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Comparison of push out bond strength of various root perforation repair materials

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Abstract

Background/ Aims: High bond strength of root perforation repair materials is essential for success of endodontic therapy. The aims of current study were to assist the push-out bond strength of 4 types of root perforation repair materials (Biodentine , Mineral trioxide aggregate, glass ionomer cement, and calcium hydroxide paste) from dentin, and to determine the modes of failure at debonded surfaces.

Materials and Methods: Forty lower premolars with a straight single root canal and matured apex were utilized. Then the teeth decorated 15 mm from the apex, and the middle third of the roots were cut perpendicular to their long axis in order to obtain sections with 1 mm thick. After that instrumentation for the canal of the dentin discs with Gates Glidden was done from sizes 2-5 to result into standardized cavities with 1.3 mm diameter. After that, specimens were divided randomly into 4groups with 10 specimens in every group as follows: group I: Bio (Biodentine), group II: Mineral trioxide aggregate (MTA), group III: GI (glass ionomer), and group IV: calcium hydroxide paste ($Ca(OH)_{2)}$. Prepared cavity was then filled with each of the material tested according to the corresponding groups. after setting of the tested materials the specimens stored for one week and then push-out bond strength test preformed.

Results: push-out bond strength of Biodentine was significantly higher than other tested materials. Followed by Mineral trioxide aggregate, which exhibited significantly higher bond strength than glass ionomer and MTA materials, while the $Ca(OH)_2$ showed the lowest value of push-out bond strength.

Conclusions: push-out bond strength Biodentine, was significantly greater than MTA, GI, and $Ca(OH)_2$. Therefore, BIO can be used successfully for treatment of root perforation that might occur during endodontic therapy of the root canal.

Key words: Biodentine, $Ca(OH)_2$, Glass ionomer, MTA.

Introduction

Root perforation connects spaces of root canal with periodontal tissues. The connection may happen due to iatrogenic etiologies during root canal therapy or during prosthetic treatment of post canal penetration. It can also introduce by the external resorption of the root or by caries process.[1,2,3]

Root perforation could be sealed either with external surgical access or intracoronally. In both methods better sealing should be achieved between periodentium and tooth structure, which could be influenced by operative procedure , the location and size of perforation , and features of materials that utilized for prevent contamination.[4]

Different materials has been used for perforation repairs, which include: zinc oxide eugenol (EBA and IRM), Mineral trioxide aggregate (MTA), glass iomomer (GIC), gutta percha, and calcium hydroxide ($Ca(OH)_2$).[5,6,7,8]

MTA show superior bonding ability and biocompatibility compared to many other root perforation materials [9,10] , but its handling characteristics and slow setting time make it challenging to use, to eliminate or to reduce these problems new materials have been introduced. One of these materials is the iRoot BP (IR) Root Repair Material, it is a convenient and ready to use, white hydraulic putty bioceramic material introduced for permanent root canal repair and

surgical applications. It is radiopaque, insoluble and aluminium-free material based on a calcium silicate composition, need the presence of water to set. It claims to not shrink during setting and to have excellent physical properties. It is packaged premixed in a container.[11]

Bioactive calcium silicate cement, biodentine™ (BIO), was considered as a dentine substitute. BIO can be used for management of root or pulp floor perforations, external and internal resorption, apexifixation, retrograde filling, temporary sealing of cavities, pulpectomy, and cervical filling.[12]

Bond strength (BS) and marginal adaptation of material with tooth structure are very important factor for success of various operative procedures.[13] PBS aim to test the sealing ability and bond strength of restoration to dentin .[14] Thus, the purposes of this study were to evaluate and compare PBS of four kinds of materials used for root perforation (BIO, MTA, GI, and $Ca(OH)_2$) from dentin. In addition to that, test the modes of failures on debonded interfaces.

Materials and methods

Prepared samples:

Forty lower premolars with a straight single root canal and mature apex were used and kept in formalin "10%". Then, the teeth decorated at "15 mm" from the root apex by diamond disc (KG Sorensen SP, Brazil), and the middle third of the roots were cut perpendicular to their long axis by using mintom (Struers, Denmark) in order to obtain sections with 1 mm thick. Instrumentation for the canal of the dentin discs with Gates Glidden burs (Dentsply/Maillefer/Switzerland), from sizes 2-5 to result into standardized cavities with 1.3 mm diameter as described by VanderWeele *et al*. [15] and Nekoofer [16]. Sample diameter was checked using Motic Image software connecting to digital stereomicroscope (Motic, Taiwan). The samples were placed in 17% EDTA for 3 minutes followed by 2.5% NaOCl for the same time, and then immediately rinsed with distilled water for 2 minutes and dried. After that, specimens were divided randomly into 4groups with 10 specimens in every group as follows:

Group I: BIO (Septodent, France).

Group II: MTA (Angelus Dental

Solutions, Goias Londrina PR Barazil).

Group III: GI (Megadenta GMBLT Dental Product, Radeberg Germany).

Group IV: $Ca(OH)_2$ (Metapex, Germany)

In each group the materials were mixed following the manufactures recommendations, and then the mixture was placed into cavities and condensed with plugger. Material access was removed from the specimens surface with scalpel. Photographed was taken for both coronal and apical surfaces of each discs using computerized stereomicroscope "X 40" (Motic; Taiwan)and viewed prior testing for excluding any defects, cracks, and spaces between dentin wall and material (Figure 1). All samples were then stored at 37^{o}C and 100% humidity for one week.

Push out bond strength (PBS):

PBS was achieved using a computerized universal testing device (TERCO, MT 3037, Sweden)Figure(2): a. Specimens were placed over a hole of 1.5 mm in the center of block of an acrylic (15 mm diameter and12 mm thickness). Load was exerting by applying downward pressure on the surface of the filling material utilizing a cylindrical plunger with "1.2mm" diameter that provided full cover over the filling material without contacting the canal wall (Figure 2:b). PBS preformed at cross-head speed "0.5mm / min". Greatest reading obtained once debonding happen was recorded, and this reading represent the PBS. Surface area subject to force measured from $2\pi rh$ (r= radius, h= height). PBS in Mpa was estimated by dividing the force (N) by the area in mm^2. [15,16,17,18]

Mode of Failures:

Every specimen was viewed by digital stereomicroscope at 40X magnification to evaluate the mode of failure and placed into one of the following: (1) Adhesive at the dentine surface and tested material interface (2) Cohesive within the tested material, and (3) Mixed in both cohesive and adhesive failures.[15]

Results

One Way Analysis of Variance and Tukey Post Hoc Multiple Range Tests "$P \leq 0.05$" utilized for determination of the variations in PBS for the materials that has been used in this study. Result revealed a difference significantly on the PBS for tested materials (Table 1).

Tukey test showed significant difference in PBS between all tested materials the sequence of four materials′ PBS was as follow BIO (13.5Mpa) > MTA(9.57 Mpa) > GI (6.56 Mpa) > $Ca(OH)_2$ 2.97) as seen in Table (2).

The percentage and modes of failures were present in Table (3), and Figure (3).

Discussion

After repair of root perforation, endodontic therapy success depends on the dislodgment resistance of repair material as well as well-adapt coronal restoration. Thus the BS of the perforation repair materials clinically represents an essential factor. To evaluate BS, the PBS test has been seen to be reliable, efficient, and practical.[19]

PBS test has several advantages when compared to other bond strength measurement techniques. It permits using thin sections from every specimen and therefore several readings might be achieved from every single specimen.[17]Additionally, it provides a good evaluation of the BS than the other tests because the fracture happens parallel to the dentin-material interface.[20]

Results of present study indicate that BIO and MTA revealed greater PB than GI and $Ca(OH)_2$. This might be related to that both BIO and MTA are calcium silicate based materials that form calcium- phosphate in addition to formation of apatite- like precipitates at the dentine -cement interface and inside the tubules of the dentine. This lead to makeup tag- like structures and interfacial hybrid layer which is result in mechanical and chemical bonding between these cements and dentine.[12] The biomineralization capacity of the materials which has Calcium Silicate base is directly proportion to the quantity of Calcium ion produced by

these materials and the existence of Phosphate in the tissue fluids [22]. The highest mean values of PBS of Bio seen in the current study may be related to that Bio contains highest amount of products that release Calcium and stimulate the generation of tag- like structures at the dentin-cement interface, this lead to increase the resistance to load of dislodgement when compared to MTA [23].

In MTA some of the particles size is smaller than the dentinal tubule diameter and this might play an important role in good adhesion of MTA to dentin. [24]

This agree with finding of study down by Majeed and AlShwaimi 2016, they compared the PBS of Calcium Silicate based materials and found that BIO showed significantly higher push out bond strength than MTA. [25]

But this result disagree with finding of Nikhade et al., 2016; they found that the differences was not between the PBS of BIO and MTA.[26]

Under the conditions of our study, GI showed greater resistance to push-out forces than $Ca(OH)_2$. The differences in PBS might be related to the particles size of the material. It is well known that the differences in particles size of the test materials are of great importance for mechanical properties of the materials tested.[19]

GI is a material with important properties, Its form chemical bond to dentin by ionic bonding with hydroxyappatite to tooth substrate structure, this provides an excellent bonding. Study has shown that the bonding of GI may be compromised because of its dissolution in tissue fluid and its being technique sensitive, GI has short workKKJing time, long setting and maturation time. Furthermore, they are susceptible to fracture and have low wear resistance. [27]

In this study, $Ca(OH)_2$ result in significantly lower PBS than other repair materials. This because of $Ca(OH)_2$ is brittle, had high solubility and water sorption, and its other mechanical and physical properties were inferior or deficient than other materials tested in this study.

The results of failure modes is in coordinate with the fact that increased dislodgment resistance decreased the possibility of disruption

of the material dentin interface and increased the possibility that failure will happen within the material itself.[28] This might describe why BIO, MTA, and GI which revealed higher PBS than $Ca(OH)_2$, and also had a higher incidence of mixed failure than $Ca(OH)_2$. In evidence of the higher dislodgment resistance achieved in this study by and BIO compared to other tested materials, one can assume that BIO are must suitable repair material for perforation than that of the MTA, GI, and $Ca(OH)_2$.

Conclusions

Within the limitations of this study, it was found that the force required for the dislodgment of BIO from root dentine was significantly greater than that necessary for the dislodgment of MTA, GI, and $Ca(OH)_2$. Therefore, BIO can be used successfully for repair of root perforation.

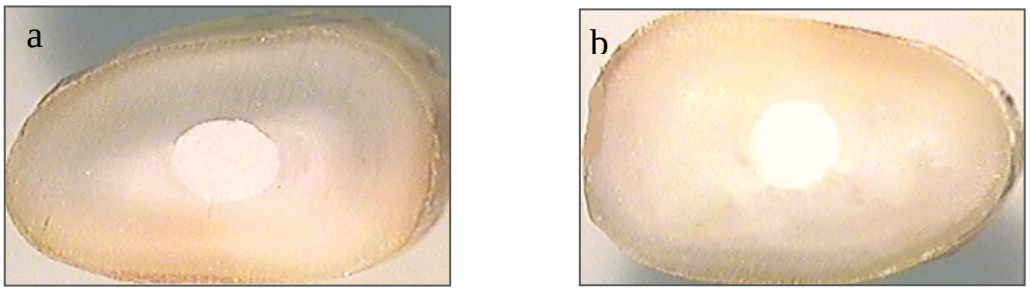


Figure 1: Prepared Specimen for PBS. a: Coronal aspect. b: Apical aspect.

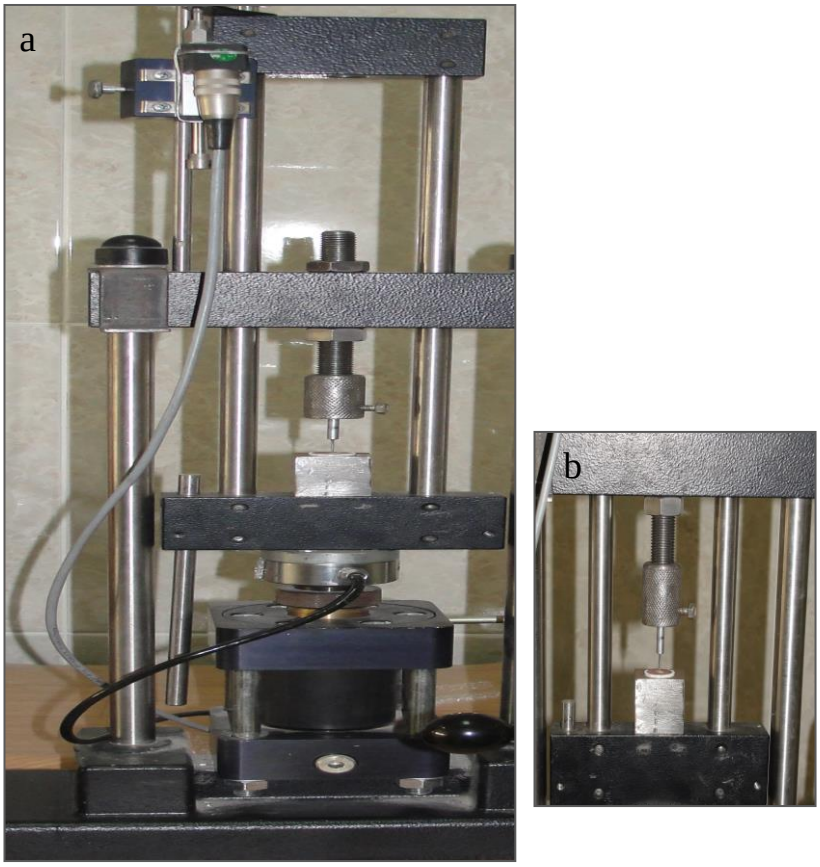


Figure 2: (a) Digital universal testing machine. (b) A cylindrical plunger fixed to the load cell of the testing machine and loading on one of the testing material inside a root section.

Table 1 : One Way Analysis of Variance for the differences on PBS between tested materials.

	Sum of squares	Df*	Mean Squares	F-Value	P-Value**
Between groups	1501.177	4	375.294	825.145	0.000
Within groups	20.467	45	0.455		
total	1521.644	49			

* Df : Degree of freedom.

* * $P \leq 0.05$ mean there is significant variation.

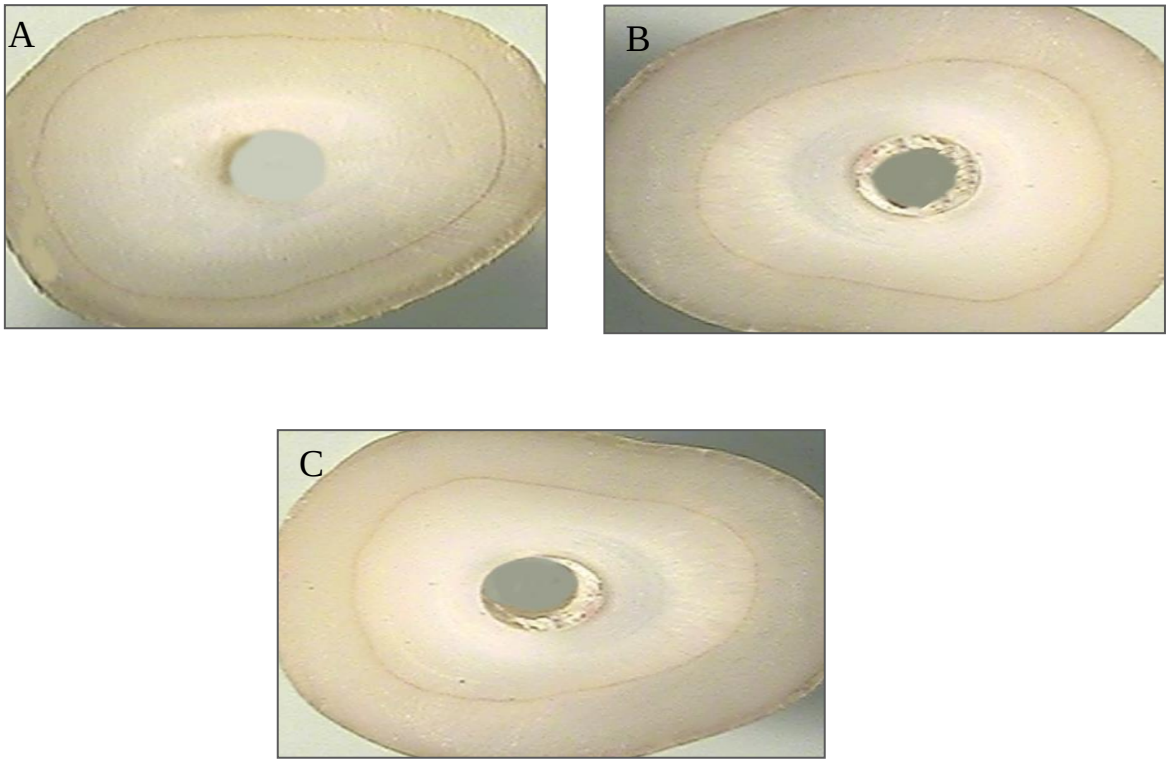
Table(2): Mean of PBS differences among tested materials.

Tested Materials	Mean(Mpa)±SD
BIO	13.5±0.53 A
MTA	9.57±0.59 B
GI	6.56±0.61 C
$Ca(OH)_2$	2.97±0.62 D

***The variable letters mean significant difference exist.**

Table(3) : Failure modes among materials tested by PBS test.

Tested Materials	Failure Mode %		
	Adhesive	**Cohesive**	**Mixed**
BIO	0	40	60
MTA	20	30	50
GI	30	20	50
$Ca(OH)_2$	70	10	20



Figure(3) : Different mode of failures. (A): Adhesive failure (B): Cohesive failure (C): Mixed failure

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