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Comparison of push-out bond strength of mineral trioxide aggregate and calcium enriched mixture cement as root end filling materials

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ABSTRACT

Background: The purpose of this study was to compare the push-out bond strength of mineral trioxide aggregate (MTA) and calcium enriched mixture (CEM) as root end filling materials.

Materials and Methods: A total of 40 root dentin slices (1 ± 0.2 mm) were prepared from freshly extracted human maxillary central teeth and their lumens were enlarged to 1.3 mm. The slices were randomly divided into two groups (*n* = 20). MTA and CEM cement were mixed according to manufacturer's instruction and introduced into the lumens. The specimens were wrapped in pieces of wet gauze soaked in distilled water and incubated at 37°C for 3 days. The push-out bond strength was measured using a universal testing machine. The slices were then examined under a light microscope at ×10 magnification to determine the nature of bond failure. The data were analyzed using Mann-Whitney test ($P < 0.001$).

Results: The mean push-out bond strength for CEM cement and MTA were 1.68 ± 0.9 and 5.94 ± 3.99 respectively. The difference was statistically significant ($P < 0.001$). The bond failure was predominantly of adhesive type in MTA group and cohesive type in CEM group.

Conclusion: CEM cement showed significantly lower bond strength to the dentinal wall compared to MTA.

Key Words: Adhesive, calcium enriched mixture cement, cohesive, mineral trioxide aggregate, push-out bond strength

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INTRODUCTION

The purpose of a root end filling material is to establish a hermetic seal of root canal system and prevent egression of microorganisms or their byproducts into periradicular tissue. The material used as root end filling should be antibacterial, non-toxic, radioopaque, biocompatible with the periradicular tissue, dimensionally stable, non-resorbable, resist dissolution or breakdown by tissue fluids, resist dislocating forces, possess good handling characteristics and capable of adapting to the dentinal walls of root canal system.[1,2] Unfortunately, most traditional root end filling materials such as amalgam, composite resins, glass-ionomer cements, cavit… have different levels of weakness in biocompatibility, sealing ability and resistance to moisture.[3,4] Consequently, in 1998, mineral trioxide aggregate (MTA) was introduced into the market to overcome these deficits. MTA is a hydrophilic powder, mainly composed of portland cement that sets into a hard mass in the presence of moisture by forming calcium hydroxide and calcium silicate hydrate gel.[5] MTA has an effective marginal adaptation[6] and its retentive characteristic increases over time.[7] In spite of its promising properties, MTA is expensive with poor handling characteristics and extended setting time.[3] Recently, a new endodontic cement called calcium enriched mixture (CEM cement) has been introduced

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to the market with different calcium compounds (calcium oxide, calcium phosphate, calcium silicate, calcium carbonate, calcium sulfate and calcium chloride).[8] One study reported that this cement has a good handling characteristic and demonstrates a shorter setting time and superior film thickness and flow in comparison with MTA.[8] It has been shown that CEM cement, when used as a root end filling material, has favorable sealing ability[8-10] and is also able to produce hydroxyapatite (HA) in normal saline solution.[11]

An ideal root end filling material should have the ability to adhere to dentinal walls of root end preparation to resist dislodging forces. Several investigations showed an increase in these dislodging forces during the mastication process.[12,13] The bond strength of root end filling material is dependent upon both material properties and the surface of root end preparation.[10] The physicochemical reaction between root end filling materials and dentin results in an adhesion reaction between them.[14,15] The bond strength of a material with dentin is a significant factor for the success of the various endodontic procedures, therefore, push-out test methods have been developed to assess this property of restorative materials.[14,15]

The purpose of this study was to evaluate and compare the bond strength of MTA and CEM cement in a push-out bond strength model.

MATERIALS AND METHODS

The 20 extracted maxillary central human teeth stored in 0.5% of chloramine-T were used in this study. All teeth had mature apices, intact roots with no cracks on them. Teeth with any sign of internal root resorption or previous endodontic treatment were excluded from this study. The crowns and apical thirds of all teeth were removed and the middle-thirds were sectioned horizontally into 40 slices with a thickness of 1 ± 0.2 mm by using a diamond saw microtome (Polycut E, Reichert-Jung, Germany). The lumen of the root dentin disks were enlarged with Gates Glidden burs (Mani, Utsunmiya, Japan), size 2-5, to achieve a standardized diameter of 1.3 mm. In order to remove smear layers, sections were immersed in 5.25% of sodium hypochlorite for 5 min then, after rinsing with distilled water, were immersed in 17% ethylenediaminetetraacetic acid (Ariadent, Tehran, Iran) for an additional 5 min and immediately washed with distilled water and dried. The sections were then randomly divided into two groups (n = 20) and the lumens were filled with MTA (Dentsply, Tulsa, USA) in group one and with CEM cement (Biunique dent, Tehran, Iran) in group 2. The MTA and CEM cements were mixed according to manufacturer's recommendations and introduced into the lumens of root dentin slices. The root slices were then wrapped in pieces of wet gauze that had been soaked in distilled water. The specimens were kept at 37°C for 72 h.

The samples were then subjected to push-out bond strength test by using a universal testing machine (Zo20; Zwick Roell, Germany). The samples were placed on a metal slab with a central hole to allow the free motion of the plunger. The compressive load was applied by exerting a downward pressure on the surface of the materials using a 0.7 mm diameter cylindrical stainless steel plunger at a speed of 1 mm/min. The maximum load applied to the materials was recorded in Newton at the time of dislodgment by a computer. In order to express the bond strength in MPa, the following formula was used:

Push-out bond strength = N/2Πrh

N = The maximum load for each specimen.

r = Root canal radius (mm) (it is the same for all specimens, 0.65 mm).

h = The thickness of root dentin slice in millimetres.

Π = 3.14.

Afterward the slices were examined under a light microscope (dine-lite, Taiwan) at ×10 magnification to determine the nature of the bond failure. Each sample was categorized into one of three failure modes: Adhesive failure at the material and dentin interface, cohesive failure within the material and mixed failure. The data were analyzed using Mann-Whitney test (P < 0.001) using SPSS 16.0 software (SPSS Benelux, Gorinchem, the Netherlands).

RESULTS

Table 1 includes the mean push-out bond strength ± standard deviation and the result of Mann-Whitney test. The mean of push-out bond strength

Table 1: Push-out bond strength of two materials

Groups	Mean ± standard deviation (MPa)	*P* value
CEM (*n*=20)	1.68±0.9	<0.001
MTA (*n*=20)	5.94±3.99	

CEM: Calcium enriched mixture; MTA: Mineral trioxide aggregate was 1.68 for CEM cement and 5.94 for MTA group. Statistical analysis showed a significant difference between two groups ($P < 0.001$).

Inspection of the samples revealed that the bond failure in the MTA group was predominantly of adhesive type (18 specimens out of 20), but the bond failure in the CEM cement group was of cohesive type (17 specimens out of 20).

DISCUSSION

An ideal root end filling material should be able to resist dislodging forces such as stresses of mastication or operative procedures.[16-19] Therefore, the bond strength of these materials should be considered as a significant factor, since it shows the adaptation of the materials to dentinal wall. Various methods for evaluating the bond strength of restorative materials to dentin have been developed, including tensile, shear and push-out strength tests. Push-out test used in the present study has been shown to be a reliable and efficient method among others.[19]

One of the findings of this study was that even after 3 days CEM cement had not completely hardened and had a semi-hard consistency in contrast to MTA. This finding is in contrast with the result of the study by Asgary *et al*. who mentioned that CEM cement sets in less than 1 h.[8] Incomplete setting of CEM cement can be considered as the main reason for its lower push-out bond strength in comparison to MTA.

The different chemical components of MTA and CEM cement may also explain the different behavior of these two materials. The predominant elements in white MTA are calcium, silicon and bismuth (in oxide form), but the major components in CEM cement are calcium, phosphorus and silicon.[2,8,20]

Another explanation for the difference in push-out bond strength of these two materials may be related to their potential difference in shape, size and distribution of the HA crystals that form during hydration and also the difference in the degree of porosity within them.

In the presence of tissue fluid, hydration of MTA powder results in the release of calcium hydroxide, formation of HA crystal and a hybrid layer between dentin and MTA.[8,10,11,15] It has been reported that the formation of this hybrid layer and also intratubular mineralization might influence the push-out bond strength of MTA.[21] These HA crystals cover MTA, fill the microscopic gap between MTA and dentin and cause chemical bonding.[15] A decrease in the push-out bond strength of MTA to dentin has been reported in the acidic environment;[22] which can be a result of greater degree of porosity in MTA when exposed to the acidic environment.[23,24]

CEM cement also has the similar capacity of forming HA. It has been reported that CEM cement produces HA, which coated the surface of this material in normal saline solution in contrast with MTA.[11] Further investigations are recommended to evaluate the potential difference in the shape and size of HA crystals and degree of porosity in MTA and CEM cement. Time is an important factor that affects the bond strength of materials to dentin as it has been shown that the bond strength between dentin and MTA has an initial increase in the first 3 days, continuing moderately up to 21 days.[25] Similar increase in bond strength may also happen for CEM cement. Therefore, future studies are recommended to evaluate the effect of time on the bond strength of CEM cement to dentin; especially because in the present study the setting of CEM cement was not complete after 3 days.

The bond failure in the MTA group was predominantly adhesive type while in the CEM cement was cohesive. The mode of bond failure of CEM cement has not been investigated in other studies to our knowledge, however, regarding MTA the result of the present study is in agreement with other studies.[22,26,27] The difference between mode of bond failures of MTA and CEM cement can be explained by the factors mentioned for the differences in push-out bond strength of these cements.

The results of this study should be interpreted cautiously. Although the push-out bond strength of MTA was significantly greater than CEM cement, the bond failure of CEM cement to dentin was cohesive, which means CEM cement is detached in the center but remains attached to dentin in peripheral parts. Therefore, in order to have a better understanding of adhesion characteristics of these materials, further investigations are recommended.

CONCLUSION

Based on the condition of this study, the push-out bond strength of MTA was significantly greater than CEM cement. Bond failure in MTA was adhesive type but in CEM cement was cohesive.

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