Journal of Oral Science, Vol. 50, No. 3, 273-277, 2008

Original

Comparison of microleakage with three different thicknesses of mineral trioxide aggregate as root-end filling material

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(Received 8 January and accepted 12 June 2008)

Abstract: The aim of this study was to compare the microleakage at three different thicknesses of mineral trioxide aggregate (MTA) as a root-end filling material. Ninety extracted human maxillary incisor teeth were selected and the root canals of the teeth were cleaned, shaped and obturated with gutta percha and AH-plus sealer. Teeth were randomly divided into 3 groups each containing 20 experimental samples, and 5 positive and 5 negative controls. In the first, second and third experimental groups, cavities of 1 mm, 2 mm and 3 mm in depth, respectively, were prepared and filled with MTA. Leakage was determined by the dye penetration method using India ink, and a stereomicroscope at ×16 magnifications and 0.1 mm accuracy. The microleakage in the 3-mm and 2-mm root-end cavities was less than at 1 mm depth, but analysis of variance revealed no significant differences among the three different thicknesses. (J. Oral Sci. 50, 273-277, 2008)

Keywords: MTA; retrograde; root-end filling material; microleakage.

Introduction

Three-dimensional obturation of the radicular space is essential to the long-term success of endodontic treatment, and the root canal system should be sealed apically, coronally and laterally. Unfortunately, all presently used materials and techniques result in leakage (1). Although nonsurgical endodontic treatment gives good results in most cases, surgery may be indicated for teeth with persistent periradicular pathoses that have not responded to nonsurgical approaches. The surgical procedure is most likely to be successful if the remaining canal system has been thoroughly cleaned and shaped to eliminate microorganisms and irritants (2,3).

Root-end cavity preparation is a crucial step in the establishment of an apical seal in periradicular surgery. The ideal preparation is a Class I cavity prepared along the long axis of the tooth to a depth of at least 3 mm. Many materials have been used as root-end fillings; including zinc oxide-eugenol cements (IRM and Super-EBA), glass ionomer cement, polyvinyl resins (Diaket), composite resins (Retroplast), resin-glass ionomer hybrids (Geristore) and mineral trioxide aggregate (ProRoot MTA). MTA (Dentsply, Tulsa Dental, OK, USA), a material developed specifically as a root-end filling, has undergone numerous in vitro and in vivo investigations comparing its various properties to Super-EBA, IRM and amalgam. When in vitro leakage models were used, MTA prevented leakage as well as composite resin and GIC (4-7). However, the setting and subsequent leakage of MTA are not affected by the presence of blood (8). Torabinejad et al. (9) developed the original product (gray MTA). The main constituents of this material are calcium silicate ($CaSiO_4$), bismuth oxide ($BisO_3$), calcium carbonate ($CaCO_3$), calcium sulfate ($CaSO_4$) and calcium aluminate ($CaAl_2O_4$). Hydration of the powder produces a colloidal gel that solidifies into a hard structure consisting of discrete crystals in an amorphous matrix. The crystals are composed of calcium oxide, and the amorphous region is composed of 33% calcium, 49% phosphate, 2% carbon, 3% chloride and 6% silica (10).

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MTA as a root-end filling material and material for the repair of lateral root perforation shows less leakage than amalgam, Super-EBA and IRM (11-15). However, there is limited data on the microleakage of MTA at different thicknesses. Therefore, the aim of this study was to compare the microleakage of MTA as a root-end filling material at three different thicknesses.

Materials and Methods

Ninety extracted human maxillary incisor teeth without resorption, cracks, calcification or fractures in the apical third, and with intact apexes, were used in this study. Working length was established using a K-type file #15 (Mani, Utsunomiya, Japan) at the apical foramen minus 1 mm in all groups. The tooth canals were prepared up to size #40 and shaped up to size #60 using step-back technique. All canals were filled with gutta percha (Aria-Dent, Tehran, Iran) and AH-plus (Dentsply, Konstanz, Germany) sealer using the lateral compaction technique. Teeth were kept in 37°C and 100% humidity for 48 hours. The apical 3 mm of each root was removed perpendicular to the long axis of the tooth with a diamond bur (D&Z, Darmstadt, Germany) using water and air spray. Teeth were randomly divided into 3 groups each containing 20 experimental samples, and 5 positive and 5 negative controls.

Experimental groups

Group 1: In 30 teeth, root-end cavities were prepared to a depth of 1 mm perpendicular to the long axis using ultrasonic retrotips CT-5 (Spartan, Missouri, USA)
Group 2: In 30 teeth, root-end cavities were prepared to a depth of 2 mm perpendicular to the long axis using ultrasonic retrotips CT-5.
Group 3: In 30 teeth, root-end cavities were prepared to a depth of 3 mm perpendicular to the long axis using ultrasonic retrotips CT-5.

MTA was prepared according to manufacturer's directions, and teeth in all experimental groups were filled with MTA using a small plastic amalgam-type carrier (Kerr Hawe, Orange, CA, USA). The quality of root-end filling was conformed by taking radiographs in two directions (mesio-distal and bucco-lingual) (Figs. 1A, B and C), while in control groups, the root-end cavities remained empty. In all experimental and positive control groups, the whole surface of the teeth except for apical portion, was covered with two layers of nail polish (Fig. 1A, B, C and D). In negative control groups, the whole surface of the teeth was covered with two layers of nail polish (Fig. 1E).

All teeth were kept at 37°C and 100% humidity for 48 h, and they were then placed into synthetic tissue fluid (STF) for 48 h. STF was a phosphate buffer saline solution (pH = 7.2) with the following composition: 1.7 g of KH_2PO_4, 11.8 g of Na_2 HPO_4, 80.0 g of NaCl and 2.0 g of KCl in 10 L of H_2O. Specimens were placed horizontally in India ink for 72 h, and were then retrieved and rinsed for 10 min in running water. After cutting the crowns of the teeth, roots were longitudinally divided into two parts by creating two facial and lingual fissures along the long axis of the

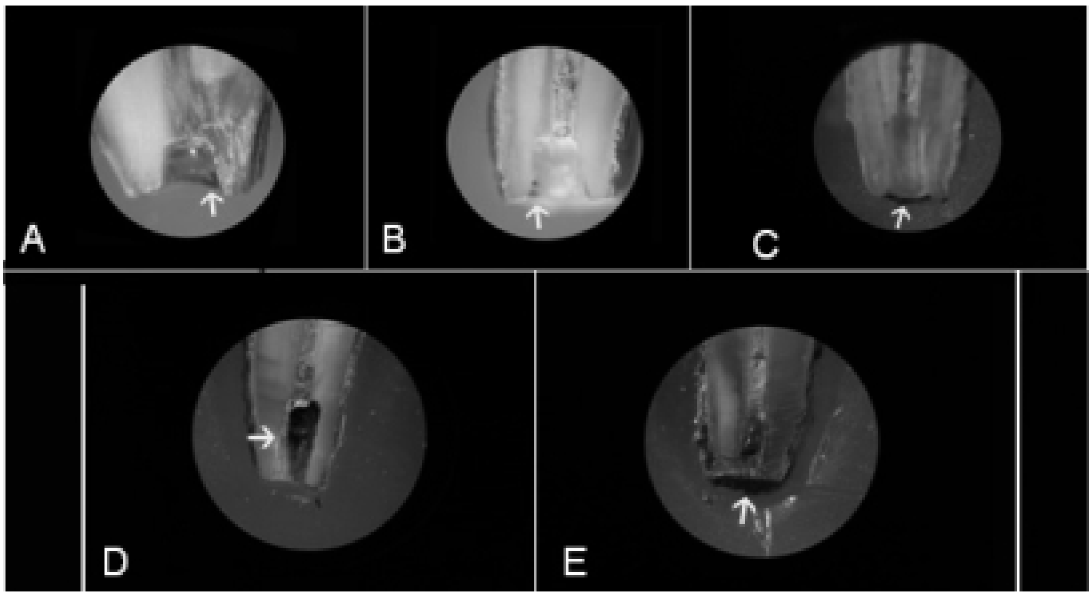

Fig. 1 Amount of microleakage in root-end cavities; A) 1 mm, B) 2 mm, C) 3 mm, D) positive controls and E) negative controls.

roots using a diamond disc (D&Z, Darmstadt, Germany).

The maximum amount of linear dye penetration was measured under a stereomicroscope (Zeiss, Muich, Germany) at ×16 magnifications with 0.1 mm accuracy (Fig. 1A-C).

Statistical analyses were carried out, and to test the assumption of normality, 'Skewness' and 'Kurtosis' were used. After testing the normal distribution for characteristics studied, natural logarithmic transformation was used. Transformed data were then analyzed using one-way analysis of variance.

Results

The amount of microleakage in the 3-mm and 2-mm groups was less than that in the 1-mm group (Fig. 1A, B and C). The amount of microleakage in the 3-mm positive controls was 3 mm (Fig. 1D), and dye penetrated throughout the cavities, while in the 3-mm negative controls, dye did not penetrate the cavity at all (Fig. 1E). The mean microleakage for the 1-, 2- and 3-mm depths was 0.04, 0.04 and 0.02, respectively (Fig. 2).

Significant 'Skewness' and 'Kurtosis' confirmed non-normal distribution of original dataset. Natural logarithmic transformation provided normal distribution of data. However, analysis of variance revealed no significant differences among the three different thicknesses (1, 2 and 3 mm) ($P = 0.42$).

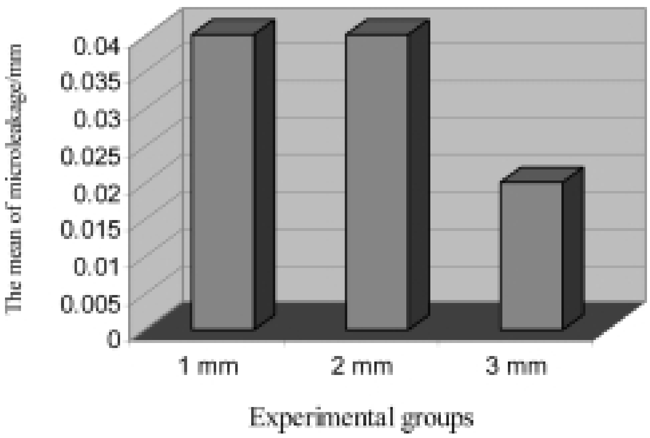

Fig. 2 Mean values depend on root-end cavity depth.

Discussion

The goals of periradicular surgery are to gain access to the affected area, evaluate the root circumference and root canal system, and place a biocompatible seal, in the form of a root-end filling, that stimulates regeneration of the periodontium.

Root-end cavity preparation and filling are indicated when the apical seal appears inadequate. A class I preparation is made with ultrasonic tips to a minimum depth of 3 mm into the canal (16). A root-end filling material is then inserted into the prepared cavity. In vitro sealing ability and biocompatibility studies comparing root-end filling materials have shown MTA to be superior to other commonly used materials (8,9,12,17-21). In various studies of periradicular surgery, 3 mm depth has been suggested for the root-end cavity; however, these studies have evaluated marginal adaptation (22), microleakage (4,6,8,13-15), sealing ability (9,11,12,15), mutagenicity (17), biocompatibility (18), cytotoxicity (19) and setting expansion (23) of MTA, rather than the depth of the root-end cavity. There has only been one study on the influence of MTA thickness on microleakage (23). Therefore, we compared the microleakage of three different thicknesses (1, 2 and 3 mm) of MTA as a root-end filling material.

The ability of the dye penetration technique to demonstrate microleakage has been emphasized in different studies (23,24). In this study, we compared the microleakage of MTA using the dye penetration technique. All of the positive controls showed microleakage throughout the cavities, thus confirming that root-end filling material was necessary to prevent microleakage; in contrast, all negative controls showed no microleakage, thus confirming that nail polish prevented microleakage, with dye only penetrating the apical portion of teeth (Fig. 1A-E).

Clinically, in periradicular surgery the root-end filling material is in contact with blood and interstitial fluid. To mimic clinical conditions, teeth in this study were placed into STF (25) for 48 h before being placed into the dye. This step has never been carried out previously. Combination of MTA and water produces calcium hydroxide, and the calcium ions of calcium hydroxide bind with phosphorus ions in the interstitial fluid, thereby forming hydroxyl apatite crystals, which are highly biocompatible and cover the surface of MTA in contact with tissues. On scanning electron microscopy, chemical binding between MTA and the dentinal wall has been observed (25). Although significant differences were not seen between the experimental groups, microleakage at 3-mm thickness was less than at 1 and 2 mm. An interesting finding in this study was that the prevention of microleakage, even at a depth of 1 mm may be related to chemical bonding between MTA and the dentinal wall, as reported by Sarkar et al. (25). However, this contrasts the results of another study (23).

There have been few studies on MTA as a root-end filling material at different thicknesses, and the majority of studies on the sealing ability of MTA have been preformed for short periods at a depth of 3 mm. Based on the results of this study, we can conclude that MTA at thicknesses of 1, 2 and 3 mm does not differ significantly with regard to preventing microleakage; however, further long-term studies are needed in order to evaluate the sealing ability of MTA at different thicknesses using interstitial fluid, as well as methods such as bacterial leakage.

Acknowledgments

The authors would like to extend their appreciation to the Office of Vice Chancellor for Research, Tabriz University of Medical Science for supporting this research.

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