International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2015): 78.96 | Impact Factor (2015): 6.391

The Sealing Ability of New Bioceramic Material Used to Repair Furcal Perforation Compared with the Traditional Repair Materials: UV Spectrophotometer Analysis

Ala' a Jawad Kadhim[1], Nagham A. Al-Hyali[2], Raghad Abdulrazzaq Alhashimi[3]

[1]B.D.S., M.Sc., Lecturer, Department of conservative Dentistry, Collage of Dentistry, Baghdad University, Iraq
[2]B.D.S., M.Sc., Lecturer, Department of conservative Dentistry, Collage of Dentistry, Baghdad University, Iraq
[3]B.D.S., M.Sc., Ph.D., Assistant professor, Department of conservative Dentistry, Collage of Dentistry, Baghdad University, Iraq

Abstract: ***Iatrogenic furcal root perforations are serious complications during dental treatment. This study was aimed to compare the sealing ability of new bioceramic root repair material TotalFill® with the other perforation repair materials (GIC, MTA and Biodentine) using a dye- extraction method.Materials and Methods: Forty extracted, human mandibular molars with non-fused well developed root were collected. Artificial perforations were made from the external surface of the teeth. Then the teeth were randomly divided into 4 experimental groups (n= 10) according to the type of repair material used in this study; Medifil glass ionomercement, TotalFill® bioceramic root repair material, Biodentine™ and MTA Plus. The specimens were then immersed in 4% methylene blue dye up to the CEJ for 48 hours followed by dye extraction with 65% nitric acid for 3 days. The samples were analyzed using ultraviolet (UV) visible spectrophotometer. Data obtained were analyzed using one way ANOVA and Tukey tests at 0.05 significant levels. Results: Statistical analysis showed highly significant differences (P<0. 05) among tested materials. Lower absorption values occurred with TotalFill® group fallowed by biodentine and MTA but higher absorption occurred with GIC group. One Way ANOVA showed highly significant differences (P<0. 05) among the groups. Tukey test showed highly significant differences when compared TotalFill® and Biodentine groups with GIC and significant difference with MTA Plus group, but among TotalFill®, Biodentine and MTA Plus groups the results were non- significant.Conclusion: TotalFill®showed better furcation sealing ability as compared to Biodentine and MTA Plus materials but with no significant differences.***

Keywords: Dye-extraction, furcation repair, perforation, spectrophotometer, TotalFill®.

1. Introduction

Furcal perforation refers to a mid-curvature opening into the periodontal ligament space and it is the worst possible outcome in root canal treatment [(1)]. Root perforation can be repaired surgically or no surgically, but Furcal perforation is surgically inaccessible so it has a more unfavorable prognosis than perforations occurring in the middle and apical root thirds [(2, 3)]. However; if such perforations are immediately diagnosed and sealed with a biocompatible material, the prognosis is usually good [(4)]. The material employed for sealing of perforation is one of the important factors for prognosis that directly interferes with the repair of these defects [(5)]. An ideal perforation repair material should be biocompatible, not affected by blood contamination, not extruded during condensation, bactericidal, provide anadequate seal, induce bone formation and healing, radiopaque, induce mineralization, cementogenesis and easy in manipulation and placement[(6)]. A wide variety of materials have been suggested to seal perforations including zinc oxide eugenol cements (IRM and Super EBA), amalgam, gutta-percha, composite resin, glass ionomer and mineral trioxide aggregate (MTA)[(7)].

Today, the most preferred furcation repair materials are bioactive materials like Mineral Trioxide Aggregate and Biodentine[(1)]. MTA was developed and recommended to treat perforations since its introduction, as the previous materials did not have the ideal characteristic [(8)]. The main drawbacks of MTA has been slow setting time and complicated handling, which rendered these technique – sensitive procedures[(9)].

In order to overcome these disadvantages, Biodentine has been introduced, it seems to have similar physiochemical, mechanical, biological properties to MTA but shorter setting time (9 - 12 minutes)[(10)]. Biodentine is a high-purity calcium silicate–based dental material composed of tricalcium silicate, calcium carbonate, zirconium oxide and a water-based liquid containing calcium chloride as the setting accelerator and water-reducing agent [(11)].

Recently, bioceramic root repair materials have been developed as ready to use, premixed bioceramic material recommended for perforation repair, apical surgery, apical plug, and pulp capping [(12)].There are several methods to evaluate leakage of perforation repair materials like dye penetration, bacterial, fluid filtration and dye-extraction [(13)]. Camps and Pashley[(14)] reported that the dye-extraction method gave the same results as the fluid-filtration method and also saved much laboratory time.

The aim of this study is to compare the sealing ability of new bioceramic root repair material Total Fill® with the other perforation repair materials (GIC, MTA and Biodentine) using a dye- extraction method.

2. Materials and Methods

Forty extracted, human mandibular second molars were collected for this study according to the following criteria:

complete root formation, minimal or no occlusal caries, non-fused diverged roots and no cracks on examination with 10X magnifying eye lens and light curing device [8].

Specimens' preparation:

The teeth were cleaned by immersion in 5.25 % sodium hypochlorite solution for 30 min. Calculus and soft tissue tags were removed by ultrasonic scaler, then the teeth were washed with tap water and stored in normal saline until use. To facilitate manipulation, the teeth were decoronated 3 mm coronal the cemento-enamel junction and the roots were amputated 3 mm apical the furcation area, using a diamond disk bur mounted on contra-angle latch type handpiece (NSK, Japan). A standardized endodontic access opening was made in each tooth using #4 round bur in a high speed handpiece (NSK, Japan) with air water coolant, and the root orifices were located [15]. The contents of the pulp chamber and root canals were removed with a spoon excavator and barbed broaches. To ensure each perforation was centered between the roots, a black marker pen was used to mark the location of the defect. Artificial perforation was created from the external surface of the tooth with a #2 round carbide bur (100 ISO size; Dentsply-Millefer, Ballaigues, Switzerland) mounted on a high-speed hand piece (NSK, Japan) with air water coolant. Then # 100 K file (Maillefer, Switzerland) was used to enlarge the perforation size and get a standardized perforation diameter of 1.32 at D16 ensure that the direction of the defect was parallel to the long axis of each tooth[16] **(Figure 1)**. The depth of the perforations depended on the dentin-cementum thickness from the pulpal floor to the furcation area. The heights of walls of the perforated area in all the teeth were 2mm which measured by using a periodontal probe. The teeth in which the thickness of dentin at the perforated area was less than 2 mm were excluded. Sticky wax was placed over the orifices of each canal and the sectioned root surface including pulpal floor, then teeth coated with two successive layers of varnish in an attempt to increase the marginal seal except for 1 to 2 mm around the perforation. Amoist cotton pellet (which did not act as a matrix for repair material) was placed in the furcation area to simulate wet clinical field [7].

Specimens' grouping:

The teeth were randomly divided into 4 experimental groups with 10 teeth in each group. The teeth divided according to type of repaired material. The manufacturer's instructions were followed while dispensing, preparing, mixing and placing the materials.

GIC Group (control group): teeth repaired with glass ionomer cement (Medifil, ProMedica, Germany), it was prepared by mixing a scoop of powder with two drops of liquid. Using a strong plastic spatula for 1 min. then the material was handled with the plastic instrument and packed into the perforation cavity gently patted into place with the end of endodontic condenser. After the setting phase (2 minutes), the glass-ionomer was covered with a copalite varnish.

TotalFill® Group: Teeth repaired with bioceramic root repair material (TotalFill®BC RRM ™, BUSA, KFG Brasseler, USA). The material is present in a ready to use, premixed bioceramic paste applied directly to perforation area using disposable tips (Setting time about 2 hours in case of moisture presence) (Figure 2).

Biodentine Group: Teeth repaired with Biodentine™ (Septodent – Saint Maur, desFoss's, France).The powder was mixed with its liquid in a capsule using a triturator (YDM, HANGZHOU YIN YA new materials CO. LTD, China) for 30 seconds.The freshly mixed Biodentine had a putty-like consistency and was packed in the perforations using a plastic filling instrument (setting time about 12 to 15 minutes).

MTA Plus Group: Teeth repaired with Mineral trioxide aggregate (PPH CERKAMED company, Polska) consist of powder which was mixed on a paper pad with distilled water in a 3: 1 powder water ratio. When the mixture exhibited putty like consistency after about 30 sec mixing time, it was immediately placed into the perforation with a carrier gun

Dye leakage measurements:

After repaired procedures and completed setting for all materials, the teeth were kept in saline at 37 o c for 24 using an incubator (Memmert, Germany) to ensure the complete setting of the materials. Then each group was placed in separate petri dishes containing 4% methylene blue (CDHR Ltd., India) such that all the teeth were immersed in dye up to the CEJ for 48hrs.[17, 18].After removal from the dye, teeth were rinsed under running water for 30 minutes and varnish was removed with a polishing disc [18]

To measure the amount of dye leakage in perforation area (sealing ability of tested materials), each tooth was stored in a vial containing 5 ml of nitric acid (65% weights) for 3 days. The solutions thus obtained were centrifuged at 3500 rpm for 5 min using centrifuge (Kokusan, M.F.G 138033, Japan). 4 ml of the supernatant liquid was then analyzed in an ultraviolet (UV) visible spectrophotometer (Cecil 7200, England) (Figure 3) at 550 nm wavelength with concentrated nitric acid as the blank and readings were recorded as absorbance units [18]. The absorption value was indication of sealing ability of tested materials.

Statistical Analysis:

Statistical analysis was performed with SPSS software package (version 20.0). Data were collected and analyzed by using variance test (One-Way ANOVA) and Tukey tests to test for any significance difference between the groups. The mean difference was significant at the 0.05 level.

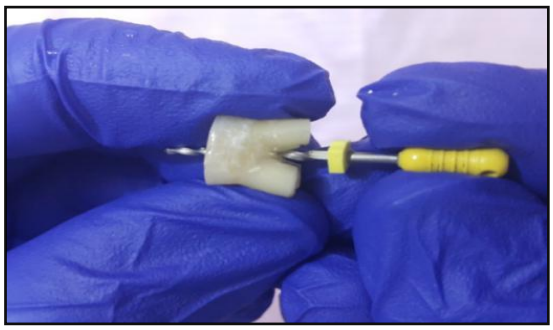

Figure 1: The furcal perforation was enlarged with # 100 k- file

Figure 2: TOTAL FILL bioceramic

Figure 3: UV spectrophotometer (Cecil 7200, England) used in the study

3. Results

Descriptive statistical analyses were carried out on the collected data to establish the values of the standard deviation (SD), standard error (SE), minimum (Min), maximum (Max) and mean of absorption values of each experimental group used in the study, as shown in the table (1).

The result showed the highest absorption values with GIC fallowed by MTA and Biodentine. But lower absorption occurred with TotalFill® group (Figure 4). One Way ANOVA (Table 2) showed highly significant differences (P<0. 05) among the groups. Tukeytest (Table 3) showed highly significant differences when compared GIC with TotalFill® and Biodentine and a significant difference with MTA Plus. But among TotalFill®, Biodentine and MTA groups Plus the differences were non- significant (p> 0.005).

Table 1: Descriptive statistic of all groups

Groups	Mean	SD	Min	Max	SE
GIC	1.795	0.4286	1.25	2.42	0.13556
TotalFill®	1.049	0.2511	0.82	1.52	0.07942
Biodentine	1.208	0.2573	0.85	1.65	0.08137
MTA Plus	1.356	0.1931	1.03	1.62	0.06107

Table 2: One way ANOVA among the groups

	Sum of Squares	df	Mean Square	F	Sig.
Between groups	3.087	3	1.029	11.748	0.000 **HS**
Within groups	3.153	36	0.088		
Total	6.240	39			

Table 3: Tukey test for comparison among the tested materials

Comparison among the groups		Mean difference	p-value	Sig.
GIC	Total Fill	0.745	0.000	**HS**
	Biodentine	0.587	0.000	**HS**
	MTA Plus	0.439	0.011	**S**
Total Fill	Biodentine	-0.158	0.632	**NS**
	MTA Plus	-0.306	0.113	**NS**
Biodentine	MTA Plus	-0.148	0.681	**NS**

The mean difference is significant at the 0.05 level

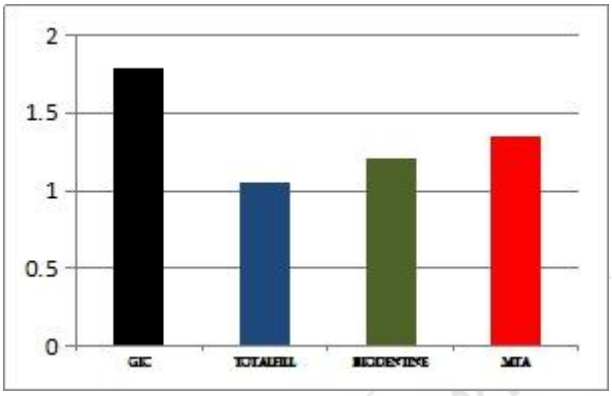

Figure 4: Bar chart showing the differences in the absorption values of tested materials

The success of the furcation repair is always dependent on the effective seal between the root canal and the periodontal ligament. This can be achieved by a suitable material which should stop the microleakage and communication between the tooth and periodontal ligament [19].

Several methods have been used to assess microleakage such as fluid filtration, dye penetration, dye extraction, bacterial and protein leakage, radioactive isotopes, artificial caries, scanning electron microscopy, neutron activation analysis, and electrical conductivity [20].

The dye-penetration technique has long been used because of its ease of performance and difficulty of other available techniques. Despite its popularity, it relies on randomly cutting the roots into two pieces, without any clue of the position of the deepest dye penetration [14].Wu MK et al., stated that the calcium oxide contained in MTA may react with water, form Ca (OH) 2 that discolors methylene blue, and that dye may be further diluted with cooling water used in sectioning teeth for a linear dye penetration study [21].

This drawback is avoided by dye extraction method; in the dye extraction method, the teeth are dissolved in acids that release all the dye from the interface, after which the optical density of the solution is measured by a Spectrophotometer [22].

The present study compared the sealing ability of new bioceramicTotalFill® material with the other perforation repair materials (GIC, MTA and Biodentine) using a dye extraction leakage method.

As shown in the result of our study, the GIC exhibited the highest dye penetration percentage and it also showed a statistically high significant difference when compared with TotalFill® and Biodentine groups and a significant difference with MTA group. This could be explained by the presence of moisture from the cotton pellet which was placed in the furcation area to simulate conditions of oral environment that might adversely affect the sealing ability of the glass ionomer cement. Also the flow of glass ionomer cement is slow; it might have not filled the defect completely since the materials placed into the furcation should have sufficient flow to fill and seal the apical ends of the perforations [23].

These results were in agreement with other studies [16, 17] that had shown that the marginal seal of glass ionomer cement compromised because of its dissolution in tissue fluid and its being technique sensitive.

MTA &Biodentine are hydrophilic endodontic cements; this feature facilitates wetting of dentin, allowed access of cement within gap/spaces associated with the perforation walls and helped the entrance of small cement particles into dentinal tubules. Furthermore, MTA and Biodentine in contrast with other dental materials exhibited slight expansion after setting [24] and enhancing adaptation of the biomaterials to the perforation walls. In addition, MTA and Biodentine form hydroxyapatite and provide an improved seal at the interface of biomaterials and dentin walls as well as the filling material [25, 26].

Despite the good physical, biological and hydrophilic properties of MTA, it has some disadvantages such as long setting time of about 4 hours, difficult handling of the material, MTA prepared by mixing its powder with a sterile water in a 3:1 ratio, which means any difference in this ratio will compromise its properties, also it is considered as an expensive material [8]. Biodentine is similar to MTA in basic composition; however it showed better sealing ability than MTA in this study. The manufactures claim that adding calcium chloride ($CaCl_2$) to the liquid component accelerates the system, therefore decreasing of the liquid content in the system decreases the setting time to harden within 9 to 12 minutes. The addition of hydrosoluble polymer systems described as “water reducing agents” or super plasticizers, help in maintaining the balance between low water content and consistency of the mixture [27]. Biodentine proves superior to MTA as it does not require a two steps obturation and as the setting is faster [28]. The results of this study have been in accordance with studies carried out by **Kumar Y et al2016**[17] and **Hassan et. al 2015** [8].

An alternative material to MTA with improved handling properties has been manufactured, which is TotalFill® root repair Material (RRM).The TotalFill® is a pre-mixed bioceramic material composed of calcium silicates, zirconium oxide, tantalum oxide, calcium phosphate monobasic thickening agents, and proprietary fillers [(12)]. It is available in two specifically formulated consistencies (syringable paste or condensable putty) and contains many of the same characteristics as TotalFill® BC Sealer™. The favorable handling properties, increased strength and shortened set time make TotalFill® highly resistant to washout and ideal for all root repair and pulp capping procedures [(29)].

The manufacturers of TotalFill® material claim that premixed TotalFill® putty have a working time of approximately 30+ minutes, a setting reaction initiated by moisture and a final set achieved approximately two hours later with the calcium silicate portion of the material produces a calcium silicate hydrate gel and calcium hydroxide. The calcium hydroxide then interacted with phosphate ions to form hydroxyapatite and water. The water produced continued to react with the calcium silicates to precipitate additional gel like calcium silicate hydrate [(12)].

In the current study, TotalFill® showed less dye absorbance but with no significant difference with biodentine and MTA. The better results can be explained by its particle size (less than 2 micron), which allows the premixed material to penetrate into the dentinal tubules and bond to adjacent dentin to provide a hydraulic seal [(30)]. Beside that no mixing is required the setting reaction begins as soon as the material is placed in contact with moist environment.

Our result is agree with the study of **Jeevani et al 2014** [(31)] that stated the Endosequence (bioceramic material) showed the lowest dye absorbance when compared with Biodentine and MTA.

Within the limitations of this study, it can be concluded that the sealing ability of TotalFill®, Biodentine and MTA are comparable to each other. However, the best seal was provided by TotalFill®, further studies on the sealing ability and physio- mechanical properties are warranted.

References

[1] Sanghavi D, Shah DN, Shah DR. Comparative analysis of sealing ability of Biodentine and calcium phosphate cement against Mineral Trioxide Aggregate (MTA) as a furcal perforation repair material (an in vitro study). NJIRM. 2013; 4(3): 56-60.
[2] Torabinejad M, Chivian N. Clinical applications of mineral trioxide aggregate. J Endod. 1999; 25: 197-205
[3] Holland R, Filho JA, Souza V, Nery MJ, Junior ED. Mineral trioxide aggregate repair of lateral root perforation. J Endod.2001; 27: 281-44.
[4] Clauder T. and Shin SJ. repair of perforation with MTA: Clinical applications and mechanism of action. Endodontic topics 2009; 15: 32-55.
[5] Balto HA. Attachment and morphological behavior of human periodontal ligament fibroblasts to mineral trioxide aggregate: a scanning electron microscope study. J Endod. 2004; 30(1):25-29.
[6] Aggarwal V, Singla M, Miglani S, Kohli S. Comparative evaluation of push-out bond strength of ProRoot MTA, Biodentine, and MTA Plus in furcation perforation repair. J Conserv Dent 2013; 16:462-5.
[7] De-deus G, Petruccelli V, Gurgel-Filho E, Coutinho-Filho T. MTA versus Portland cement as repair material for furcal perforations: a laboratory study using a polymicrobial leakage model. Int. Endo J. 2006; 39:293-98.
[8] Hassan N., Al HadiD, Saeed MH. Furcal perforation repair using MTA & Biodentine an in vitro evaluation using dye extraction method. Int. Rec. Sci. Research J 2015; 6 (3):3172-3175.
[9] Parirokh M &Torabinejad M. Mineral trioxide aggregate: A comprehensive literature review-Part III: Clinical application, draw backs, and mechanism of action. J Endod. 2010; 36: 400-413
[10] Nikoloudaki G, Kontogiannis T, Meliou H, Kerezoudis N. A Comparative In-Vitro Study of Sealing Ability of Four Different Materials Used in Furcation Perforation. Open Journal of Stomatology 2014; 4(8):402-411.
[11] Koubi G, Colon P, Franquin JC, Hartmann A, Richard G, Faure MO, et al. Clinical evaluation of the performance and safety of a new dentine substitute, Biodentine, in the restoration of posterior teeth - a prospective study. Clin Oral Investig. 2012;17:243–249
[12] Ma J, Shen Y, Stojicic S, Haapasalo M. Biocompatibility of two novel root repair materials. J Endod. 2011; 37:793–8
[13] HasbemAA, Hassanien EE: ProRoot MTA, MTA-Angelus and IRM used to repair large furcation perforations: sealing study. JOE 2008; 34(1):59-61.
[14] Camps J, Pashley DH. Reliability of the dye penetration studies.J Endod 2003; 29:592– 4. 22.
[15] Uyanik MO, Nagas E, Sahin C. Effect of different irrigation regimens on sealing properties of repaired furcal perforation. Oral Surg. Oral Radio Endo 2009; 107: e 91-5.
[16] Alaajam WH, Alrawi IE, Farheen U, Ashishkumar K. Evaluation of the sealing abilities of three different materials used to repair furcal perforations. IJCD 2013; 4(2) :19-25.
[17] Kumar Y, Singh F, Jindal N, Aggarwal K. An in-vitro comparative evaluation of sealing ability of resin modified glass ionomer cement, mineral trioxide aggregate and biodentine as a furcation repair material: analysis by confocal laser microscopy. J. of Den. and Med. Sci.2016; 15 (3): 26-30
[18] Sinkar R, Patil S, Jogad N, Gade V. Comparison of sealing ability of ProRoot MTA, RetroMTA, and Biodentine as furcation repair materials: An ultraviolet spectrophotometric analysis. J Conserv Dent. 2015; 18(6): 445–448.
[19] Samuel A, Asokan S, Geetha Priya P R, Thomas S. Evaluation of sealing ability of Biodentine™ and mineral trioxide aggregate in primary molars using

scanning electron microscope: A randomized controlled in vitro trial. ContempClin Dent 2016; 7:322-5.
[20] Gogna R, Jagadis S, Shashikal K. A comparative in vitro study of microleakage by a radioactive isotope and compressive strength of three nanofilled composite resin restorations .J Conserv Dent. 2011; 14:128–31.
[21] Wu MK, Kontakiotis EG, Wesselink PR. Long-term seal provided by some root-end filling materials. J Endod. 1998; 24:557-560.
[22] Sikri VK. Color: Implications in dentistry. J Conserv Dent.2010; 13: 249–55.
[23] Chaudhari P, Shivanna V. Perforation repair with artificial floor technique - A microleakage study. J IntClin Dent Res Organ 2009; 1: 65-75.
[24] Asgary S, Shahabi S, Jafarzadeh T, Amini S, Kheirieh S. The properties of a new endodontic material. Endod J 2008; 34(8):990–3.
[25] Sarkar NK, Caicedo R, Ritwik P, Moiseyeva R, Kawashima I. Physicochemical basis of the biologic properties of mineral trioxide aggregate. Endod J 2005; 31(2):97–100].
[26] Asgary S, Eghbal MJ, Parirokh M, Ghoddusi J. Effect of two storage solutions on surface topography of two root-end fillings. AustEndod J. 2009; 35(3):147–52.
[27] Septodont, R & D Department, Biodentine, Active Biosilicate Technology, Scientific File
[28] Guneser MB, Akbulut MB, EldenizAU. Effect of various endodontic irrigants on the push-out bond strength of Biodentine and conventional root perforation repair materials. JOE. 2013; 39: 380-384.
[29] Availableat:http:// www.fkg.ch/products/endodontics/obturation/totalfill. [Date accessed September 1, 2016].
[30] Koch K, Brave D &Nasseh A. A review of bioceramic technology in endodontics. BJMMR 2012; 4(12):6-32.
[31] Jeevani E, Jayaprakash T, Bolla N, Vemuri S, Sunil C, Kalluru R. Evaluation of sealing ability of MM-MTA, Endosequence, and biodentine as furcation repair materials: UV spectrophotometric analysis. J Conserv Dent. 2014; 17(4): 340–343