Original Article

Effect of Root Resection on Sealing Ability of Orthograde Apical Plugs of Mineral Trioxide Aggregate and Calcium Enriched Mixture

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Abstract

Objective: There is some concern that root resection may alter the seal of the previously set orthograde material. The aim of this study was to evaluate the apical sealing ability of orthograde mineral trioxide aggregate (MTA) and calcium enriched mixture (CEM) plugs after resection of the roots.

Materials and Methods: The fluid filtration method was carried out on a total of 51 roots in three experimental (n=15) and two control (n=3) groups. The root canals were prepared 3 mm shorter than the working length. In groups A and B, 4 mm of MTA and CEM were placed in an orthograde technique, respectively, and after setting, 3 mm of the root end was resected. In group C, the apical 3 mm of each root was resected, root end preparation was carried out to a depth of 3 mm and filled with MTA. Apical microleakage values of each group were measured. Data was analyzed using Kruskal-Wallis test.

Results: Means and standard deviations of apical microleakage in groups A (MTA orthograde), B (CEM orthograde) and C (MTA retrograde) were 2.31×10^{-4} (0.32×10^{-4}), 3.33×10^{-4} (0.29×10^{-4}) and 4.42×10^{-4} (0.40×10^{-4}) $\mu l.min^{-1}.cmH2o^{-1}$, respectively. The mean values were greater in group C; however, statistical analysis revealed no significant differences between these groups (P>0.05).

Conclusion: Based on the results of this study, when there is an orthograde access to the root canal and surgery is likely to be necessary in the future, MTA and CEM can be placed in an orthograde technique and it just resects the root during surgery.

Key Words: Dental Leakage; Mineral Trioxide Aggregate; Retrograde Obturation; Root Canal Filling Material

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INTRODUCTION

Incomplete obturation of the root canal system and presence of communication between the root canal system and its surrounding tissues can lead to failure in endodontic treatment [1]. Orthograde or retrograde filling materials should three-dimensionally seal the root canal. Occasionally, when nonsurgical root canal treatment fails, endodontic surgery may be required. Several different materials have been recommended as root-end filling materials, including amalgam, zinc oxide-eugenol, glass-ionomer cements, composite resins and more recently, mineral trioxide aggregate (MTA) [2–5]. MTA has various clinical advantages, such as superior sealing ability [6,7], setting in a moist environment [8], biocompatibility [9] and bactericidal activity [10]. Unfortunately, delayed setting time and poor handling characteristics are the disadvantages of this material as a root-end filling material. In addition, it tends to be washed out easily [11,12].

Recently, a calcium-containing cement has been introduced to dentistry, referred to as calcium enriched mixture (CEM). Asgary et al. showed that CEM comprises water-soluble calcium and phosphate and forms hydroxyapatite after setting [13]. The clinical uses of CEM are the same as those of MTA; they have similar working time, PH and dimensional stability [14]. In another study, Asgary et al. [15] showed that CEM has significantly better antibacterial properties compared to MTA. CEM can induce hard tissue healing [16], sets in humid environments and has appropriate setting time, good handling characteristics [17] and an excellent seal when used as a root-end filling material [18].

In some conditions in which anatomic access and retrofilling are difficult or impossible during periradicular surgery, and in cases requiring nonsurgical retreatment, in which the root canal is obstructed and access up to the working length is impossible, the obturating material can be placed via an orthograde technique, while nonsurgical retreatment is performed. In these instances, if periradicular surgery is subsequently required, the clinician may elect to resect the root end and expose the previously set MTA, rather than placing new MTA, as a root-end filling material [19]. This way, root-end preparation and filling is no longer required and the stages of surgery are simplified and performed faster than conventional methods. There is some concern that root resection may alter the seal of the previously set orthograde material [19].

The aim of this study was to assess the sealing ability of orthograde MTA and CEM in resected roots with fluid filtration method and to compare it with retrograde MTA during conventional periradicular surgery.

MATERIALS AND METHODS

A) Tooth preparation

Fifty-one extracted human maxillary anterior teeth, with closed apices, single and straight root canals, without cracks, caries, restorations and resorption, were selected. The teeth were stored in normal saline solution and kept moist before and during the study. To maintain uniformity of the root canal lengths, the teeth were cross-sectioned at the CEJ with a carborundum disk (Brasseler USA, Savanna, GA) to obtain 15-mm-long roots. Working length was determined by reducing 1mm from a #10 K-file (Dentsply Maillefer, Switzerland) visible at the apex. The root canals were instrumented up to a #40 master apical file, 3 mm shorter than the working length using the step-back technique and the coronal portions were flared using Gates-Glidden drills # 2, 3 and 4 (Dentsply Maillefer, Ballaigues, Switzerland). The root canals were irrigated with 1 mL of 5.25% sodium hypochlorite as an irrigant between each file. To remove the smear layer from the canal walls, each specimen was irrigated with 1 mL of 17% EDTA (Ariadent, Asia Chemi Teb, Tehran, Iran), which was left in the canal for 1 minute, followed by a final rinse with 3 mL of 5.25% sodium hypochlorite solution. The root canals were completely dried with paper points (Aria Dent, Tehran, Iran) before obturation.

B) Obturation of the canals

The specimens were divided into three equal experimental groups of 15 with simple randomization. Two control groups of three teeth each (one sample in the positive control group and one sample in the negative control group for each experimental group) were prepared too.

In the experimental groups A and B, MTA (ProRoot; Tulsa Dental, Tulsa, OK, USA) and CEM (CEM Cement, Yektaz Dandan; Bionique Dent, Tehran, Iran) were mixed according to manufacturers' instructions and placed in the canal in an orthograde direction with a messing gun (needle gauge# 1mm) (Endogun; Medidenta, Woodside, NY, USA) and applied within the canal with an endodontic plugger (size# B) (Hu-Friedy, Chicago, IL, USA) to create an apical plug measuring 4 mm in thickness, 3 mm shorter than the working length. Radiographs were taken to ensure void-free placement and plug thickness. The remaining canal space was left unfilled, but a cotton pellet moistened with saline was placed in contact with the materials. The coronal seal was established by 2-3 mm of Cavit (Premier Dental, King of Prussia, Pa). The samples were stored in an incubator at 37°C and relative humidity for 48 hours. After setting the material, the 3-mm root-end portions of each sample in both groups were resected perpendicular to the long axis of the root to expose the previously set material. Finally, there should be a 4-mm-thick plug of both materials in the apical part of the resected roots. Another radiograph was taken in this step to ensure the thickness and absence of vacuity in the root canal.

In the experimental group C, the apical 3 mm of each sample was resected perpendicular to the long axis of the tooth and the root end was prepared to a depth of 3 mm using ultrasonic tip (CPR-2D) powered by an ultrasonic unit (Spartan, Fenton, MO, USA). To provide an intracanal matrix to condense the root-end filling material against, a customized gutta-percha cone (Ariadent, Iran) was prepared and adapted to the apical part of the canal, leaving a root-end void of 3 mm, which was confirmed by a periodontal probe and radiographs. The canals and the cavities were dried with sterile paper points and MTA was mixed according to the manufacturer's recommendations and placed in the root-end cavity with a messing gun and condensed with endodontic pluggers. After the cavity was completely filled, the intracanal barrier was replaced with moistened paper points and the density and depth of the filling material was verified by radiography. Finally, the teeth were temporarily sealed. This group served as a gold standard.

Three samples that were instrumented, but not obturated were used as the positive control group, but in the negative controls, the canals were obturated according to each experimental group; group A with 4 mm MTA orthograde, group B with 4 mm CEM orthograde and group C with 3 mm MTA retrograde.

Two layers of nail varnish were applied to the surfaces of all the teeth in the experimental and positive control groups, excluding the 3-mm apical portion and the access cavity. In the negative control groups, the entire root surfaces were covered with two layers of nail varnish, except for the access cavity. All the nail varnish layers were covered with Parafilm tapes (Parafilm "M", Laboratory Film, Chicago, USA) for double sealing.

C) Evaluation of the leakage

The method used in this study for fluid filtration measurements was previously described by Javidi et al. [20]. The apical parts of the specimens were inserted into a plastic tube (Guihua, China), measuring 5 mm in diameter and 4 cm in length, from the apical end and cyanoacrylate glue (Zapit, Dental Venture of America, Anaheim Hills, CA) was applied circumferentially between the Parafilm tapes on the outer root surface and the plastic tube. The plastic tube was attached to a micropipette (Microcaps, Fisher Scientific, Philadelphia, PA) via a tri-valve tube and all the system was filled with distilled water.

The fluid filtration system measured water movement through the obturated root canal under a constant pressure of 0.5 Atm by monitoring the movement of an air bubble within the micropipette.

An oxygen tank equipped with a manometer (to precise adjustment of pressure) was utilized. The movement of the air bubble was measured in mm/min and by using the volume of the micropipette, this was converted to µL/min. Apical sealing ability of each sample was measured at 2-minute intervals for a duration of 8 minutes and the average value was recorded. The amount of microleakage was expressed as µL/min/cmH_2O. Statistical analysis of the data was accomplished using Kruskal-Wallis test. Statistical significance was defined at $P<0.05$.

RESULTS

Apical microleakage values (means and standard deviations) of the groups A (MTA orthograde), B (CEM orthograde) and C (MTA retrograde) were $2.31\times10\text{-}^{4}$ (0.32×10^{-4}), 3.33×10^{-4} (0.29×10^{-4}) and 4.42×10^{-4} (0.40×10^{-4}) $\mu l.min^{-1}.cmH2o^{-1}$, respectively (Table 1). The positive controls showed an excessive amount of leakage, significantly more than the experimental groups, while the specimens in the negative control group showed no microleakage. All of the three experimental groups demonstrated apical leakage. Kruskal-Wallis test showed no significant differences between the groups ($p= 0.154$); however, group C exhibited more leakage than the other groups.

DISCUSSION

MTA is currently used as a root-end filling material [21]. MTA may also be placed either as an apical plug or to obturate the entire root canal using an orthograde technique [19]. In these instances, if periradicular surgery is subsequently required, the root-end fragment may be resected and the previously set material will be exposed [19].

The sealing ability of various orthograde or retrograde filling materials have been assessed by dye, radioisotope, and bacterial penetration, scanning electron microscopy, electrochemical, and fluid filtration techniques [22].

This in vitro study evaluated the effect of root resection on the sealing ability of orthograde MTA and CEM plugs compared to conventional MTA retrofillings by using a fluid filtration device.

The validity and reliability of the device used in this study is proved by Javidi et al. [20]. No significant differences were observed between the apical seal of resected MTA- and CEM-placed orthograde and the apical seal of MTA-placed retrograde as a root-end filling.

These findings corroborate with previous findings of Andelin et al. [19] and Milani et al. [23].

Milani et al evaluated the sealing ability of two retrofilled groups of MTA and CEM and two groups with apical plugs of these materials by dye leakage method. The resected groups showed more microleakage than the retrofilled groups, which was significant in CEM groups.

Table 1. Mean (SD) (×1000) apical microleakage values of three experimental groups as $\mu l.min^{-1}.cmH_2o^{-1}$

Group	N	Material/Technique	Mean (SD)
A	15	MTA orthograde	$2.31\times10^{--4}$ (0.32×10^{-4})
B	15	CEM orthograde	3.33×10^{-4} (0.29×10^{-4})
C	15	MTA retrograde	4.42×10^{-4} (0.40×10^{-4})

They concluded that root-end resection increases microleakage of CEM, but the sealing ability of MTA is not affected by root resection. They also reported less microleakage in CEM compared to MTA, with no significant differences [23], consistent with the results of this study, in which there were no significant differences in sealing abilities of MTA and CEM orthograde apical plugs. It is pertinent to point out that in the present study, MTA and CEM were utilized alone in the root canals and the remainder of the canal was left empty. Although this practice is a departure from what would have been done clinically, this design was adopted to evaluate the definite microleakage of obturating materials without interfering with the sealing capacity of gutta-percha and sealer. This method has also been used by other investigators [24, 25]. In addition, in retrograde fillings the moisture absorbs from the end of the root not from the internal of the root, but in the present study moistened paper points were placed in the root canal to assimilate with the other groups. In the present study, based on a study by Hachmeister et al. [26], apical plugs measuring 4 mm in thickness were used, Hong [25] and de Leimburg [27] also used plugs measuring 2 mm and 1, 2 and 3 mm in thickness, respectively, reporting that all had acceptable seal. Lamb et al. [28] evaluated the minimum thickness of MTA apical plug to provide an acceptable seal after root resection. They reported that root resection did not significantly influence the sealing ability of MTA when at least 3 mm of the material was left in the canal. Their findings are consistent with those of the current study, in which resection of the 4-mm apical plug did not affect the sealing properties of the material. Martin et al. [29] compared the sealing ability of a 3-5-mm-thick MTA apical plug with the whole-canal orthograde MTA fillings and concluded that the whole-canal obturation technique provided a better seal during the first 48 hours.

It is clear that increasing the plug thickness may improve resistance to leakage. In the present study, the thickness of orthograde fillings (MTA and CEM) was 4mm, but retrograde MTA was 3mm in depth. Ultrasonic tips are 3mm in height that produce the minimum accepted thickness (3mm) for retrograde fillings and the clinicians have no opportunity to increase it.

In orthograde fillings, the operator can even prepare the whole canal for fillings. We choose 4mm thickness to assimilate with the retrograde group, because when the root was resected it might cut some of the fillings too.

The fluid filtration system, originally described by Derkson et al. [30], has been demonstrated to be an acceptable method for microleakage assessment and it is widely used to test the sealing ability of various materials in endodontics [7,31,32].

This technique provides a quantitative measurement of microleakage over a period of time and is a non-destructive method that allows repeated evaluation of leakage of the same samples [33].

However, there is no standardization in the materials and methods of this technique. Besides, the equipment and devices may not be found everywhere [20].

In the present study, microleakage of each sample was measured at 2-minute intervals for 8 minutes, similar to the methods used by Yildirim et al. [24], Lamb et al. [28], Yatsushiro et al. [31] and Garip et al. [33]. The fluid filtration test was conducted under 0.5 atmospheric constant pressure according to a previous study by the authors [20,34].

As a clinical consideration, an important issue is the healing process after using set or fresh MTA, which has been assessed in some studies [34, 35]. In an in vivo study, Habibi et al. [34] declared that there were no significant differences between healing processes and hard tissue formation with the use of set and fresh MTA during surgery on cat teeth.

Apaydin et al. [35] compared the healing processes and extent of cementum deposition on the resected set MTA with those of fresh MTA as a root-end filling material in dogs. Based on their results, it appears that fresh MTA is more inductive than resected set MTA. However, the presence of resected set MTA adjacent to periradicular tissues did not prevent regeneration of these tissues in the majority of cases.

CONCLUSION

Based on the results of this study it appears that the sealing ability of MTA and CEM placed in an orthograde technique and allowed to set is not affected by root-end resection. This may prove to be beneficial in cases where difficult access and isolation might prevent placement of MTA as a root-end filling material.

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