IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 16, Issue 12 Ver. IV (Dec. 2017), PP 82-86
www.iosrjournals.org

Comparison of Sealing Ability of Biodentine, Bioactive Bone Cement And MTA As Furcation Repair Materials

Dr. Ajmal Mir[1], *Dr. Omer Hussain Misgar[2],Prof. (Dr) Riyaz Farooq[3], Dr. Aamir Rashid Purra[4],Dr. Fayaz Ahmed Ahanger[5]
[1,2,3,4,5]Department of Conservative Dentistry and Endodontics, Govt. Dental College and Hospital, Srinagar
*Corresponding Author: *Dr. Omer Hussain Misgar*

Abstract
Introduction: *Furcal perforation is a common occurrence during endodontic treatment. Prompt intervention and use of proper repair materials is very important to improve the prognosis of involved tooth. Material qualities are also determining factor of success. Search for newer materials that are easy to manipulate, cost effective with better physical and biological properties is a never ending process.*
Methodology: *Seventy six extracted human molars were perforated in furcation area and randomly divided into four groups. Perforations in three groups of samples were repaired with MTA, Biodentine and bioactive bone cement while as fourth group of samples was left unrepaired as control. Simultaneously samples were subjected to dye leakage test and values calculated as absorbance units with spectrophotometer.*
Result: *Results showed that bioactive bone cement is as good as MTA in terms of sealing ability while as sealing ability of Biodentine is significantly better than both MTA and bioactive bone cement.*
Conclusion: *Bioactive Bone cement can be used as furcal perforation repair material in cases where easy handling and quick setting of repair material is needed with satisfactory sealing quality.*
Keywords: *Biodentine, Bone Cement, Dye Extraction, Furcal Perforation, MTA.*

Date of Submission: 27-11-2017 Date of acceptance: 09-12-2017

I. Introduction

Maintaining the integrity of the natural dentition is essential for full function and natural esthetics. Endodontic therapy can play a vital role in achieving this goal. Technical problems do occur occasionally during endodontic treatment, one of which is perforation of the furcal wall. An endodontic perforation is an artificial opening in the tooth or its root, created by clinician during entry to the canal system or by biological event such as pathological resorption etc. resulting in communication between root canal and periodontal tissue [1]. Root perforations are reported as second greatest cause of failure accounting for 9.62% of all unsuccessful cases [2]. Furcation perforation refers to a mid-curvature opening into the periodontal ligament space and is the worst possible outcome in root canal treatment [3]. Favorable healing of periodontal tissue has been reported to occur when defects were closed as compared to those left open [4]. The choice of sealing material is a crucial factor that influences the outcome of treatment [5]. The most commonly used repair material are amalgam, resin modified glass ionomer cement, calcium hydroxide, glass ionomer cement, composite resin, and MTA. Mineral trioxide aggregate (MTA) is a biomaterial that has been investigated for endodontic applications since the early 1990s. Despite its many advantages, MTA has some drawbacks such as a long setting time [6], discoloration potential [7] among others. So, efforts have been made to overcome these shortcomings, new calcium silicate based bioactive restorative cement has been developed, namely Biodentine. Advantages of this material are short setting time, high compressive and flexure strength [8], and color stability [9] along with ease of manipulation.

Bone cement is a potentially new repair material that has been investigated in dentistry recently, although it has been used in orthopedic surgery for past 40 years especially for fixation of implants such as artificial hip joints with living bone. However, it lacks ability to directly bond with living body and hence needs to be modified to incorporate bioactivity in bone cement. Bioactive Bone cement has many characteristics that make it well suited as a repair material for variety of endodontic treatments [10]. The purpose of this study was to evaluate the sealing ability of MTA, bioactive bone cement and Biodentine as furcation repair materials in molar teeth using dye extraction leakage model.

II. Materials And Methods

Seventy six extracted human mandibular molar teeth with non-fused and well developed roots, no caries or cracks were used in this study. Teeth were disinfected in 5% Sodium hypochlorite solution (Shivam Industries, Jammu, India) for 30 minutes and stored in physiological saline until they were used in this study. A standard endodontic access opening was prepared in all the teeth. Teeth were then decoronated 3 millimeters above cemento-enamel junction using diamond disc under continuous water cooling. Similarly, roots were amputated 3mm below the furcation. Sticky wax was placed over the orifice of each canal and the sectioned root surface including the pulpal floor. Teeth were then coated with two layers of varnish (Pyrax, India) and perforations made in furcation area. To ensure each perforation was centered between the roots, an indelible black marker pen was used to mark the location of the perforation. A perforation of 1mm diameter was made from external surface of tooth with number 2 round carbide bur (SS White, USA) mounted on high speed handpiece with air water coolant. The chamber and perforation were then flushed with saline and air dried.
Specimens were randomly divided into four groups (n=19) according to the perforation material used:
Group 1: MTA group
Group 2: Bioactive bone cement group
Group 3: Biodentine group
Group 4: Control group

2.1Group1: MTA Group

MTA powder (MTA Angelus, Brazil) was mixed with distilled water in a grainy consistency and carried to perforation using messing gun and condensed flush to the pulpal floor with round condenser of diameter slightly larger than the perforation diameter held from the furcation side to simulate the normal periodontal tissue resistance against which repair material is condensed.

2.2Group 2: Bioactive Bone Cement Group

Both powder and liquid of bone cement (Surgical Simplex P, Stryker) were modified with MTA powder and silane coupling agent (Ultradent Products Inc., USA) respectively to make bone cement bioactive so as to be used as perforation repair material. 0.4mg of MTA powder was mixed with 0.6mg of bone cement powder and thoroughly mixed until all MTA particles were uniformly distributed in polymer powder of bone cement. 1 drop of silane coupling agent was added with 1ml of monomer liquid of bone cement and mixed till two liquids were completely miscible. The modified powder and liquid were mixed together in the ratio of 2:1 under ambient conditions at room temperature. While in dough like consistency mixture was carried with a plastic instrument into the perforation and condensed flush to the pulpal floor as in MTA group.

2.3Group 3: Biodentine Group:

Biodentine powder (Septodont, Saint Maur des Fosse's, France) was mixed with manufacturer provided liquid as per manufacturers recommendations and condensed into perforations similar to MTA group.

2.4 Group 4: Control Group:

Perforations of control group samples were left unrepaired. After repair of perforations all the samples were kept in an incubator for 72 hours at 37°C in such a way that all specimens were immersed in phosphate buffered saline up to cemento-enamel junction. After three days specimens were washed with distilled water and subjected to dye leakage testing. Each sample was placed in a separate Petri dish containing 2% methylene blue for 48 hours in a way that all the teeth were immersed in dye up to the cemento-enamel junction for retrograde dye challenge and dye was added to access chamber of each tooth so that it was filled for orthograde dye challenge. After removal from the dye all the samples were thoroughly rinsed with tap water and varnish removed with a polishing disc. Each tooth was placed in a vial containing 1000µl of concentrated (65wt %) nitric acid for 3 days. The solution thus obtained, was centrifuged at 3500 rpm for 5 minutes. 100µl of the supernatant was then analyzed in an ultraviolet-visible spectrophotometer (UV-1800, Shimadzu Scientific Instruments, Japan) at 550 nm wavelength with concentrated nitric acid as the blank and reading was recorded as absorbance units (AU).

III. Results

SPSS (Version 16) and Microsoft excel software were used to carry out the statistical analysis of data. Mean and standard deviations were calculated. For intra group analysis, analysis of variance (ANOVA) and Least significance difference test (LSD) were employed. For intergroup analysis, Student's independent t-test was used. A P-value of less than 0.05 was considered statistically significant. The mean absorbance values of experimental groups and controls in the current study showed that the control group (Group 4) in which perforations were left unrepaired had the highest dye absorbance of all groups followed by bioactive bone cement and MTA while as Biodentine group showed least dye absorbance (Table 1). Statistical analysis showed that the sealing ability of Biodentine was best among the three materials tested (Table 2) whereas sealing ability of bioactive bone cement was similar to the MTA (P=0.696) as perforation repair material.

Table 1: Mean, Standard Deviation (SD) Values for Absorbance Units (AU) of four groups of materials

Group	Mean	SD	95% Confidence Interval		Median	Minimum	Maximum	P-value (ANOVA)
			Lower Bound	Upper Bound				
MTA	0.22	0.043	0.198	0.239	0.20	0.16	0.29	<0.001 (Sig.)
BBC	0.24	0.049	0.215	0.262	0.23	0.16	0.32	
Biodentine	0.15	0.035	0.137	0.170	0.15	0.10	0.22	
Control	0.88	0.086	0.838	0.920	0.87	0.71	1.07	

Table 2: Comparison between individual groups

Comparison	Mean Difference	P value
MTA vs BBC	-0.02	0.696
MTA vs Biodentine	0.064*	0.004
MTA vs Control	-0.661*	<0.001
BBC vs Biodentine	0.084*	<0.001
BBC vs Control	-0.641*	<0.001
Biodentine vs Control	-0.725*	<0.001

*The mean difference is significant at the 0.05 level.

IV. Discussion

The principle goal of an endodontic therapy is to remove microbes and seal the root canal system effectively. Inadvertent perforation interferes with this goal because of damage to the periodontal attachment apparatus and subsequent bacterial proliferation. Perforations can be successfully managed with the use of a nonsurgical coronal approach by immediate placement of the reparative material in the perforation to prevent bacterial infection [11]. Long term success of a perforation repair is related to several factors among which the foremost is the biocompatibility of the material and ability of repair material to provide an adequate seal. The perforation of pulpal floor into the furcation area of posterior teeth may occur iatrogenically due to inadequate knowledge of the pulp chamber anatomy, tooth malalignment or failure to consider anatomic variations. The calcification of the pulp chamber as a consequence of aging, trauma or other irritants may increase the risk of perforation during access and location of canal orifices. Non-iatrogenic causes of furcation perforation include internal resorption and dental caries. Furthermore moisture, bleeding, unconventional access and a bottomless cavity makes repair of perforation a complicated procedure.

Many techniques including dyes (India ink, methylene blue), chemical tracers, radioactive isotopes, scanning electron microscopy and electrical conductivity have been used to test the sealing properties of restorative materials both *in vivo* and *in vitro*. Dye penetration techniques have been most frequently used methods to evaluate the sealing ability of dental materials since they are easy to perform and do not require sophisticated materials. Dye-extraction provides more reliable results than dye penetration study because of its ability to measures all of the dye taken up in the root. The dye-extraction technique is as good as fluid filtration technique because it also takes into account all of the porosities of the interfaces between the filling material and the root. In addition, both techniques are based on quantitative measurements of the passage of a liquid within these interfaces. [12] In this study, perforation width was standardized with the diameter of a # 2 round carbide bur [13, 14]. The depth of perforations that varied with the thickness of dentin and cementum in the floor of pulp chamber was checked using a periodontal probe and if this was not within 1-1.5 mm range, the tooth was excluded and new sample included. All surfaces were coated with varnish and canals were occluded with sticky wax to ensure that dye penetration occurs only along the interface of repair material and dentine in perforation defect.

MTA is a mixture of a refined Portland cement, bismuth oxide and gypsum and is reported to contain trace amounts of SiO_2, CaO, MgO, K_2SO_4, and Na_2SO_4 [15,16,17]. MTA has been extensively used as perforation repair material due to its reported favorable sealing ability, biocompatibility and dentinogenic activity [15]. However, its long setting time [6] along with sensitivity to excessive or deficient moisture affects its setting and properties in detrimental way [18]. Discoloration of teeth restored with white MTA still seems a problem in some clinical cases [7].Biodentine is a bioactive [19] dentine substitute specifically designed as a "dentine replacement" material. The powder component of the material consists of tricalcium silicate, dicalcium silicate, calcium carbonate and oxide filler, iron oxide shade, and zirconium oxide. Tricalcium silicate and dicalcium silicate are indicated as main and second core materials, respectively, whereas zirconium oxide serves as a radiopacifier. The liquid, on the other hand, contains calcium chloride as an accelerator and a hydrosoluble polymer that serves as a water reducing agent [20]. It has also been stated that fast setting time [8], one unique characteristics of the product, is achieved by increasing particle size, adding calcium chloride to the liquid component, and decreasing the liquid content. The setting period of the material is as short as 9–12 minutes. This shorter setting time is an improvement compared to other calcium silicate materials. The material is characterized by the release of calcium when in solution like MTA [21]. The third material used in the study to repair furcation perforation was bioactive bone cement. Bone cement consists of polymethylmethacrylate (PMMA) and methylmethacrylate (MMA) and is widely used for fixation in orthopedic fields but due to lack of bioactivity a number of modifications have been used [22,23]. The essential requirement for an artificial material to show bioactivity is the formation of a biologically active bone-like apatite layer on its surface in the body environment [24]. Miyazaki et al have shown that apatite formation can be induced by release of calcium ion (Ca^{2+}) from the modified bone cement into the body fluid and by a catalytic effect of Si-OH groups formed on the surface of material [10]. Addition of MTA powder to bone cement acts as a source of calcium ions whereas addition of silane to liquid component provides Si-OH group due to hydrolysis of alkyloxysilane after exposure to the body environment that induces heterogeneous nucleation of hydroxyapatite. Addition of silane also improves the mechanical properties of bone cement because chemical bonding can be formed with polymerized MMA.

Bioactive bone cement showed equally effective sealing ability as MTA. This can be attributed to the fact that on exposure to simulated tissue fluid, it gets covered with layer of apatite crystals which nucleate and grow, filling the microscopic space between bone cement and the dentinal wall [10]. Being osteoinductive in nature, it acts as a medium for crystal growth and nucleation. The exothermic reaction of polymethylmethacrylate (PMMA) bone cement during its setting does not seem to have any negative effects due to very small amount needed in perforation repair [25]. Also the slight expansion of MTA during setting [26] counteracts any polymerization shrinkage of PMMA resulting in improved sealing of modified bone cement. Biodentine showed the least microleakage in all the specimens of this study. Biodentine is calcium silicate based cement that exhibits lower porosity than ProRoot MTA and has higher compressive strength [8][20]. Better sealing ability of Biodentine may be attributed to firm attachment of apatite crystals to the underlying dentine surface [27] and excellent adaptability of this material to the underlying dentine due to nanostructure and small size of the forming gel [28].

V. Conclusion

Within the limitations of this study it can be concluded that the seal provided by bioactive bone cement is as good as MTA. However, ease of manipulation along with low cost makes bioactive bone cement an excellent alternative for repair of perforations.

References

[1]. Jew RC, Weine FS, Keene JJ, Jr., Smulson MH. A histologic evaluation of periodontal tissues adjacent to root perforation filled with Cavit, Oral Surg Oral Med Oral Pathol Oral Radiol Endod, 54, 1982, 124-35

[2]. Seltzer S, Bender IB, Smith J, et al. Endodontic failures-an analysis based on clinical, roentgenographic, and histologic findings. II, Oral Surg Oral Med Oral Pathol Oral Radiol Endod, 23, 1967, 517-30

[3]. West J, Roane J, Goerig A. Cleaning and shaping the root canal system, in Cohen S, Burns R (Ed.), Pathways of the Pulp. 6th ed, (Saint Louis: Mosby-yearbook Inc.; 1994) 179-218.

[4]. Lantz B, Persson PA. Periodontal tissue reactions after root perforations in dog's teeth, A histologic study, Odontol Tidskr, 75,1967, 209-37

[5]. Rafter M, Baker M, Alves M, Daniel J, Remeikis N. Evaluation of healing with use of an internal matrix to repair furcation perforations, Int Endod J, 35, 2002, 775-83.

[6]. Ding SJ, Kao CT, Shie MY, Hung C Jr, Huang TH. The physical and cytological properties of white MTA mixed with NA_2HPO^4 as an accelerant J Endod. 34, 2008, 748-51

[7]. Watts JD, Holt DM, Beeson TJ, et al. Effects of pH and mixing agents on the temporal setting of tooth colored and gray mineral trioxide aggregate, J Endod, 33, 2007, 970-3.

[8]. Grech L, Mallia B, Camilleri J. Investigation of the physical properties of tricalcium silicate cement-based root end filling materials, Dent Mater, 29(2), 2013, e20-8.

[9]. Valles M, Mercade M, Duran-Sindreu F, Bourdelande JL, Roig M. Influence of light and oxygen on the color stability of five calcium-silicate based materials, J Endod, 39, 2013, 525-8.

[10]. Miyazaki T, Ohtsuki C, Kyomoto M, et al. Bioactive PMMA bone cement prepared by modification with methacryloxypropyltrimethoxysilane and calcium chloride, J Biomed Mater Res, 67, 2003, 1417-23.

[11]. Friedman S. Considerations and concepts of case selection in the management of post-treatment endodontic disease (treatment failure), Endod Topics, 1, 2002, 54-78.

[12]. Camps J, Pashley D. Reliability of the dye penetration studies, J Endod, 29, 2003, 592-4.

[13]. Alhadainy HA, Abdalla Al. Artificial floor technique used for the repair of furcation perforations: a microleakage study, J Endo, 24, 1998, 33-5.

[14]. Weldon JK Jr, Pashley DH, Loushine RJ, Weller RN, Kimbrough WF. Sealing ability of mineral trioxide aggregate and Super-EBA when used as furcation repair materials: a longitudinal study, J Endod, 28, 2002, 467-70.

[15]. Sarkar NK, Caidedo R, Tirwik P, Moiseyeva R, Kawashima I. Physicochemical basis of the biologic properties of mineral trioxide aggregate, J Endod, 31, 2005, 97-100.

[16]. Camilleri J, Montesin FE, Brady K, Sweeney R, Curtis RV, Pitt Ford TR. The constitution of mineral trioxide aggregate, Dent Mater, 21, 2005, 297-303.

[17]. Dammaschke T, Gerth HV. Chemical and physical surface and bulk material characterization of white ProRoot MTA and two Portland cements, Dent Mater, 21, 2005, 731-8.

[18]. Walker M P, Diliberto A, Lee C. Effect of setting conditions in mineral trioxide aggregate flexural strength, J Endod, 32, 2006, 334-6.
[19]. Han L, Okiji T. Uptake of calcium and silicon released from calcium silicate-based endodontic materials into root canal dentine, Int Endod J, 44, 2011, 1081–7
[20]. Biodentine™ Active Biosilicate Technology™, Scientific file, Available from: http://www.plandent.no/images/Marketing/Infosenter/Biodentine%20Scientific%20File_web_dokumentasjon.pdf
[21]. Camilleri J, Kralj P, Veber M, Sinagra E. Characterization and analysis of acid-extractable and leached traced elements in dental cements, Int Endod J, 45, 2012, 737-43.
[22]. Harper EJ. Bioactive bone cements, Proc Inst Mech Eng H, 212, 1998, 113–120.
[23]. Shinzato S, Kobayashi M, Mousa WF, Kamimura M, Neo M, Kitamura Y, Kokubo T, Nakamura T. Bioactive polymethyl methacrylate-based bone cement: comparison of glass beads, apatite- and wollastonite-containing glass-ceramic, and hydroxyapatite fillers on mechanical and biological properties, J Biomed Mater Res, 51, 2000, 258 –272.
[24]. Kim HM. Bioactive ceramics: challenges and perspectives, J Ceram Soc Japan, 109, 2001, S49 – S57.
[25]. Badr AE. Marginal adaptation and cytotoxicity of bone cement compared with amalgam and mineral trioxide aggregate root-end filling materials, J Endod, 36, 2010, 1056-60.
[26]. Storm B, Eichmiller FC, Tordik PA, Goodell GG. Setting expansion of gray and white mineral trioxide aggregate and Portland cement, J Endod, 34, 2008, 80-2
[27]. Gjorgievska ES, Nicholson JW, Apostolska SM, et al. Interfacial properties of three different bioactive dentine substitutes, Microsc Microanal, 19, 2013, 1450-7.
[28]. Koubi S, Elmerini H, Koubi G, Tassery H, Camps J. "Quantitative evaluation by glucose diffusion of microleakage in aged silicate-based open-sandwich restorations". International Journal of Dentistry, Vol. 2012, Article ID 105863, 6 Pages, 2012

Dr. Ajmal Mir. "Comparison of Sealing Ability of Biodentine, Bioactive Bone Cement And MTA As Furcation Repair Materials." IOSR Journal of Dental and Medical Sciences (IOSR-JDMS) , vol. 16, no. 12, 2017, pp. 82–86.