ProRoot MTA, MTA-Angelus and IRM Used to Repair Large Furcation Perforations: Sealability Study

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Abstract

The ability of two mineral trioxide aggregate (MTA) compounds and Intermediate Restorative Material (IRM) to seal large furcation perforations were evaluated using a dye-extraction leakage method. The furcation perforations were repaired with and without the use of internal matrix before placement of repair material. Eighty extracted human mandibular first molars were divided into positive ($n = 10$), negative ($n = 10$), and three experimental groups ($n = 20$) according to the repair material used. Each experimental group was divided into two subgroups ($n = 10$) according to whether internal matrix was used or not. Dye leakage was tested from an orthograde direction, and dye extraction was performed using full concentration nitric acid. Dye absorbance was measured at 550 nm using spectrophotometer. ProRoot MTA (Maillfer, Dentsply, Switzerland) with and without internal matrix and MTA-Angelus (Angelus, Londrina, PR, Brazil) with internal matrix showed the least dye absorbance. IRM (Caulk, Dentsply, Milford, DE) without internal matrix showed the highest dye absorbance. IRM with internal matrix and MTA-Angelus without internal matrix had insignificant difference and came at intermediate level between the other groups. *(J Endod 2008;34:59–61)*

Key Words

Dye extraction, furcation perforation, IRM, MTA-Angelus, root MTA

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Perforations can be defined as mechanical or pathologic communications between the root canal system and the external tooth surface (1). Seltzer et al. (2) in their in vivo histologic study on monkeys found that the repair of perforations was dependent on the location of perforation and the time lapsed before sealing the defect. Sinai (3) stated that middle third and apically situated perforations were less serious than those that occurred in the coronal third of the canal, including furcal perforations.

Several materials have been used to repair furcation perforations, including zinc oxide-eugenol cements (IRM and Super-EBA), glass ionomer cement, composite resins, resin-glass ionomer hybrids, and mineral trioxide aggregate (MTA) (4). MTA was developed at Loma Linda University in the 1990s as a root-end–filling material. Lee et al. (5) compared the sealing ability of MTA with that of amalgam and IRM in experimentally induced lateral perforations. They found that MTA had significantly less leakage. Torabinejad et al. (6) compared the sealing ability of MTA with that of amalgam and Super-EBA when used as root-end fillings. They showed that most of the MTA samples had no dye penetration.

Pitt Ford et al. (7) evaluated the histologic tissue response to experimentally induced furcation perforations in dog teeth repaired by either MTA or amalgam. They found that most MTA samples showed no inflammation and cementum deposition, whereas Amalgam samples showed moderate to severe inflammation with no cementum deposition.

The chemical composition of MTA was determined by Torabinejad et al. (8). The material consisted of fine hydrophilic particles, and the main components were tricalcium silicate, tricalcium aluminate, tricalcium oxide, and silicate oxide. Bismuth oxide acted as a radioopacifier. They declared that calcium and phosphorus were the main ions in MTA. Arens and Torabinejad (9) reported two cases of large furcation perforation that were repaired by MTA. They stated that MTA was an ideal material for such cases. It did not need a barrier. The extruded material showed no adverse side effects, indicating its biocompatibility. Cemental deposition had been noted also.

Sluyk et al. (10) evaluated the effect of time and moisture on setting, retention, and adaptability of MTA when used to repair furcation perforations. The authors noted that the presence of moisture in perforations during the placement of MTA increased its adaptation to perforation walls. They concluded that a moistened matrix can be used under MTA to prevent over- or underfilling of the material. Bryan et al. (11) reviewed the etiology, diagnosis, prognosis, and material selection of nonsurgical repair of furcation perforation. They stated that furcal perforations had a bad prognosis. To improve it, they should be sealed immediately with a biocompatible and sealable material. MTA showed promise in this respect and could enhance the treatment modality for furcation perforation repair.

Holland et al. (12) evaluated the healing process of intentional lateral perforations in dog teeth after repair with either MTA or Sealapex. Histologic evaluation showed new cementum deposition and absence of inflammation in most samples sealed by MTA. They concluded that hard tissue deposition, which was seen with both MTA and Sealapex, meant that they have similar properties. They speculated that calcium oxide present in MTA might undergo a reaction with tissue fluids and form calcium hydroxide.

Studies comparing MTA with Portland cement showed their similarity in composition, properties, and tissue reactions (13–16). Until recently, two commercial forms of MTA have been available; ProRoot MTA (Maillfer, Dentsply, Switzerland) is available in either the gray or white form. According to the information supplied in the material safety datasheet, ProRoot MTA consists of 75% Portland cement, 20% bismuth oxide, and 5% calcium sulfate dehydrate. Recently, MTA-Angelus (Angelus, Londrina, PR, Brazil) has also become available as an alternative to ProRoot MTA. MTA-Angelus

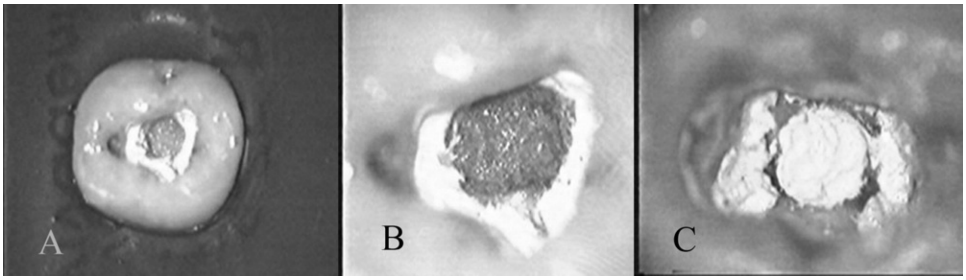

Figure 1. (*A*) Internal matrix (collagen) placed in the furcation area. (*B*) Perforation repair with ProRoot MTA (22×). (*C*) Perforation repair with IRM (22×).

contains 80% Portland cement and 20% bismuth oxide, with no addition of calcium sulfate in an attempt to reduce setting time (2 hours for ProRoot MTA and 10 minutes for MTA-Angelus) (17).

Several methods to evaluate leakage of perforation repair materials have been used including dye penetration (18), bacterial (19), and fluid filtration (20). Camps and Pashley (21) reported the use of a new method for leakage evaluation called the dye-extraction method. They compared it with the classic dye penetration and fluid-filtration techniques. A statistically significant correlation was found between the results obtained with the dye-extraction and those obtained with the fluid-filtration technique. Using the dye-extraction method, Hamad et al. (22) compared the sealing ability of gray and white MTA when used for furcation perforation repair. No significant difference was observed.

The aim of this study was to evaluate the sealing ability of two MTA compounds (gray ProRoot MTA and gray MTA-Angelus) and IRM when used to repair large furcation perforations, with and without the use of internal matrix.

Materials and Methods

Eighty human permanent lower first molars were used in this study. Collected teeth had minimal caries or restoration, and none had fused roots. Any tooth that had a crack or defect was discarded. Molars were amputated 3 mm below the furcation area by using a tapered diamond stone. Endodontic access cavity was made in every molar by using a high-speed long shank round bur #4 (#4RC; SybronEndo Europe, The Netherlands) for the initial entry followed by Endo-Z (Maillfer, Dentsply, Switzerland) for lateral extension and finishing of cavity walls. A temporary filling material (Coltosol; Coltene/Whaledent AG, Altstatten, Switzerland) was placed over the orifice of each canal. Every molar was covered completely including cavity walls and pulpal floor with two successive layers of clear nail varnish.

A large perforation was made between the orifices to the furcation area by using a high-speed long shank round bur #4. Care was taken to centralize the perforation between the mesial and distal orifices. Molars were divided into three experimental positive and negative groups as follows: (1) group 1, 20 molars in which perforations were repaired with ProRoot MTA; (2) group 2, 20 molars in which perforations were repaired with MTA-Angelus; (3) group 3, 20 molars in which perforations were repaired with IRM; (4) group 4, 10 molars in which perforations were left unsealed (positive control); and (5) group 5, 10 molars without perforation (negative control).

The three experimental groups were further subdivided into the following subgroups: subgroup a, 10 molars in which no internal matrix was used, and subgroup b, 10 molars in which internal matrix (collagen) was used.

Molars were placed in Eppendorf tubes containing cotton moistened with saline in an attempt to stimulate clinical conditions. The molars were sealed to the tubes by using cyanoacrylate adhesive. The tubes were fixed in a table vise (PanaVise Products Inc, Reno, NV), and rubber dam (OptraDam, Vivadent, Germany) was placed. The repair procedure was performed under 14× using surgical microscope (Opmi-Pico; Karl Zeiss, Jena, Germany).

In subgroups b, Internal matrix (ETIK; Pierre Rolland, Acteon, France) was adapted to interradicular area by using hand pluggers (Buchanan pluggers; SybronEndo Europe, Amersfoort, The Netherlands) (23, 24). ProRoot MTA, MTA-Angelus, and IRM were mixed according to the manufacturer instructions. They were applied to the perforation site in increments by using the microapical placement system (MAP, Produits Dentaires SA, Vevey, Switzerland) and lightly condensed using Buchanan pluggers (Fig. 1). Moist cotton pellets were placed over the repair materials, and molars were kept in 100% humidity for 24 hours to allow materials to set. Molars were then placed in Petri dishes according to each group. Methylene blue dye was applied inside the access cavity of all samples for 24 hours. Molars were placed under running tap water for 30 minutes to remove all residues of methylene blue and then varnish was removed with a Parker blade #15 and polishing discs.

Molars were placed in vials containing 1 mL of concentrated (65 wt%) nitric acid for 3 days. Vials were centrifuged (Universal 16R; Hettich Zentrifugen, Tuttlingen, Germany) at 14,000 rpm for 5 minutes. Two hundred microliters of the supernatant from each sample was transferred to a 96-well plate. Sample absorbance was read by an automatic microplate spectrophotometer (SLT Spectra II; Labinstruments A-5082, Salzburg, Austria) at 550 nm using concentrated nitric acid as a blank (21).

Statistical analysis was performed by using one-way analysis of variance. A Duncan post hoc test was used for pair-wise comparison between the means when analysis of variance test was significant. The significance level was set at $p \leq 0.05$. Statistical analysis was performed with SPSS 14.0 (SPSS Inc, Chicago, IL) for Windows (Microsoft, Redmond, WA).

Results

The positive control showed the highest dye absorbance (0.6 ± 0.1). IRM without internal matrix (0.21 ± 0.07) came second with significantly higher dye absorbance than other groups. MTA-Angelus without matrix (0.168 ± 0.08) and IRM with matrix (0.167 ± 0.07) had no significant difference in between, and they were significantly higher than the remaining groups. MTA-Angelus with matrix (0.122 ± 0.06) and ProRoot MTA with (0.115 ± 0.09) and without matrix (0.118 ± 0.07) showed no significant difference. However, they were significantly higher than the negative control group (0.068 ± 0.01) ($p \leq 0.05$) (Fig. 2).

Discussion

The dye-penetration technique has long been used in endodontics because of its ease of performance and difficulty of other available techniques. However, it has several drawbacks including the smaller

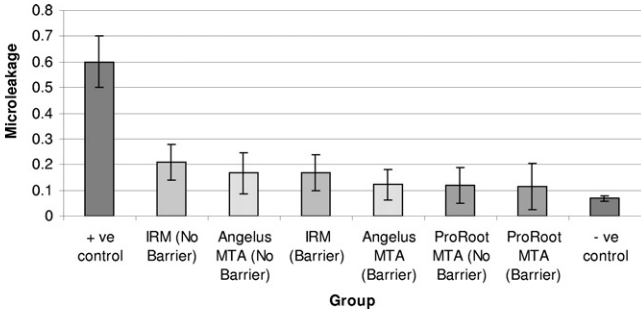

Figure 2. A histogram showing the mean dye absorbance and standard deviation values of different groups.

molecular size of the dye molecules than bacteria, which do not measure the actual volume absorbed by the sample but merely measure the deepest point reached by the dye (21). It relies on randomly cutting the roots into two pieces, without any clue of the position of the deepest dye penetration (21). Despite these drawbacks, Torabinejad et al. (6) stated that a material that is able to prevent the penetration of small molecules (dye) should be able to prevent larger substances like bacteria and their byproducts. Based on this, the dye-extraction method seems to be a reliable technique. It takes into account all absorbed dye by the samples. Camps and Pashley (21) reported that the dye-extraction method gave the same results as the fluid-filtration method and also saved much laboratory time.

Furcation perforations were induced by a #4 long shank carbide round bur from pulpal floor to furcation area. This resulted in perforations of almost 2 mm in diameter. This size is considered large compared with the 1-mm perforation size induced by the carbide bur #2 in Hamad et al. study (22). Internal matrix has been advocated by Lemon (23) to limit the overextension of the repair material. The collagen matrix used in this study is a soft material, which expands because of moisture and has a hemostatic effect. It seems suitable to be used with MTA and IRM because these materials are pastes and do not require forces of condensation as with amalgam. This was also stated by Bargholz (24).

Negative control samples had low dye absorbance (0.068) close to that of blank (nitric acid), which showed absorbance of 0.043. This small difference can be attributed to the yellowish color of teeth, whereas blank is colorless. Positive control samples in which perforations were not repaired had the highest dye absorbance of all groups denoting the accuracy of the technique (22).

ProRoot MTA with and without matrix showed almost the same dye-absorbance results. The use of matrix with ProRoot MTA seems not necessary as previously mentioned by Arens and Torabinejad (9). Being hydrophilic and easily adapted to cavity walls may be the main reasons for this similarity in dye absorbance between the two subgroups.

Contrary to ProRoot MTA, MTA-Angelus showed significantly higher dye absorbance when used without matrix. This could be explained by the difference in composition between ProRoot MTA and MTA-Angelus. MTA-Angelus does not contain calcium sulfate and has lower percentage of bismuth oxide as stated by Song et al. (25). This resulted, according to the manufacturer, in a reduction of the setting time from 2 hours for ProRoot MTA to 10 minutes for MTA-Angelus (17). However, this reduction in the setting time may have prevented MTA-Angelus from having better wetting and adaptation to cavity walls (10). This needs further investigation. The presence of matrix seems to be necessary with MTA-Angelus to improve adaptation. This is similar to the use of a band for class II amalgam.

IRM without matrix showed the highest dye absorbance of all experimental groups. The presence of matrix significantly decreased the dye absorbance of IRM. Like other paste filling materials, the matrix will prevent overextension and control moisture, which will lead to more adaptation, resulting in better sealability.

Based on the results of this study, we can conclude the following: (1) ProRoot MTA has excellent sealing ability and can be used with or without matrix in repair of large furcation perforations; (2) MTA-Angelus should be used with internal matrix to repair large furcation perforations; and (3) the use of IRM to repair large furcation perforations should be limited, and, if used, it must be used with an internal matrix.

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