotton pellet was placed at the canal orifice. The samples underwent radiographic examination to evaluate the quality of the root canal obturation [Figure 1].

In the positive control group, a master cone gutta-percha point was placed in the root canal without sealer. The negative control samples were obturated with gutta-percha and AH<sub>26</sub> sealer using the lateral compaction technique up to the whole root length (13 mm). The coronal end of the root canals were sealed with sticky wax.

The external surfaces of all the samples in all the groups were covered with 2 layers of nail varnish (Revlon Inc., NY, USA) except for 2 mm of the root end and the coronal third of roots were sealed with sticky wax, except for the negative control samples in which all the external surfaces were covered with nail varnish and sticky wax.

A 5 mm length of the tapered end of a plastic Eppendorf tube was cut away and the samples were placed within the
tube, with 4-5 mm of the root surface out of the tube. The space between the sample and the tube wall was sealed with cyanoacrylate glue. Then, the Eppendorf tube was fixed with cyanoacrylate glue and elastic rings within the cap of a penicillin vial, the middle of which had been perforated. The system was sterilized with ethylene oxide gas for 12 h. Then, the system was placed within a sterile penicillin vial containing 10 mL of sterile brain-heart infusion (BHI) broth, with 2 mm of the apical end of the root floating within BHI. Figure 2 shows the schematic representation of the system for inoculation of bacteria. The whole system was incubated at 37°C for 3 days to ensure that the system was sterile. Then, 1 mL of the solution containing $1 \times 10^9$ Enterococcus faecalis (1393: ATCC) colony-forming units was injected into the Eppendorf tube and kept in an incubator at 37°C. Every other day, the solution containing the bacteria was refreshed. During 120-day period, the tubes were evaluated daily in relation to turbidity, and the time of turbidity for each sample was recorded. Data were analyzed with Fisher’s exact test using SPSS version 18 for Windows (SPSS Inc., Chicago, USA) at a confidence interval of 95%.

RESULTS

In the gutta-percha group samples, turbidity was observed between 12 and 35 days. In the MTA group, turbidity was observed in 4 samples between 74 and 113 days. Turbidity was observed in all the positive control samples in 2 days; however, in the negative control group, no sign of bacterial microleakage was observed in any samples throughout the study period of 120 days [Table 1]. Fisher’s exact test revealed significant differences in bacterial microleakage between the gutta-percha and MTA groups ($P < 0.001$).

DISCUSSION

Different techniques are available for the evaluation of microbial microleakage of root canal obturation materials, including dye penetration, fluid diffusion, bacterial and endotoxin penetration, radioisotope penetration, and autoradiography and electrochemical techniques. Each technique has some advantages and disadvantages. In the present study, bacteria were used for the evaluation of microleakage because this technique has the greatest similarity to the biologic and clinical conditions of the oral cavity compared to other techniques.

In the present study, E. faecalis was selected for the evaluation of microleakage because it is a member of the oral microflora and is usually isolated, along with other aerobic and anaerobic bacterial species, in infections and in endodontically treated teeth, which have failed and require retreatment. In addition, it is one of the bacteria that can survive the harsh conditions within the root canal.

There are different techniques to prepare and evacuate the coronal third of root canals for post placement. In the present study, the hot plugger technique was used to evacuate gutta-percha from the coronal third of the root canal because rotary instruments can perforate the root or entangle gutta-percha within the root canal and displace it. However, use of a hot plugger can help remove gutta-percha from the root canal space in layers up to the level desired.
Oliveira et al. exposed the teeth in which the root canal spaces had been prepared, obturated, and evacuated for post placement to saliva. In these teeth, only 2 mm of gutta-percha remained in the apical end of the root canals. They reported that after 24 h, leakage occurred in 90% of the samples. However, in teeth in which the post had been cemented, leakage occurred in 70% of the samples after 40 days. The study showed that evacuating the coronal third of the canals has a negative effect on the coronal seal.\textsuperscript{16}

Muñoz et al. left 5 mm of gutta-percha in the apical end of the root canal after post space preparation, believing that the minimum length of gutta-percha necessary to provide apical seal was 5 mm.\textsuperscript{17} When 2-3 mm of gutta-percha remains in the apical end of the root canal, leakage occurs; however, 4 mm of gutta-percha or more prevents or minimizes microleakage.\textsuperscript{18,19} The length of the post should be at least two-thirds of the clinical root length or at least equivalent to the crown length.\textsuperscript{20} The maximum length of the crown of single-rooted teeth is almost 10.5 mm;\textsuperscript{21} therefore, the minimum length of the post to be placed in the root canal of single-rooted teeth is 10 mm. Since the aim of the present study was to evaluate coronal microleakage in teeth with short roots and the minimum length of remaining gutta-percha is 3 mm to provide adequate seal,\textsuperscript{22} root samples were prepared with a length of 13 mm so that 3 mm of gutta-percha would be left in the apical third of the root canal after post space preparation. Sakaue et al. obturated the root canals with open apices in one group with MTA and in two groups with gutta-percha and a resin-based sealer and a silicone-based sealer. Coronal leakage was evaluated with methylene blue and spectrophotometry. Leakage of dye in the MTA group was significantly less than that in the other two groups at 15- and 30-day intervals.\textsuperscript{23}

Yıldırım et al., evaluated the use of an MTA plug in teeth needing a post. In one group, MTA plug measuring 5 mm in length was placed in the root canal end and in the other group, the root canal was obturated with gutta-percha. After post space preparation, 5 mm of gutta-percha was left at the apical end of the root canal. Fluid diffusion technique was used to evaluate the leakage of root canal obturation materials. The results showed that microleakage of the MTA plug was significantly less than that of 5 mm of gutta-percha,\textsuperscript{24} consistent with the results of the present study. In the present study, the sealing ability of the MTA plug was compared with that of 3 mm of gutta-percha because gutta-percha is the most commonly used root canal obturation material. Although obturation of the root canals is commonly carried out with gutta-percha using lateral compaction technique and it has been considered the gold standard for many years, bubbles may form with the use of this technique, which might remain empty or filled with sealer that might be dissolved over time, compromising the quality of the root canal obturation.\textsuperscript{25,26}

One of the advantages of using MTA plug in teeth with short roots, which need a post, is the fact that there is no need to remove the obturation material from the apical end of the root canal and the root canal walls are not damaged during post space preparation. Another advantage of this technique is the fact that during post space preparation, the gutta-percha at the apical end of the short root canals is not removed accidentally and the seal is not disturbed. One of the disadvantages of this technique is that placing an MTA plug measuring 3 mm in length at the apical end is difficult, especially in posterior teeth. In addition, preparation of the apical portion should be carried out to ≤50 K-file so that adequate space would be created for the penetration of the plugger to the apical portion. Furthermore, the accessory canals are not obturated with the use of this technique. In addition, it is difficult to remove MTA from the apical end of the root canal when retreatment is necessary.

**CONCLUSION**

Based on the results of the present study, the microbial leakage of 3 mm length of MTA plug was significantly less than that of gutta-percha. Therefore, it is suggested that in teeth with short roots, which need a post, MTA plug measuring 3 mm in length should be placed in the apical end of the root canal.

**Financial support and sponsorship**

Nil.

**Conflicts of interest**

There are no conflicts of interest.

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Coronal microleakage of MTA versus gutta-percha

Khademi and Shekarchizade

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