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Original Article

Comparison of the push-out bond strength between root mineral trioxide aggregate(MTA) and calcium-enriched mixture (CEM) cement

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Abstract

Introduction: Root mineral trioxide aggregate (MTA) is a type of MTA that has been introduced in the Iranian market. There have been few studies on this substance. This study compared the push-out bond strength of Root MTA and CEM cement, which were both Iranian products.

Materials & Methods: This in vitro study was performed on 20 extracted maxillary incisors. Samples were divided in two groups. The canals of the first group were filled with Root MTA and the second group by CEM cement. In order to investigate the push-out bond strength, the device applied a force in the direction parallel to the longitudinal axis of the sample so that the desired materials would fail. Each sample was classified into one of three types of failureincluding adhesive (failure in the material and dentin interface), cohesive (failure in the material itself) or a combination of both.

Results: There was no significant difference between the mean pressure on teeth for the two groups (P>0.05). There was no significant difference between the frequencies of different types of failure between the two groups (P>0.05). Cohesive failure in the CEM group was twice as high as in the MTA group (P>0.05).

Conclusion: There was not any significant difference between the push-out bond strength of CEM cement and Root MTA cement. These findings demonstrated that Root MTA material showed a satisfactory result in the bond strength test compared to CEM material, and could be used as an alternative to CEM cement.

Keywords: Adhesives, Mineral trioxide aggregate, Calcium-enriched mixture cement

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مقایسه استحکام باند فشاری دو ماده Root Mineral trioxide aggregate (MTA) و Calcium-enriched mixture (CEM) cement

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چکیده

مقدمه: Root MTA نوعی MTA است که در بازار ایران معرفی شده است. مطالعات اندکی در ارتباط با این ماده انجام شده است. در این مطالعه استحکام باند فشاری سمان های Root MTA و CEM cement که هر دو محصولات ایرانی هستند ، مقایسه شد.

مواد و روش ها: این مطالعه ی آزمایشگاهی بر روی ۲۰ دندان کشیده شده اینسایزور فک بالا صورت گرفت. نمونه ها به دو گروه تقسیم شدند کانال گروه اول توسط Root MTA وگروه دوم توسط CEM cement پر شد. جهت بررسی استحکام باند فشاری دستگاه نیرویی را در جهت موازی محور طولی نمونه وارد کرد تا مواد مورد نظر دچار شکست شوند. هرکدام از نمونه ها در یکی از ۳ نوع شکست طبقه بندی شدند که شامل adhesive (شکست در اینترفیس ماده و عاج) ، cohesive (شکست در خود ماده) و یا ترکیبی از هردو بود.

یافته ها: اختلاف معناداری بین میانگین فشار وارده بر دندان ها در بین دو گروه مشاهده نشد ($p>0.05$). اختلاف معناداری بین فراوانی های انواع شکست در بین دو گروه مشاهده نشد ($p>0.05$). فراوانی شکست cohesive در گروه CEM دو برابر گروه MTA بود ($p>0.05$).

نتیجه گیری: استحکام باند فشاری بین سمان CEM و سمان Root MTA از لحاظ آماری اختلاف معنی داری نداشت. ماده ی Root MTA در تست استحکام باند در مقایسه با ماده ی CEM نتیجه ی امیدوار کننده ای را نشان داد. و می تواند به عنوان جایگزین سمان CEM مد نظر قرار گیرد.

واژگان کلیدی: ادهزیو، Mineral trioxide aggregate ، Calcium-enriched mixture cement

Introduction

Root canal therapy is considered a standard treatment for non-vital teeth or with irreversible pulpitis. [1] The goal of root canal treatment is to prevent apical periodontitis and return the tooth to normal function. Treatment of pulp and periradicular diseases is aimed at complete and three dimensional filling of coronal apical and lateral root canals to remove irritants and residues of microorganisms and provide a suitable environment to repair and improve the periapical region preventing recontamination or bacterial infiltration or the release of residual bacteria within the canal system and dentinal tubules. [2] The purpose of the filling material at the end of the root canal is to create a perfect seal in the root canal system to prevent the penetration of microorganisms and their by-products into the periradicular space. Materials used for this purpose should have some features such as being antibacterial, non-toxic, radiopaque, biocompatibility with

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periradicular tissue, dimensional stability, dissolution resistance, ease of use and compatibility with the root canal dentinal wall. [3] The MTA was launched in 1998, with satisfactory clinical results in pulp capping treatments, Cvek pulpotomy, epoxogenesis, root canal filling in endodontic surgery, and root perforation repairmen. [4] This material is a hydrophilic powder that has good marginal adaptation.

The operating time of this material is 4 minutes and the final setting time is 4 hours. [5] Recently, an Iranian endodontic cement called CEM cement has entered the market, the indications for its use are the same as MTA, but compared to MTA, it has a shorter setting time and ease of use and better film thickness and flow [6, 7] and as a filler, it can create a suitable seal at the root end and releases hydroxyapatite in normal saline solution. [8]

Bond strength of endodontic material to root dentine is an important factor for long term clinical success. The adhesion of the material to the surrounding dentin makes it resistant to any displacing force applied during functioning or procedures. Among shear, tensile and push-out bond strength tests to determine the adhesion of materials to the surrounding dentin, the push-out test has been evaluated as more reliable and practical. [9]

Root MTA is a type of Iranian made MTA in which there is not much information available about the chemical properties of this substance and few studies have been performed in this regard. Due to the high price of gold standard MTAs, in this study, we decided to compare the push-out bond strength of Root MTA and CEM cement, which are both Iranian products.

Materials & Methods

This study was approved by the Ethical Committee of Babol University of Medical Sciences (IR.MUBABOL.HRI.REC.1398.175). This experimental study was performed on 20 extracted single canal maxillary incisors with mature roots. Single canal maxillary incisors with a straight root of at least 14 mm and a fully formed epoxy were included in the study, and decayed and cracked teeth with root resorption were excluded from the study. Then the chosen teeth were divided in half, and 20 pieces of maxillary incisors were used in each group; in one group canals were filled with Root MTA and in the other group, canals were filled with CEM cement.

The crown and one-third of the apical were removed for all teeth by the diamond disk, leaving only one-third in the middle to get 2 slices from each tooth and finally 40 slices with a thickness of 1 mm. The root canals were expanded by Peeso Reamer (Mani, Japan) No. 1 to 4 with a milling machine (Frasgarat F1, Degussa) to a diameter of 1.3 mm.

In order to remove the smear layer, the slices were immersed in sodium hypochlorite 25.5% (Golrang, Iran) for 5 minutes and then washed with distilled water and immersed in EDTA17% (Master dent, USA) for 5 minutes, then immediately washed with distilled water and dried.

Root MTA (Salamifar Dental supply, Tehran, Iran) and CEM cement (bionique Dent, Tehran, Iran) were prepared according to the manufacturer's instructions. The samples were randomly divided into two groups, the first group of canals was filled by Root MTA and the second group by CEM cement. For every 5 teeth, materials were prepared according to the manufacturer's instructions and the canals were filled randomly. The samples were then placed in contact with wet gas with distilled water and kept at 37 ^{o}C for 72 hours. After 72 hours, the samples were removed from the incubator and their setting was checked by a catheter.

To measure push-out bond strength, a global measuring device (KOOPA, Iran) was used. The device having a 1.2 mm diameter pin, applied a force at 0. 5 mm/min in the direction parallel to the longitudinal axis of the mold to fail the desired material. Applied force was recorded in Newtons and converted to megapascals based on the following formula.

$$CS = \frac{N}{2rh\pi}$$

N = Maximum force applied in Newton

r = radius of root canal (0.65mm)

h = thickness of the root dentin in millimeters

The samples were magnified under an optical microscope (Milano, Italy) with a magnification of 10x to investigate the type of bond failure. Each sample was classified into one of three types of failure, which included adhesive (failure in the material and dentin interface), cohesive (failure in the material itself) or, a combination of both.

The data were investigated using SPSS 24 statistical software and independent T-Test to examine the differences between the means, and the chi-square test was used to investigate the relationship between the frequency of failures and the two studied materials. $P<0.05$ was considered significant.

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Results

Push-out bond strength of CEM cement was 28.29±16.3 MPa and push-out bond strength of Root MTA was 24.76±12.59 MPa. According to the Independent T-test, there was no significant difference between the mean pressure on the teeth for the two groups until failure (P>0.05) as shown in Figure 1.

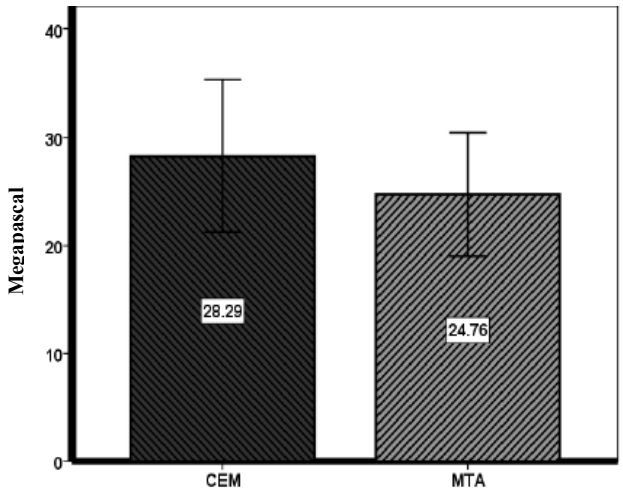


Figure 1. Megapascal variable for the studied groups

According to the Chi-square test, there was no significant difference between the frequencies of different types of failure for the two groups (P <0.05). The frequency of Cohesive failure in the CEM group was twice that of the Root MTA group, but this difference was not significant. The most common type of failure in both groups was mixed, but this difference was not statistically significant. The frequency of failure types is shown in Table 1 and and Figure 2.

Table 1. Frequency of failure types for the studied groups

Group Failure type	CEM (%) Frequency	MTA (%) Frequency	P-value
Adhesive	(17.4) 4	(23.8) 5	0.56
Cohesive	(34.8) 8	(19) 4	0.42
Mixed	(47.8) 11	(57.1) 12	

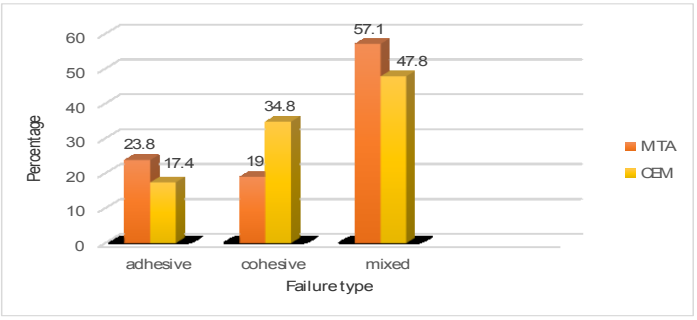


Figure 2. Comparison of the frequency of different failure types for the two groups

Discussion

In the present study, the push-out bond strength of Root MTA and CEM cement which are both Iranian products have been studied and compared. In this study, there was no significant difference between the mean push-out bond strength for the CEM and Root MTA groups. However, the push-out strength of the CEM cement was slightly higher than that of the MTA cement.

In a study by Lotfi et al. in 2014, the bond strength of CEM cement was not significantly different from that of MTA cement. The removal of the smear layer did not affect the results in this study (White MTA, Tulsa dental). [10] In a study by Ertas et al. [11], the push-out bond strength of CEM cement did not differ significantly from MTA Angelus. Similarly, In a study by Sahebi et al. , CEM cement showed better performance than MTA Angelus, although the smear layer wasremoved.[12] In contrast, the study by Adl et al.[3] indicated that the amount of push-out bond strength in the MTA cement of Tulsa dental was much higher and about 4 times that of the CEM cement, which was a significant difference. According to studies, many factors affect the bond strength of these two cements which can explain this difference.

Shojaee et al.[13] concluded in a study that slight changes in water-to-CEM powder ratio could have a significant effect on the push-out bond strength. In his study, a water to powder ratio of 0.33 had the best result. In the study by Shokouhi et al., the positive effect of calcium chloride on bond strength CEM was observed, and in the study by Sobhnamayan et al. in 2017, the positive effect of propylene glycol on compressive bond strength of MTA and CEM cement was seen. [14, 15] In another study by Sobhnamayan et al. in 2015, the negative effect of pH increase on CEM bond strength was reported. [16]

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Different studies have shown different results about the removal of the smear layer effect on bond strength. Lotfi et al. in 2014. stated that the removal of the Smear layer increases the bond strength of CEM cement, however no significance revealed of bond strength increase using White MTA cement. [10] Lotfi et al. in 2013 revealed that White MTA showed better bond strength by adding Disodium hydrogen phosphate (Na2HPO4) if the smear layer was removed. [17] The composition of the materials seems to play a very effective role in this process. These factors and their impact as well as differences in sub-components with respect to the manufacturer can justify the differences in the results of these studies.

Also in this study, there was no significant difference between the frequencies of different types of failures between the two groups. The frequency of mixed failures, which is a combination of both types of failures, was higher in both cements than in cohesive and adhesive failures alone.

It is noteworthy that in the present study, the frequency of cohesive fractures in the CEM group was twice the Root MTA group. This means that the cohesive failure occurs more frequently in the CEM cement, which involves the failure of the cement itself rather than its connection to the dentine walls. In a study by Sahebi et al. [12] on CEM cement, most failures were of a cohesive type and most MTA Angelus failures were a combination of both types.

In the study by Adl et al. [3], most failures in CEM cement were of cohesive type and for the MTA cement of Tulsa dental company, most failures were of adhesive type. It should be noted that the MTA cement used in two aforementioned studies was made by another company, and the slight difference between these studies and the present study can be due to different manufacturers and the difference in sub-compounds that will certainly affect the biomechanical properties of cement. Based on the results of the mentioned studies, it can be concluded that the junction of CEM cement to the dentine walls of the canal is somewhat stronger. Considering the higher push-out bond strength of this cement in the present study, it could be concluded that the conjunction of CEM cement to dentine wall was slightly stronger than that of the Root MTA cement, although this difference was not statistically significant.

In different studies, various methods have been used to measure the sealing of filler materials at the root end, and the effect of a series of factors on the bond strength of these materials has been measured, too. In a study by Asgary et al. a color solution was used to evaluate the apical seal of CEM and Root MTA cements. [18] According to their results, the two cements had no significant difference in the apical seal, although the performance of the CEM cement was slightly better.

The selection of the right cement or root filler is very important for dentists because the success of treatment can also depend on the properties and clinical function of that material. In the present study, there was no significant difference in bond strength between CEM and Root MTA cements. This suggests that both substances perform relatively similar in terms of bond strength to the dentine wall and perform well in laboratory conditions. It should be noted that compatibility with the canal dentine wall and its conjunction is only one of the factors of a suitable root filling material and other factors are also involved. In addition, laboratory studies such as the present study although providing useful information cannot be a complete and definitive simulator of the oral environment and the forces applied to the teeth and roots. In order to evaluate the clinical success of these substances, it is better to conduct a clinical trial study to determine and compare the clinical performance and durability of these substances in the long run.

Conclusion

The push-out bond strength of CEM cement was slightly higher than the Root MTA cement, but this difference was not statistically significant. This results so far have been promising to use Root MTA as a suitable alternative to CEM and other MTAs due to the satisfactory results in bond strength test compared to CEM material. Future studies need to be carried out to confirm other therapeutic properties of Root MTA.

Most of the observed failures were a combination of two types of cohesive and adhesive failures, and the cohesive failure in CEM cement was twice that of Root MTA cement.

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Author's Contribution

The study was designed by Akam Saeidi. The study data were collected by Reza Tavasoli. Elham Mahmoudi and Naeim Berijani edited and reviewed the article, and the results were evaluated and analyzed by Hemmat Gholinia.

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