IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 15, Issue 11 Ver. X (November. 2016), PP 65-68
www.iosrjournals.org

Comparative Evaluation of Push-Out Bond Strength Of Calcium Silicate Based Materials: An Ex-Vivo Study.

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Abstract:
***Materials and Methods**: 15 single rooted premolars were selected and middle portion of each root was sectioned perpendicular to the long axis to produce two discs of 2.00 ± 0.05 mm thickness using a diamond disk. 30 root slices were produced and canal lumen was widened using Gates Glidden drills to produce standardized internal diameter of 1.3mm and root sections were filled with ERRM, MTA and Biodentine. Root sections were randomly divided into two subgroups and immersed in PBS for 1 week and 3 weeks. The bond strength was measured using universal testing machine and the failure modes were determined by using stereomicroscope.*
***Results:** The bond strength of ERRM was found to be higher at both incubation periods. No significant difference was found between the bond strength of MTA & Biodentine at either 1 week or 3 weeks.*
***Conclusion:** ERRM had significantly higher bond strength to root canal walls compared to MTA and Biodentine.*
Keywords: *Bond Strength, Endosequence Root Repair Material; Mineral Trioxide Aggregate, Biodentine.*

I. Introduction

Root repair materials are commonly used in endodontic procedures. An ideal endodontic root repair material should be biocompatible, radiopaque, antibacterial, dimensionally stable, easy to manipulate, and unaffected by blood contamination. It is also desirable for the selected material to induct or conduct bone deposition, provide a good seal against bacteria and fluids, set in a wet environment, and have sufficient compressive strength and hardness[1]. Numerous materials have been advocated as root repair materials including, calcium hydroxide, glass ionomer cement, composite resin, bio-aggregate, calcium silicate based materials and Portland-based cements.[2]

Endosequence Root Repair Material was introduced by Brasseler. Bioceramic materials with osteoinductive properties are used in medicine and dentistry as an replacements and implants.[3] Bioceramic materials are Alumina, bioactive glass, zirconia, hydroxyapatite and some calcium silicate based. ERRM (Brasseler USA), a new bioceramic material, is a hydrophilic, insoluble, radiopaque and aluminium free material. It is delivered as a premixed product in both low viscosity paste form dispensed from a syringe and a high viscosity putty form. Moisture is required for the materials to set and harden. The working time is more than 30 minutes, and the setting time is 4 hours under normal conditions. Available in premixed syringe with calibrated intracanal tips. ERRM is of alkaline Ph[4], biocompatible[3,5], and antibacterial[6], able to seal root-end cavities[7].

Mineral Trioxide Aggregate has been investigated as a potential compound to seal off the pathways of communication between the root canal system and the external surface of the tooth. This material was introduced to dentistry, in the field of endodontics in 1993 by Mahamoud Torbinejad at Loma Linda University, as a material for root end filling and perforation repair.It’s a modified Portland cement. MTA consists of fine powder of tri-calcium silicate, di-calcium silicate, tri-calcium aluminate, tetra-calcium aluminoferrite and bismuth oxide. Two types – Gray and White MTA and difference between the 2 types is the absence of iron in white MTA. Mineral trioxide aggregate is good biomaterial for root-end filling, perforation repair, pulpotomies and apexification.[8,9]

Loss of dentin is perhaps one of the major losses which hamper the integrity of the tooth structure to a significant extent. The dentin loss, whether be in the coronal portion or the radicular one, must be substituted with an artificial material, which can restore the physiological integrity of the tooth structure. Septodont’s research group has developed a new class of dental material named **Biodentine** which could conciliate high mechanical properties with excellent biocompatibility as well as a bioactive behaviour. Biodentine is the first all-in-one bioactive and biocompatible dentine substitute used to treat damaged dentine both for restorative and endodontic purposes. Composed of Powder: Tri-calcium Silicate (C_3S) - Main core material, Di-calcium Silicate (C_2S)-Second core material, Calcium Carbonate and Oxide Filler, Iron Oxide-Shade, Zirconium Oxide–radiopacifier and liquid: Calcium chloride, Accelerator and Hydro soluble polymer, Water reducing agent.[10]

Bond strength of endodontic material to dentin is an important property as it minimizes the risk of detachment of filling material from dentin during the condensation forces.Dislodgement may lead to reinfection and failure which can be prevented by effective bond strength.

Aim: An ex-vivo comparison of push out bond strength of Endosequence root repair material (ERRM), Mineral trioxide aggregate (MTA) and Biodentine (BD) after incubation in phosphate buffered saline (PBS) for 1 week and 3 weeks.

II. Methods and Materials

Preparation of samples :

15 freshly extracted single rooted mandibular premolars were selected for the study. The middle portion of each root was sectioned perpendicular to the long axis to produce a discs of 2.00 ± 0.05 mm thickness using a diamond disc with continuous water irrigation. Finally, 30 root slices were produced. The canal lumen of each specimen was widened using size 2 to 5 Gates Glidden burs (Dentsply Maillefer, Ballaigues, Switzerland), to produce a standardized internal diameter of 1.3 mm. The specimens were immersed in 17% EDTA for 3 minutes followed by 3 % sodium hypochlorite for the same period of time and then washed with distilled water and dried. The root specimens were divided randomly into 3 groups:

- Group I (ERRM): Consist of 5 samples which were filled with Endosequence Root Repair Material. (ERRM) putty, which is premixed by the manufacturer.
- Group II (WMTA): Consist of 5 samples which were filled with White Mineral Trioxide Aggregate (MTA)was mixed following the manufacturer's instructions and placed inside the lumens of the root slices.
- Group III (BD) : Consist of 5 samples which were filled with Biodentine was mixed following the manufacturer's instruction and placed inside the lumens of the root slices.

A Phosphate buffered saline (PBS) solution containing 1.7 g of KH2PO4, 11.8 g of Na2HPO4, 80.0 g of NaCl, and 2.0 g of KCl in 10 L of H2O (pH=7.2) was pre-pared. Specimens were wrapped in pieces of gauze soaked in PBS for 1 hour.

Each group was divided into two subgroups each of 5. In subgroups E_1, M_1 and B_1 the root sections were immersed in Eppendorf plastic tubes containing 2ml of PBS and stored in it for 1week and subgroups E_2, M_2 and B_2 for 3 weeks. The PBS solution was replenished every 5 days to replenish buffering capacity of the PBS. All specimens were incubated at 37°C.

Push-Out Test:

After the experimental periods, the specimens were submitted to the push-out test. The samples were placed on the metal slab containing central hole to allow a free motion of plunger with a 1mm diameter, at a constant vertical pressure of speed 1mm/min. The plunger tip was positioned to contact the tested material only .The maximum load applied to the filling material before debonding was recorded in Newton. To express the bond strength in megapascals (MPa), the load at failure recorded in Newton (N) was divided by the canal wall area in mm^2.

Bond Strength (Mpa) = Force for dislodgement (N)/Bonded surface area (mm^2)

Where, area if bonded interface (sq/mm) = $2\pi rh$

π= 3.1416, r = radius of the root canal and h = thickness of dentin slice in millimetre.

Evaluation of failure patterns :

After the push-out testing, the root sections were examined under a stereomicroscope at 25X magnification to determine the failure mode. Modes of failure were defined as follows:

(1) Cohesive: failure was entirely within the material;

(2) Adhesive: failure was at the material/dentin interface;

(3) Mixed failure : which is the combination of the two failure mode.

Observation Table:

	Material		Mean Difference (I-J)	Std. Error	P-Value	95% Confidence Interval	
						Lower Bound	Upper Bound
1st Week	ERRM	MTA	0.64	0.75	1.000,NS	1.45	2.74
		Biodentine	5.65*	0.75	0.000,S	3.55	7.75
	MTA	Biodentine	6.30	0.75	0.000,S	4.19	8.40
3rd Week	ERRM	MTA	9.25	1.10	0.000,S	6.17	12.32
		Biodentine	2.41	1.10	0.149,NS	0.65	5.48
	MTA	Biodentine	6.83*	1.10	0.000,S	3.76	9.90

III. Statistical Analysis

Descriptive and analytical statistics were done. The Paired sample t-test and one way analysis of Variance (ANOVA) with Bonferroni post hoc was used to check the differences between mean bond strength of different materials.

IV. Results

Bond strength of Endosequence root repair material (ERRM)was found to be to be significantly higher than that of Mineral trioxide aggregate(MTA) and Biodentine (BD)at 1 week and 3 weeks .By increasing the incubation time, the bond strength of all material increased significantly. The push-out bond strength values were higher with ERRM followed by MTA and BD. The failure mode was cohesive for ERRM at both the incubation time and mixed type of failure was seen with MTA and BD.

V. Discussion

In the present study, bond strength of ERRM putty was significantly higher than those of MTA and BD at both 1 week and 3 weeks. Failure mode for ERRM at both incubation times was mainly cohesive. Noushin Shokouhinejad et.al in 2013[11], the higher bond strength values obtained for ERRM is most likely due to its greater adherence to dentinal walls, the higher bond strength of ERRM compared to MTA and BD might be attributed due to the delivery system of these materials, which is premixed putty for ERRM and separate powder and liquid for both MTA and BD. The thickening and filler agents added to ERRM to make it putty form might be associated with higher bond strength.

It has been reported that the presence of zirconium oxide improved certain physical properties of composite bioceramics[12]. The presence of zirconium oxide in the composition of ERRM might also result in higher bond strength of ERRM. To investigate the other physicochemical properties of new bioceramic material ,more number of studies are required.

Biodentine has a similar composition to MTA, differing mostly by being aluminium-free[13] and having tantalum oxide as a radiopacifier in place of the bismuth oxide .[14,15] This is claimed to be associated with improved biological property.[13]The results of the present study revealed that the bond strength of BD was similar to that of MTA at both incubation times.

In the present study, MTA, BD, and ERRM had higher bond strength values at 3 weeks compared with those observed at 1-week. This could be attributed to the bioactivity of calcium-silicate based materials.[16,17,18]

Physicochemical interaction between MTA and root canal walls in the presence of a phosphate-containing fluid resulted in a chemical bond between the apatitic surface of MTA and dentin [14] that may modify the retention and friction of cements on dentin walls [19]. Reyes-Carmona JF et al. in 2009 [17] ,found that sample immersed in PBS for 3 weeks had a significantly greater resistance to displacement than that observed for the samples at 1 week.

Jessie F. Reyes-Carmona, Mara S. Felipe and Wilson in 2010[19], found that all samples immersed in PBS displayed a significantly greater resistance to displacement than that observed for the samples in contact with a wet cotton pellet for 72 hours ($p < 0.05$). MTAs displayed a significantly greater resistance to displacement than Portland cements. It was concluded that the bio-mineralization process positively influenced the push-out bond strength of the cements, particularly the MTA groups.

Ahmed Abdel Rahman Hashem and Suzan Abdul Wanees Amin in 2012[2], studied the effect of acidic environment on the dislodgement resistance of mineral trioxide aggregate (MTA) and Bio aggregate (Innovative BioCeramix, Vancouver, Canada) when used as perforation repair materials. And concluded that MTA is more influenced by acidic pH than BA. Storage for 30 days in PBS can reverse the affected bond of MTA by the acidic environment.

Huffman et al. in 2009[20], reported that ProRoot Endo Sealer (Dentsply Tulsa Dental Specialties, Tulsa, OK, USA) had higher push- out strength values after immersion in a phosphate-containing fluid for 4 weeks. Therefore, in the present study ,to partially simulate the in vivo conditions ,the root sections were stored in PBS

Using ideal biocompatible material like Endosequence root repair material, calcium silicate based material and mineral trioxide aggregate is to increase the bond strength of tooth, to achieve a good seal against a micro-organisms and fluids.

VI. Conclusion

Following the incubation time of 1 week and 3 weeks in PBS, ERRM had greater bond strength as compared to BD and MTA to the canal walls. Bond strength of all material was increased significantly, increasing the incubation time.

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