Differences in microleakage between MTA and *Biodentine*™ as material for treatment of access perforation

2017 J. Phys.: Conf. Ser. 884 012104

(http://iopscience.iop.org/1742-6596/884/1/012104)

IOP Conf. Series: Journal of Physics: Conf. Series **884** (2017) 012104 doi:10.1088/1742-6596/884/1/012104

Differences in microleakage between MTA and *Biodentine*™ as material for treatment of access perforation

R Abimanyu, R Meidyawati* and Kamizar

Department of Conservative Dentistry, Faculty of Dentistry, Universitas Indonesia, Jakarta, Indonesia

*E-mail: meidyawati58@gmail.com

Abstract. Perforation is one of the most common complications in endodontic treatment and can result in significant negative effects. It occurs when practitioners are trying to create an access pathway to the pulp chamber. Contamination from the perforation site to the root canal decreases healing ability; therefore, perforation must be treated as soon as it happens. The aim of this study was to evaluate microleakage of Mineral trioxide aggregate (MTA) and *Biodentine*™ as materials for treatment of access perforation. Microleakage was evaluated by using a stereo microscope to assess methylene blue 1% solution penetration between the restoration material and the perforation site. The data was analyzed with the Kolmogorov-Smirnov test. Based on statistical analysis of the data, there is no significant difference in microleakage between MTA and *Biodentine*™ as a material for treatment of access perforation.

1. Introduction

As a dental treatment, the goal of a root canal procedure is to maintain function of the tooth without showing pathological symptoms. Teeth that receive root canal treatment and are restored properly can survive and function optimally. However, not all procedures progress as expected. The prognosis may change during treatment depending on the circumstances found at the time of treatment [1]. Perforation is a mistake that can cause widespread negative impact on endodontic treatment. It occurs while accessing the pulp chamber and involves the periodontal tissue [2,3]. Contact between this tissue and microorganisms leads to decreased healing capabilities of the tissue which supports the tooth, resulting in damage to the tooth and the surrounding bone. Therefore, perforation must be closed immediately in order to minimize any contamination which could occur during or after the treatment [2].

The material used for treating a perforation must have certain qualities. It must have good biocompatibility, be non-toxic, radiopaque, and non-soluble, have an antibacterial effect, and have good closure capability [4]. Materials that might be used include amalgam, calcium hydroxide, glass ionomer cements (GIC), zinc oxide-eugenol, and Mineral trioxide aggregate (MTA). Since its development in 1993, MTA has often been used because of its biocompatibility and good closure density. In several studies this material shows good results regarding microleakage in comparison to amalgam, resin-modified GIC, and zinc oxide-eugenol. However, the time required for MTA to set is four hours, which is considered to be too long, since it may allow the entry of liquid or

microorganisms into the treatment space, thus interfering with the prognosis [5]; and the manual manipulation of the material can lead to differences in treatment results [5].

In addition to MTA, a new restoration cement material with a tricalcium silicate base (3CaO.SiO2) has been developed and is marketed under the trade name *Biodentine*™. It is similar to MTA in nature and basic materials; however, compared with MTA, *Biodentine*™ has a faster setting time of 12 minutes and it is manipulated mechanically using a machine that can minimize operator error [6]. No research has been conducted to compare the two materials; therefore, it is necessary to do further assessment in terms of their effectiveness for treatment of root canal system perforation. This study aims to analyze the differences between microleakage of MTA and *Biodentine*™ when used for treating access perforation.

2. Materials and Methods

This research was an experimental laboratory study conducted in the Postgraduate Biomedical Laboratory at Universitas Indonesia. The materials used were: *ProRoot*® MTA, *Biodentine*™, glass ionomer cements (GIC), nail polish, and methylene blue 1% solution. The tools used were: plastic instruments, a glass plate, a cutter disc, an amalgamator, a #14 round diamond bur, and a 15xmagnifyingZeiss Discovery V12 stereo microscope. 40 mandible premolars were cleaned with a scaler, then immersed in NaCl solution until the preparation and perforation closure were performed. Access to the pulp chamber of the tooth samples was done with a #14 round diamond bur; then the access was formed and outlined with a cylindrical bur. A simulation of a perforation to the pulp chamber was created 1 mm below the cervical line with the diamond bur. The samples were randomly separated into two treatment groups of 20 teeth each. One group was treated with MTA while the other group was treated with *Biodentine*™.

For the MTA group, the MTA was manipulated according the manufacturer's instructions and inserted into the perforation from the pulp chamber direction until it was full and dense. The excess material that came out in the buccal section was flattened with a plastic instrument up to the surface of the tooth. For the *Biodentine*™ group, the *Biodentine*™ was manipulated according the manufacturer's instructions and inserted into the perforation from the pulp chamber direction until it was full and dense. The excess material that came out in the buccal section was flattened with a plastic instrument up to the surface of the tooth. Finally, in both groups, the pulp chamber access in the occlusal section of the tooth was closed using GIC.

After completing the closure of the perforation, each sample was checked for closure density using a digital radiographic photograph. Then the samples were stored for 24 hours in humid conditions using a sponge placed in a plastic container. The samples were then dried with air spray and all tooth surfaces were covered with nail polish, leaving 1 mm in the area around the restoration on the buccal section. Next, the samples were immersed in methylene blue 1%solution for 24 hours, then rinsed under running water for 10 minutes and drained. The samples were split in a buccolingual direction using the disc under cooling water. Next, a stereo microscope was used to observe the teeth. Data was collected regarding the permeation of dye along the perforation closure, and the depth of permeation was measured using ZEN 2011software. Two statistical tests were used to analyze the dye penetration. Chi-square analysis was used to test the statistical significance of differences in the two groups, with a significance limit $p<0.05$. However, requirements for the Chi-square analysis were not fulfilled; therefore a Kolmogorov-Smirnov test was used as an alternative analysis.

3. Results and Discussion

3.1 Results

The leakage data was obtained by assessing the penetration of a methylene blue 1% solution using a 15x magnifying stereo microscope. The leakage score was rated with a value of 0 for no penetration, a value of 1 for penetration less than 0.5 mm, a value of 2 for penetration from 0.5 mm to 1 mm, and a value of 3 for penetration of more than 1 mm. Table 1 shows that 20% of the MTA group had a leakage score of 0, while 35% of the *Biodentine*™ group had a leakage score of 0. Meanwhile, 45% of

the MTA group had a leakage score of 3, while 30% of the *Biodentine*™ group had a leakage score of 3.

At the beginning of the study, the intent was to analyze and compare the two groups using Chi-square analysis. However, this was not possible because, when tested, requirements of the Chi-square analysis for sample size were not met. The results were not eligible because the sample size was too small, i.e. more than 20% of the contingency cells had expected values < 5. Instead, the data was analyzed using the Kolmogorov-Smirnov test. Based on the Kolmogorov-Smirnov test, the significant value between MTA and *Biodentine*™ for treating access perforation is greater than 0.005, $p = 0.978$. Thus, there are no statistically significant differences between MTA and *Biodentine*™ regarding microleakage in treatment of access perforation.

Table 1. Distribution of microleakage scores in the MTA and *Biodentine*™ groups

Group	Micro Leakage Scale								Total
	0		1		2		3		
	n	%	n	%	n	%	n	%	
MTA	4	20	6	30	1	5	9	45	20
Biodentine™ ™	7	35	3	15	4	20	6	30	20
Total	11		9		5		15		40

3.2 Discussion

A dye penetration method is the most commonly used method to observe microleakage. This method is done by immersing the specimen in dye for a certain time period and then observing the border between the tooth and the restorative material [7]. The presence of stain in the border area shows that a microleakage happened. Dye penetration testing can be done easily without any chemical reaction [7]. In this study, testing for microleakage was done by a methylene blue 1% solution penetration method, using an immersion time of 24 hours. Methylene blue 1% solution was used in this study because its molecule size is very small, even smaller than bacteria [8]; thus, methylene blue 1% solution can penetrate farther than other dyes because of its small molecular size (0.5-0.7 nm). As a result, methylene blue 1% solution might provide a false positive value and a more extreme leakage rate than is found in the clinical state [8]. Simulation of a lateral perforation was performed using a round #14 diamond bur on the buccal section, placed at 1 mm below the cervical line. This was done because, according to research by Tsesis (2010), lateral perforation is the second most perforated region after the bifurcation [9]. The perforation closure materials were placed through the access to the pulp chamber using a plastic instrument; the material was inserted little by little until a solid filling of the perforation area was achieved. Radiography was used to see whether the closure perforation was complete, or a gap remained between the restoration material and the perforated wall of the tooth.

Biodentine™ material bonds well with the tooth structure. This is because the calcium carbonate crystals which form after the setting process provide anchoring that goes into the dentin tubules to form micromechanical tags. These help improve the bonding of the material to the tooth structure [10]. In addition, the material chemically bonds with dentin to form a structure resembling hydroxyapatite that has adhesion with dentin walls [10]. Notwithstanding this fact, only 35% of the *Biodentine*™ group received a leakage score of 0 (Table 1). This could have been caused by several factors. One possibility is that the humidity of the tooth samples was reduced so that the reaction between the *Biodentine*™ and the dentin walls was influenced by a fluid level in the dentinal that was not optimal. Another possibility is that, because the perforated simulation was parallel to the direction of the dentin tubules, the crystals of calcium carbonate which were expected to enter into the dentin tubules and form micromechanical tags did not do so, as they might have done if the perforation had intersected the direction of the dentin tubules. A third possibility is that placement of the closure material was difficult, and therefore placement was not perfect and solid, thus failing to close the perforated pathway.

The MTA material also has good sealing ability and edge adaptation. Due to the nature of the material, MTA experiences expansion during setting, which supports its adaptation to dentin. The MTA also binds chemically to the dentine wall because the calcium hydroxide that it releases reacts with phosphate ions and produces a hydroxyapatite-like precipitate which will react and bind to the dentine structure. A study by Reyes- Carmona reported the presence of interfacial layers that were formed by biomineralization between MTA and dentin [11]. However, only 20% of the MTA group had a leakage score of 0 (Table 1). The possible causes for this are identical to the ones influencing leakage scores in the *Biodentine*™ sample: reduced humidity of the tooth samples so that the chemical reaction between the MTA and dentin walls was not optimal; parallel placement of the simulated perforation so that the calcium crystals did not form tag-like structures in the dentin tubules; and/or imperfect placement of closure material so that the perforated pathway was not closed. It should also be noted that both groups of samples were kept in humid conditions, as it was suggested by Reyes-Carmona that the tricalcium silicate-based material would harden well under humid conditions [11]. Thesimulation of humid conditions was carried out by putting the sample on a moistened sponge in a sealed plastic container for 24 hours.

At least a portion of the samples received a leakage score of 0, which indicates they were in accordance with the conditions that allowed the bioactive character of both cements to be utilized by the fluid contained in dentin tubules, initiating the hardening process and resulting in the formation of hydroxyapatite-like precipitate [11]. The extracted teeth may not have had natural fluid on their dentin tubules, so that calcium hydroxide resulting from the reaction of the calcium silicate of the hydrated restorative material did not react to create the hydroxyapatite-like precipitate to bind with the dentin structures. From the perspective of statistical analysis, the MTA and *Biodentine*™ showed no significant difference in terms of microleakage, but descriptively the leakage scores distribution obtained by the *Biodentine*™ sample group was better than for the MTA group in the scores of 0 and 3. This was probably caused by the setting time of *Biodentine*™, which was faster, so that the expansion due to the setting reaction also occurred more quickly, making the closure tight and providing a good adaptation to the dentine in the area of the perforation. Another possibility is that, because the manipulation process of *Biodentine*™ was done by machine rather than manually, the powder and liquid could be mixed perfectly and the consistency of the material produced more closely met the parameters recommended by the maker.

4. Conclusion

In this study, no statistically significant difference in microleakage was found when comparing the use of *Biodentine*™ and MTA as materials for treatment of access perforation.

References

[1] Gutman JL 1992 Problem Solving in Endodontics. 2nd ed. (St. Louis: Mosby) pp 1-10.
[2] Yildirim G, Dalci K 2006 Treatment of Lateral Root Perforation with Mineral Trioxide Aggregate : A Case Report. *Oral Surg. Oral Med. Oral Pathol. Oral Radiol. Endod.* 102 55-8.
[3] Mehrvarzfar P, Taleghani AD, Saghiri MA, Karamifar K, Shababi B, Behnia A 2010 The Comparison of MTA, Geristore and Amalgam With or Without Bioglass as a Matrix in Sealing The Furcal Perforation : In Vitro Study. *Saudi Dental Journal* 22 119-24.
[4] Kaya S, Ayaz SG, Dogan MS, Aydin H 2011 Comparing MTA and Ketac Molar Easymix for Furcation Perforation Repair Using a Volumetric Method. *Int. Dent. Res.* 1 13-7.
[5] Unal GC 2010 Repair of Furcal Iatrogenic Furcation with Mineral Trioxide Aggregate. *European Journal of Dentistry* 4 475-81.
[6] Septodont USA *Biodentine* [Cited in November 25th 2013]. Available from: http://www.septodontusa.com/products/biodentine.
[7] Tawil SB, Dokky NA, Hamid DA 2011 Sealing Ability of MTA Versus Portland Cement in the Repair of Furcal Perforations of Primary Molar: a Dye Penetration Leakage Model. *J American Sci.* 7 1037-42.

[8] Fabianelli A 2008 The Relevance of Microleakage Studies. *International Dentistry SA.* 9 64-74.
[9] Tsesis I, Rosenberg E, Faivishevsky V 2010 Prevalence and Associated Periodontal Status of Teeth with Root Perforation : A Retrospective Study of 2,002 Patient's Medical Records. *J. Endod.* 36 797-800.
[10] Plasse NP, Tran XV, Colon P 2010 Physico-Chemical Properties. *Septodont. Publication and Communication* 16-31.
[11] Reyes-Carmona JF, Felippe MS, Felippe WT 2010 The Biomineralization Ability of Mineral Trioxide Aggregate and Portland Cement on Dentin Enhances: The Push Out Strength. *J. Endod*. 36 286-91.