Dental Research Journal

Original Article

Comparison of sealing ability of ProRoot mineral trioxide aggregate, biodentine, and ortho mineral trioxide aggregate for canal obturation by the fluid infiltration technique

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Received: January 2018
Accepted: April 2018

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ABSTRACT

Background: Adequate seal of the root canal is necessary to prevent recontamination and ensure the long-term clinical success. The aim of this study was to evaluate the sealing ability of ProRoot mineral trioxide aggregate (MTA), Biodentine, and Ortho MTA as the root canal obturation materials using the fluid infiltration method.

Materials and Methods: In this *invitro* study a total of 66 extracted human mandibular premolars were randomly divided into five groups according to the material used for the root canal obturation. Group I - ProRoot MTA (20 samples), Group II - Biodentine (20 samples), Group III - Ortho MTA (20 samples), Group IV - negative group (3 samples), and Group V-positive group (3 samples). MTA, Biodentine, and Ortho MTA were applied using a cotton-tipped K-file #30 and hand plugger into the root canals of each group. In Group 4 (negative control), no filling material was used. In Group 5 (positive control), a single gutta-percha size #40 was inserted into the root canal without using a sealer. The teeth were mounted and exposed to the fluid infiltrarion system. Statistical analysis was performed using Kruskal–Wallis test the level of significance was set at $\alpha = 0.05$.

Results: Mean values of microleakage in MTA ProRoot, Biodentine and Ortho MTA groups were 1.83 ± 0.62, 1.95 ± 1.27 and 1.72 ± 0.83 μL in 8 minutes. No statistically significant difference was observed between the sealing ability of ProRoot MTA, Biodentine, and Ortho MTA ($P = 0.091$).

Conclusion: Within the limitations of this study, microleakage values were similar to MTA ProRoot, Biodentine, and Ortho MTA using the fluid infiltration technique.

Key Words: Dental leakage, filtration, mineral trioxide aggregate, root canal filling materials

INTRODUCTION

The main objective of endodontic treatment is elimination or reduction of bacteria from the root canal system and providing a hermetic seal to prevent apical or coronal fluid leakage.[1,2] Studies have shown that the most endodontic failures occur as a result of

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How to cite this article: Mousavi SA, Khademi A, Soltani P, Shahnaseri S, Poorghorban M. Comparison of sealing ability of ProRoot mineral trioxide aggregate, biodentine, and ortho mineral trioxide aggregate for canal obturation by the fluid infiltration technique. Dent Res J 2018;15:XX-XX.

incomplete obturation, lack of three-dimensional seal, and leakage of bacteria and their products.[3] Therefore, the root canal filling material should provide a persistent seal, biocompatibility, adhesion to root canal walls, dimensional stability, insolubility, easy manipulation, short setting time, and radiopacity.[4,5] Recently, it has been suggested that mineral trioxide aggregate (MTA) was able to produce a tight seal with dentin that was superior to many other existing materials.[6] Therefore, its use for a variety of clinical situations in endodontics, including orthograde filling of the entire root canal, was advocated.[7]

MTA is a root canal filling material providing antimicrobial activity, biocompatibility, and sealing ability in the presence of bleeding and moisture.[7] Nonetheless, Vizgirda *et al.* assessed the potential of using MTA as a root canal filling material and suggested that gutta-percha and sealer obturation might provide a superior seal than MTA.[8] MTA contains tricalcium silicate, dicalcium silicate, bismuth oxide, tricalcium aluminate, tetracalcium aluminophyrite, tricalcium oxide, and calcium sulfate dihydrate.[8] Whenever filling the root canal is not possible using the conventional gutta-percha material, MTA can be an effective substitute.[9] Moreover, MTA is commonly known as the material of choice for sealing the root canals in apical surgery[10] and the management of perforations.[11,12]

Researchers have developed a new active calcium silicate-based material named Biodentine (Septodont, Saint Maur des Fossés, France) which claims to have beneficial properties such as excellent sealing ability, biocompatibility, good dimensional stability with the added advantage of short setting time, improved mechanical strength easy manipulation, and quite economical thereby fulfilling the drawbacks of MTA, and therefore, can be thought to be used as a root filling material.[13]

It contains a powder and liquid. The powder mainly contains tricalcium and dicalcium silicate and calcium carbonate. Zirconium dioxide is the contrast medium. The liquid contains calcium chloride serving as a setting accelerator and water reducing agent in aqueous solution with a mixture of polycarboxilate as superplasticizing agent.[14] The material can be applied directly in the cavity as a bulk dentin substitute without any conditioning treatment.[13,14] Studies have shown its biocompatibility, sealing ability, and antimicrobial activity against endodontic pathogens.[13-15] Furthermore, it has been shown to have a positive effect on vital pulp cells and stimulates tertiary dentin formation.[16,17]

Recently, a new type of MTA (Ortho MTA; BioMTA, Seoul, Republic of Korea) has been proposed for use as a root canal filling material.[18,19] According to the manufacturer, Ortho MTA prevents microleakage by forming an interfacing layer of hydroxyapatite between the Ortho MTA and the canal wall. Furthermore, it exhibits a bioactive characteristic; it releases calcium ions through the apical foramen and neutralizes the apical portion of the root, thus forming an interfacial hydroxyapatite layer.[20] The calcium ions released help induce regeneration of the apical periodontium.[18] These characteristics and mechanisms of Ortho MTA are not clear; therefore, more studies about Ortho MTA are required to evaluate its clinical use.

OrthoMTA is mainly composed of tricalcium silicate and contains less heavy metal than the original ProRoot MTA.[18] Yoo *et al.* in 2014 suggested antibacterial effect of orthograde obturation with OrthoMTA in infected root canals.[19]

Several *in vitro* and *in vivo* studies are needed to reveal the different properties of newly introduced dental materials. Therefore, the purpose of this study was to compare the sealing ability of ProRoot MTA, Biodentine, and Ortho MTA. this in-vitro study has been approved in ethics and research committee of Isfahan University of Medical Sciences (NO # 396411).

MATERIALS AND METHODS

This in-vitro study has been approved in ethics and research committee of Isfahan University of Medical Sciences (NO # 396411). A total of 66 single-canal human extracted mandibular premolars were selected for this study. The selected teeth did not have any fractures or resorption and had complete apices. The teeth were soaked in sodium hypochlorite 3% solution for 24 h for disinfection. To facilitate the cleaning and shaping process, the crown of the teeth was cut at the cementoenamel junction by the high-speed handpiece. K-file #10 (Dentsply Meillefer, OK, USA) was inserted in the root canal to the length that its tip was seen in the apex of the tooth. Thereafter, this length was subtracted by 1 mm to reach the working length during the root canal preparation. Step-back technique with hand K-files was followed beginning with an initial K-file #25 to master apical file #40. Shaping was continued to K-file #80. The root canals were then dried using paper points (DiaDent, Seoul, South Korea).

Then, the teeth were divided into five groups as follows: Group 1 consisted of 20 teeth filled with MTA ProRoot (Dentsply, Tulsa, OK, USA); Group 2 consisted of 20 teeth filled with Biodentine (Septodont, Saint Maur des Fossés, France); Group 3 consisted of 20 teeth filled with Ortho MTA (BioMTA, Seoul, Korea); Group 4 as the negative control consisted of 3 teeth without root filling; and Group 5 as the positive control consisted of 3 teeth which were filled by a single gutta-percha point #40 (DiaDent, Seoul, South Korea) and the root surface except the apical foramen was covered with two layers of nail polish.

MTA, Biodentine, and Ortho MTA were mixed according to the manufacturers' instructions to reach the desired consistency and were applied using a cotton-tipped K-file #30 and hand plugger (Dentsply Meillefer, OK, USA) into the root canals. In Group 4 (negative control), no filling material was used. The coronal section of the canal was sealed with the intermediate restorative material (IRM) (ID Caulk, Milford, DE). IRM is a reinforced zinc oxide-eugenol restorative material. In Group 5 (positive control), a single gutta-percha point #40 was inserted into the root canal without using a sealer.

Following filling procedures, all the teeth were wrapped in sterile gauze moistened with sterile normal saline placed in a plastic bag for 7 days. The gauze was moistened with normal saline every day to provide 100% humidity condition. After 7 days, two layers of nail polish were applied to the root surfaces of all teeth to seal any superficial cracks in tooth structure and prevent from the extravasation of fluid. In the experiment groups and the positive control group, the root surface except the apical foramen was covered using nail polish. In the negative control group, nail polish was applied to the entire access cavity and the root surface including the apical foramen. Thereafter, the teeth were mounted and exposed to the fluid infiltration. The fluid infiltration technique is a technique that uses the induction of fluid pressure behind the experimental surface and determination of volume of fluid passed through the surface during certain time. Infiltration duration was recorded for each group. In Figure 1 the system used for the fluid infiltration technique is depicted. Plastic tubes with an internal diameter of 5 and 30 mm length were prepared and attached to the tooth apex as the apex was placed in the tube. The outer surface of the tube in the attachment area was sealed by cyanoacrylate to prevent any potential penetration from this area. After preparation of samples, the fluid level of the pipette (TPC, Thebarton, Australia) is adjusted at zero using a tube attached to a syringe containing colored liquid at the one end and barometer and nitrogen gas capsule system at the other end. The pipette had an accuracy of 0.1 μL and the pressure was set at 50 kPa. Experiment duration for each sample was 10 min. The initial 2 min was for the expansion of the tube attached to the system and maintaining a sustainable condition in the system. After 2 min, the fluid level in the pipette was recorded. After 8 min the final fluid level in the pipette was recorded. The amount of reduction in fluid level was considered as the microleakage as microliter per minutes.

Statistical analysis was performed using Kruskal–Wallis test using Statistical Package for the Social Sciences (SPSS, software version 22, IBM, Chicago, IL, USA). The level of significance was set at $\alpha = 0.05$.

RESULTS

Based on the experiments, the mean values of microleakage in MTA ProRoot, Biodentine, and Ortho MTA groups were 1.83 ± 0.62, 1.95 ± 1.27, and 1.72 ± 0.83 μL during 8 min [Table 1].

Figure 1: Fluid infiltration system.

Table 1: Statistical analysis of mean microleakage (μL/8 min) recorded in all the groups

Filling material	*n*	Mean±SD
Biodentin	20	1.9500±1.27630
Orth MTA	20	1.7250±0.83873
Proroot MTA	20	1.8350±0.62178
Total	60	1.8367±1.32153

MTA: Mineral trioxide aggregate; SD: Standard deviation

Mean values of microleakage in the positive control group were 20 μL during 8 min and in the negative control group was 0.03.

No statistically significant difference was observed between the sealing ability of ProRoot MTA, Biodentine, and Ortho MTA ($P = 0.091$) [Figure 2].

DISCUSSION

The three-dimensional hermetic seal is a primary condition for the success of root canal treatment. Studies have confirmed that the leakage of bacteria and their byproducts from coronal or apical pathways lead to failure of endodontic therapy.[21] Advances in endodontics provided access to novel material to allow the better adaptation of root canal filling material with canal walls and thus less microleakage. The present study compared microleakage of thr three endodontic materials using the fluid infiltration technique. Al-Hezaimi *et al*. suggested that orthograde filling of the root canal with an MTA may be more resistant against leakage than vertically condensed gutta-percha and sealer.[22] These results differ from those of Vizgirda *et al*. who reported that the apical seal produced using the traditional gutta-percha techniques were superior to that produced by an MTA.[8]

Several techniques are available for the determination of microleakage of endodontic material including dye penetration, saliva penetration, bacterial penetration, clarification, spectrophotometry, radioisotope, and fluid infiltration.[23] The fluid infiltration technique was first introduced by Derkson *et al.* and developed by other investigators for endodontic applications.[23,24]

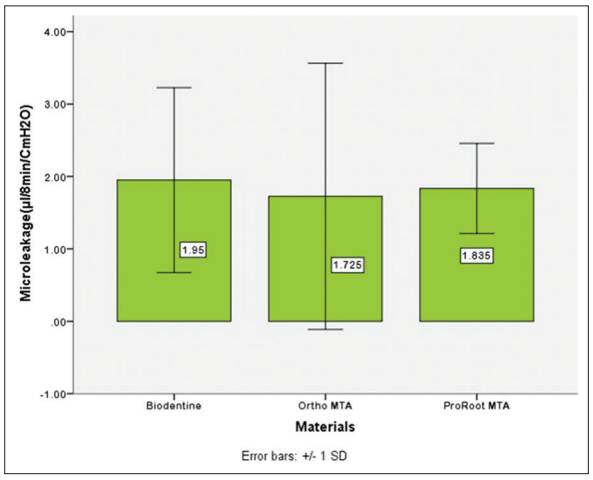

Figure 2: Mean and standard deviation values of microleakage for Biodentine, Ortho, and ProRoot mineral trioxide aggregate.

This technique quantifies microleakage as a continuous amount of volume in a specific period of time due to a certain pressure value. Distilled water or normal saline is neutral fluids which can simulate body fluids and can be incorporated in this method. Another advantage of the fluid infiltration technique is the preservation of the samples that allows repetition of the measurements after some time.[24,25]

According to the findings of this study, ProRoot MTA, Biodentine, and Ortho MTA had similar microleakage amounts. This finding was inconsistent with results of Nikoloudaki *et al.* in which they compared the sealing ability of four endodontic material including Biodentine and MTA.[26] They had used the dye penetration technique for microleakage measurement and stated that microleakage was significantly less in MTA compared to Biodentine. It is worth mentioning that the Ortho MTA was qualitatively superior to handle than both MTA ProRoot and Biodentine.

Moreover, Soundappan *et al.* used scanning electron microscopy to assess the marginal adaptation of Biodentine and MTA and IRM in retrograde root filling. They concluded that both MTA and IRM possess the better marginal adaptation compared to Biodentine.[27] Kokate and Pawar have previously reported that microleakage of Biodentine is significantly less than MTA and gloss ionomer.[28] This result is not in agreement with the results of the study and the study of Nikoloudaki *et al.* or Soundappan *et al.*[26,27] Similarly, Kumar *et al.* in their study concluded that Biodentine possesses the better sealing ability compared to MTA.[29] Furthermore, the results of the study performed by Khandelwal *et al*. show the less microleakage of Biodentine compared to MTA using confocal laser scanning microscope.[30] Different results obtained in these studies can be attributed to different procedures and techniques recruited in each study. However, from a general point of view, studies are suggesting the promising applicability of Biodentine in different procedures within the endodontics field such as perforation repair[31,32] and root-end filling.[33]

Some studies explain the relatively good marginal integrity of Biodentine with the ability of calcium silicate materials to form hydroxyapatite crystals at the surface.[34]

These crystals may potentially increase the sealing ability, especially when formed at the interface of the material and dentinal walls. It is also mentioned that the nanostructure and small size of the forming gel of the calcium silicate material is one of the factors that

influenced the seal ability as this texture allows the material to better spread on the surface of the dentine. Slight expansion is also noted as an influential contributing to its better adaptation.[35]

As Biodentine is a relatively novel dental material, inconsistencies in the findings of different studies indicate the need for further investigations. The properties of Biodentine for endodontic applications have been evaluated at *in vitro* environment. Moreover, there have been isolated reports published in short communications (ideas, editorials, and expert opinions) regarding the clinical applications of Biodentine.[33]

Ortho MTA was introduced for orthograde root canal filling, perforation repair, and retrograde filling. The manufacturer claims that Ortho MTA has similar components as ProRoot MTA but less heavy metal contents than ProRoot MTA.[18]

OrthoMTA is relatively cheap and easy to manipulate. Ortho MTA developed mainly for orthograde root canal obturations as well as retrograde fillings and perforation repairs, consists of tricalcium silicate, dicalcium silicate, tricalcium aluminate, tetracalcium aluminoferrite, gypsum, free calcium oxide, and bismuth oxide. It also has a bioactive characteristic.[20]

The orthograde techniques with OrthoMTA have resulted in a considerable improvement in the quality of orthograde root canal filling and significantly improved the success rate,[18] but in this study, there was no statistically significant difference between Ortho MTA and the other two groups. Extrapolation of the results of this study to clinical situations should be done with caution. The clinician should also know that the application of Ortho MTA, biodentine, and ProRoot MTA for orthograde root canal obturation may present some clinical disadvantages. First, preparation for the postspace is often required immediately following the canal filling for restoration purposes. This procedure may be harder to perform when these materials mix is still soft. Second, once completely set, MTA and MTA-like materials are difficult to retrieve from the root canal. This may impose surgical intervention even in cases where nonsurgical retreatment could have been indicated. It has been recognized that for retreatment purpose, apical surgery should be performed only as a secondary effort to salvage failed endodontic treatment.[36]

CONCLUSION

based on the results of this study, microleakage values were similar in ProRoot MTA, Biodentine, and OrthoMTA using the fluid infiltration technique. However, further studies are required for consolidating this finding.

Acknowledgment

Contributors of this study sincerely acknowledge Dr. Aziz Moraditalab for his help and support in the implementation of the fluid infiltration procedure.

Financial support and sponsorship

Nil.

Conflicts of interest

The authors of this manuscript declared that they have no conflicts of interest, real or perceived, and financial or nonfinancial in this article.

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