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Evaluation of sealing abilitiy of mineral trioxide aggregate mixed with propylene glycol as a root canal sealer: A *in vitro* study

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ABSTRACT

Background: Sealing ability is one of the most important features of endodontic sealers. The main goal of the present study was to compare sealing ability of mineral trioxide aggregate (MTA)-propylene glycol (PG) with two commonly used resin-based and MTA-based sealers.

Materials and Methods: In This *in vitro* study Seventy extracted single-root teeth were used. Canal preparation was carried out using hand and RaCe rotary files. Ten teeth were used as control. The root canals in positive and negative control groups were left empty. Remaining 60 teeth were randomly divided into following four groups (n = 15): In Group 1, the canals were dried using paper cones and obturated using MTA-PG sealer. In Group 2, saline was removed from canal using a syring, but paper cones were not used. Obturation was done using MTA-PG sealer. In Groups 3 and 4, the canals were dried using paper cones and obturated with AH26 and MTA Fillapex, respectively. Two-chamber method was used to evaluate bacterial leakage using *Enterococcus faecalis* (ATCC 29212). Turbidity of the lower chambers was checked every day during 90 days. Chi-square, Kaplan–Meier analysis, and logrank tests were used to compare groups regarding leaked samples at the end of the study. The level of significance was set at 0.05.

Results: There was no significant difference among groups regarding rate of leakage throughout the study. However, at the end of the study, the groups were statistically different regarding leaked samples (P = 0.034). MTA Fillapex and MTA-PG in dry canal showed the most and least leaked samples at the end of the study, respectively (P < 0.05).

Conclusion: MTA mixed with PG has superior sealing ability than MTA Fillapex.

Key Words: Dental leakage, mineral trioxide aggregate, propylene glycol, sealing

INTRODUCTION

Mineral trioxide aggregate (MTA) has several desirable properties such as high biocompatibility and low cytotoxicity,[1] release of calcium hydroxide ($Ca(OH)_2$),[2] sealing ability against the bacteria and saliva,[3] antibacterial features,[4] ability of setting in the presence of bleeding or serum,[5] adequate compressive strength, and acceptable hardness.[4] Thus, it has been one of the commonly used biomaterials in endodontics.

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Despite these advantages, long setting time[4] and difficult manipulation[2] are the drawbacks of MTA. To improve these properties, some changes have been made in its liquid or powder.[6-8] One of the materials that have been mixed with MTA to enhance its manipulation is propylene glycol.[7,9]

Propylene glycol (1,2-propanediol) (PG) is a dihydric alcohol without toxicity, carcinogenicity, or genotoxicity.[10] One of the vital properties of PG is its suitable consistency which results in better handling of materials.[7] Furthermore, studies have shown that PG has antibacterial characteristics against the bacteria involved in endodontic infections.[11] In addition, the dentine penetration of PG is more than distilled water (DW).[10] Furthermore, mixing $Ca(OH)_2$ with PG resulted in improved release of Ca^{2+} and OH and increased pH of dentin and cementum.[12] According to these desirable properties of PG, several studies have investigated the use of this material to improve handling of MTA.[6,8]

Aforementioned favorable properties of MTA persuaded researchers to use it as a root canal sealer; however, sandy consistency of MTA mixed with water makes it unsuitable as a sealer. Mixing MTA with PG causes improved consistency with low film thickness and facilitates its insertion in the root canal. Hence, this mixture may potentially be used as a sealer. Studies evaluating MTA-based sealers such as MTA Fillapex have shown disadvantages like higher cytotoxicity and lower sealing in comparison to resin-based sealers,[13,14] and furthermore, some studies reported lower biocompatibility of MTA Fillapex than MTA.[15] These drawbacks have been attributed to low percentage of MTA in the sealer composition and presence of resin and other additives.[13,14]

The main goal of the present study was to compare sealing ability of MTA-PG with two commonly used resin- (AH26) and MTA-based (MTA Fillapex) sealers.

MTA and PG both have hydrophilic characteristics, and studies have suggested that moisture is needed for the setting of MTA-based sealers.[16] If MTA is used as a sealer (e.g., MTA-PG or MTA-based sealers), complete drying the canal before sealer placement may theoretically inhibit complete setting.[17] Nagas *et al*.[17] showed that the canal drying technique influenced the bond strength between MTA-based sealers and dentine. This was also confirmed by Tasdemir *et al*.[16] They proposed that it may be advantageous to leave canals slightly wet before obturating with MTA-based sealers. The question is whether canal drying technique influence sealing ability of MTA-based sealers. There is no study in literature to answer this question. Therefore, the second goal of the present study was to evaluate the effect of canal moisture on sealing ability of MTA-PG sealer.

MATERIALS AND METHODS

This *in vitro* study was approved by the Research and Ethics Committee of Tabriz University of Medical Sciences. Seventy extracted human single-rooted premolar teeth extracted for periodontal reasons were selected for this study. All the teeth had mature single straight roots, with no root caries, previous endodontic treatments or anomalies. Furthermore, the teeth with cracks or fractures and pulp chamber or canal calcifications were excluded. Following extraction, each tooth was stored in 3% chloramine-T solution at 4°C. The external root surface was cleaned with ultrasonic tips to remove the remnants of periodontal tissues. The coronal portions of the teeth were then dissected to achieve the root lengths of 15 mm. Teeth were selected with apical foramina approximately matching the size of #30 K-Flexofile (Dentsply, Maillefer, Ballaigues, Switzerland). The working length was determined with #15 K-Flexofile, 1 mm from the radiographic apex. All the root canals were prepared in a crown down manner using #4 and 3 Gates-Glidden drills (Dentsply, Maillefer, Ballaigues, Switzerland) for coronal two-thirds preparations, followed by the use of 40/0.10, 35/0.08, 25/0.04, 25/0.06, 30/0.06, and 35/0.06 RaCe rotary instruments (FKG Dentaire, La Chaux-de-Fonds, Switzerland). The size of master apical file was ascertained at #35. Each canal was irrigated with 2.5% NaOCl (Taj Corp, Tehran, IRI) throughout the instrumentation sequence. The smear layer was removed using 1 mL of 17% ethylenediaminetetraacetic acid (Pulpdent Corp., Watertown, MA, USA) for 3 min, followed by a rinse with 1 mL of 5.25% NaOCl for 3 min. Finally, the canals were irrigated with 5 mL of normal saline (injection pharmaceutical products company, Tehran, Iran) solution.[12]

Experimental groups

The 70 samples were randomly divided into four experimental groups (n = 15) and one positive

control and negative control groups (n = 5). The experimental groups were subjected to each of the following experimental treatment protocols: Group 1: after drying the canal with paper point (Meta Biomed, Korea, Iran) and MTA (Angelus, Londrina, Brazil) +50% PG (Merck, Germany) and 50% DW was placed in the root canals by a lentulo size #40. Then, the Gutta-percha cones were coated with sealer, and the canals were obturated with Gutta-percha (Gapadent, Korea) and MTA-PG sealer using a lateral condensation technique. Group 2: the normal saline existing in the canals was removed using a 2 mL syringe (Ava Luer lock, Tehran, Iran) and 27G needle (Ava pezeshk, Tehran, Iran). However, paper point was not used for drying the canals. Other procedures were performed same as Group 1. In Groups 3 and 4, the treatment protocols were carried out same as Group 1, but the sealers were AH26 (Dentsply, DeTrey, Konstanz, Germany) and MTA Fillapex (Angelus, Londrina, Brazil), respectively. The DW/PG ratios were determined by volume, and the powder/liquid ratio was the same for Groups 1 and 2 (1 g powder to 0.33 mL liquid). The root canals in positive and negative control groups were left empty. All the root surfaces of the teeth were covered with two layers of cyanoacrylate adhesive (Super Bonder, Loctite) except for 2 mm of apical portion. In the negative control, the specimens were completely sealed with two layers of cyanoacrylate adhesive. After that, the samples were stored at 37°C and 100% humidity for 48 h.

Bacterial leakage test

A double-chamber method was used for evaluating the sealing ability of the samples. Each tooth was inserted in a plastic microtube (0.5 mm × 1.5 mm) that worked as a bacterial reservoir. The tube end was pierced to make the root end come out of the tube. The interfaces between the teeth and the tube holes were sealed with cyanoacrylate adhesive (Super Bonder, Loctite). The system (tooth inserted in a plastic tube) was autoclaved at 15 psi and 121°C for 15 min and placed in a sterilized 50 ml glass flask containing 10 ml sterile brain–heart infusion broth (BHI-Oxid Ltd, Hanks, USA) in a way that the 2 mm root end was placed in the BHI broth. The interface between the tube and glass flask was also sealed with cyanoacrylate adhesive. Then, the samples were incubated in 37°C for 7 days. In this time period, any samples of BHI broth which had become turbid was excluded from the study.

A bacterial suspension of *Enterococcus faecalis* (ATCC 29212, Reference Laboratories of Iran Research Center, Tehran, Iran) at concentration of 0.5×10^8 CFU/mL was used. 0.1 mL of the bacterial suspension was injected in the pulp chamber of the teeth existing in the microtubes every other day. The whole system was incubated at 37°C for 90 days, and the BHI turbidity was evaluated every day. The turbid solutions were recorded as positive leakage and the date also recorded.[12]

Statistical analysis

Statistical analysis was performed using SPSS software (SPSS version 20.0, SPSS, Chicago, IL, USA). Kaplan–Meier analysis and logrank test were used to compare the rate of bacterial leakage between groups. Chi-square test was used to compare groups regarding leaked samples at the end of the study. The level of significance was set at 0.05.

RESULTS

The positive control group showed leakage in all specimens in the first 24 h while the negative control group showed no sample with leakage at the end of 90 days. At the end of the study, the groups were statistically different regarding the number of samples that showed leakage (P = 0.034) [Table 1]. According to Table 1, MTA Fillapex (93.3%) and MTA-PG (46.7%) showed the most and the least number of samples with leakage in dry canals at the end of the study period ($P < 0.05$). However, there was not any significant difference among groups regarding rate of leakage during study (P = 0.519) [Figure 1].

DISCUSSION

Sealing properties of root canal sealers have vital role in success of endodontic treatment. Ideally, the root canal obturating materials should be biocompatible and seal the root canal system.[18] Several studies have evaluated the efficacy of mixture of MTA with different vehicles, to improve the characteristics of MTA-based sealers.[16,18] According to the previous studies indicating desirable PG properties as a vehicle,[9,10] this study compared sealing ability of MTA-PG with two commonly used resin- (AH26) and MTA-based (MTA Fillapex) sealers using bacterial leakage test.

Several methods such as electrochemical leakage,[19] dye leakage,[20] fluid infiltration,[21] protein leakage

Table 1: Number (percentage) of samples with leakage at the end of 90 days

Study groups	MTA-PG in dry canals	MTA-PG in wet canals	MTA fillapex	AH26
n (%) of samples with leakage	7 (46.7%)[a,*]	12 (80%)[a,b]	10 (66.7%)[a,b]	14 (93.3%)[b]

*The different superscript letters show the statistically significant difference. MTA: Mineral trioxide aggregate, PG: Propylene glycole

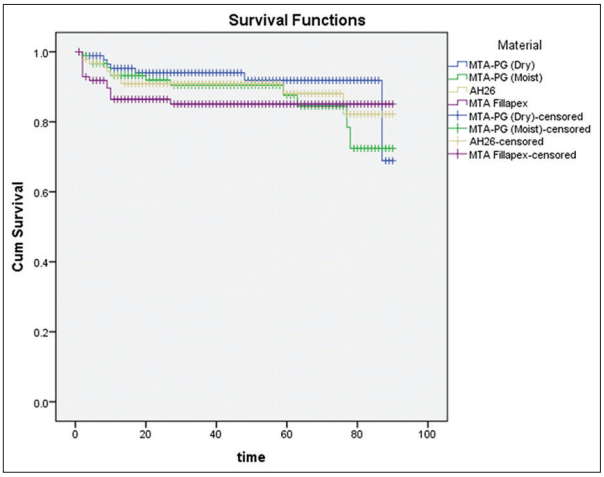

Figure 1: The rate of bacterial leakage in study groups during 90 days of study. CUM: Cumulative.

test,[3,22] and bacterial leakage[12] have been used to evaluate leakage in various studies. The present study used bacterial leakage test since this model most closely simulates clinical situation.[22]

Various bacteria species have been used to assess the bacterial penetration in different studies.[23,24] In this leakage study, *E. faecalis* was evaluated. This microorganism is commonly isolated pathogen in persistent endodontic infections.[25] Furthermore, *E. faecalis* is a highly resistant bacteria, and it grows without synergic supports. Furthermore, it has been widely used in previous bacterial leakage studies.[18,26]

The results of the present study showed that although the leakage of MTA-PG in dry canals was lower than canals with moisture, the difference was not statistically significant. Ehsani *et al*.[27] reported contrasting results about MTA-based sealers (MTA Fillapex) and stated that moisture could negatively affect the sealing of all sealers except for MTA-based sealers. In contrast, Nagas *et al*.[17] and Tasdemir *et al*.[16] in two different studies concluded that the canal moisture significantly affects the bond strength of MTA-based sealers to root dentin, and canals with mild moisture had the highest bond strength.

According to the results of this study, although the leakage of MTA Fillapex was more than AH26 at the end of the study, the difference was not statistically significant. In concordance, Reyhani *et al*.[28] showed similar results. However, Sönmez *et al*.[29] in a study with dye penetration method reported that the leakage of MTA Fillapex was significantly more than MTA and AH26. Furthermore, Razavian *et al*.[14] and Oliveira *et al*.[18] in two different bacterial leakage studies demonstrated that the sealing ability of AH26 was significantly better than MTA Fillapex. This contrast may be attributed to the smaller sample size in the present study.

In this study, MTA-PG (46.7% leakage) showed significantly better sealing ability in dry canals in comparison to MTA Fillapex sealer (93.3%). This superiority of MTA-PG may be attributed to higher amount of MTA in the composition of MTA-PG. Furthermore, Brito-Júnior *et al*.[12] showed that adding PG to MTA increased its sealing ability in furcal perforations. These advantages of MTA-PG were attributed to the better homogeneity and decrease in cement porosity.[12] Furthermore, the other possible reason of improved sealing ability of PG-MTA is that this mixture may expand on setting.[30]

The present study showed promising results about the sealing ability of MTA-PG mixture as a root canal sealer. However, further studies including animal studies and also with other bacterial species of oral flora are necessary.

CONCLUSION

Based on the results of this *in vitro* study, MTA mixed with PG has superior sealing ability than MTA Fillapex, and the root canal moisture has no significant effect on the bacterial leakage.

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Conflicts of interest

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

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