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ORIGINAL ARTICLE

Comparative Evaluation of Sealing Ability of Biodentine and White MTA-Angelus as Furcation Repair Materials: A Dye Extraction Study

[1]Azeez Ajas, [2]Babu Anulekh, [3]Sakkir Nasil, [4]Khaleel A Thaha, [5]Varughese J Mary

ABSTRACT

Context: Mineral trioxide aggregate (MTA) is widely advocated as perforation repair material even though it has limited handling properties and prolonged setting time. Biodentine is an advanced calcium silicate material, which can overcome various disadvantages of MTA.

Aim: To evaluate and compare the sealing ability of MTA and Biodentine as furcation perforation repair materials.

Materials and methods: Thirty-five extracted permanent mandibular molars were collected and divided into two experimental groups and one control group. Standard access openings were prepared in all the samples and completely covered with nail varnish. Furcations were created in the experimental samples using a no. 4 round bur and repaired with Biodentine in group I (n = 15) and white MTA-Angelus in group II (n = 15). The negative control group, group III (n = 5), was left intact without perforation; 2% methylene blue dye was applied inside the access cavities of all the samples and stored in the dye for 48 hours. After complete removal of the dye, samples were immersed in concentrated nitric acid for extraction of the dye. The solutions were analyzed in a spectrophotometer at 550 nm with concentrated nitric acid as blank to detect the amount of dye and the values were recorded as absorbance units.

Statistical analysis used: One-way analysis of variance (ANOVA) and Scheffe multiple comparison test.

Results: Statistically significant difference (p-value < 0.001) in the mean dye leakage values was obtained on comparing Biodentine with MTA, where Biodentine exhibited less leakage.

Conclusion: Biodentine exhibited significantly less microleakage compared with white MTA-Angelus when used as a furcation perforation repair material and may be considered over MTA for the purpose.

Keywords: Biodentine, Dye extraction, Perforation repair, Ultraviolet spectrophotometry, White MTA-Angelus.

[1-5]Assistant Professor

[1,2,4,5]Department of Conservative Dentistry and Endodontics Government Dental College, Thiruvananthapuram, Kerala, India

[3]Department of Conservative Dentistry and Endodontics Melaka-Manipal Medical College, Manipal University, Melaka Malaysia

Corresponding Author: Khaleel A Thaha, Assistant Professor Department of Conservative Dentistry and Endodontics Government Dental College, Thiruvananthapuram, Kerala India, Phone: +919895836151, e-mail: kathaha12@gmail.com

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INTRODUCTION

Perforation is a pathologic or iatrogenic communication between the root canal space and the attachment apparatus.[1] Perforations may occur primarily due to three possible reasons: Iatrogenic errors occurring during root canal treatment or postspace preparation, resorptive processes, and caries. Most perforations result from iatrogenic errors due to misaligned use of rotary burs during endodontic access preparation and search for locating root canal orifices.[2] Among the perforations, furcal perforations occur in the furcation areas of posterior teeth, and thereby compromise the attachment apparatus and can have a negative impact on the overall prognosis of the tooth.[3]

Factors that influence the outcome of perforated teeth include size of the perforation, level and location of the perforation, time of repair, and presence of periodontal or pulpal diseases.[3] Based on clinical and radiographic findings, it can be decided if the perforation can be managed either surgically or nonsurgically, and the prognosis is generally excellent if the problem is well diagnosed and the defect is properly repaired with a material which can provide proper sealing ability and biocompatibility.[4] All perforations should be repaired as quickly as possible so as to prevent bacterial contamination.

Historically, different materials have been used for repairing furcal perforations; however, none fulfill all the criteria of an ideal repair material which should seal the pathways of communication between the root canal system and its surrounding tissues. Mineral trioxide aggregate, which was introduced in 1993 by Dr Mahmoud Torabinejad, has been regarded as an ideal material for retrograde filling, perforation repair, pulp capping, and apexification procedures.[5] When used as a repair material for furcal perforations, MTA has many favorable properties, including good sealing capability, biocompatibility, bactericidal activity, radiopacity, and the ability to set in

the presence of moisture. Despite its good physical and biological properties, it has certain drawbacks like inferior strength, slow setting time, and difficult handling characteristics, and these make MTA less desirable in some clinical situations including repair of furcal perforations.[6]

As in any other field of dentistry, in the field of endodontics too, the quest for a new material is never ending. Biodentine, introduced by Septodont in 2009, is specifically designed as a dentin replacement material. The material is actually claimed as a modification of MTA to overcome its disadvantages. The material has proven advantages over MTA with superior compressive strength, fast setting time, and better handling properties. The material is also biocompatible and induces the formation of hydroxyapatite crystals with good tissue-repairing abilities.[7] Since an ideal perforation repair material should effectively seal the pathways of communication between the root canal system and the periodontal tissues, the sealing ability of Biodentine should be investigated for evaluating the scope of the material to be used as an ideal candidate for repair of perforations. Thus, the present study was designed to evaluate and compare the sealing ability of Biodentine and white MTA-Angelus as furcation perforation repair materials using dye extraction method.

MATERIALS AND METHODS

Thirty-five extracted, intact human mandibular molars with well-developed and nonfused roots were used in this study. Samples were divided into three groups. Two experimental groups contained 15 samples each and the control group contained 5 samples.

Tooth Preparation

Tooth samples were cleansed of saliva, blood, and visible debris and stored in normal saline until use. A standard endodontic access opening was prepared in all the samples and the canals were negotiated using endodontic hand files. The canal orifices were closed with sticky wax and samples were decoronated 5 mm coronal to the cementoenamel junction and the roots were amputated 5 mm apical to the furcation. The samples were completely covered by two successive layers of clear nail varnish, including cavity walls and pulpal floors. A perforation was made in the furcation area of all the experimental group samples from the pulpal floor using a carbide round bur no. 4. A defect of 2 mm diameter was created and the chamber and perforation were flushed with water and dried.

Perforation Repair

Modeling wax was placed beneath the perforation of all the experimental group samples in order to facilitate the placement of repair materials. Group I samples (n = 15) were repaired with Biodentine (Septodont, Saint Maur des Fosse's, France) and group II samples (n = 15) were repaired with white MTA-Angelus (Angelus, Londrina, PR, Brazil). Group III samples (n = 5) in the negative control group were left intact without perforation. All the samples were placed in 100% humidity for 24 hours to allow the repair materials to set.

Microleakage Evaluation by Dye Extraction Method

Samples were placed in petri dishes according to each group and 2% methylene blue dye was applied inside the access cavity of all the samples (including control group) for 48 hours for checking the microleakage by dye extraction method. After 48 hours, samples were placed under running tap water for 30 minutes to remove all residues of the dye. All the samples were placed in test tubes containing 2 mL of concentrated nitric acid for 3 days for the extraction of the dye. After 3 days, solutions were transferred to Eppendorf tubes according to each group. Centrifugation of the samples was done at 14,000 rpm for 5 minutes to separate debris from extracted dye; 1 mL of the supernatant from each sample was collected and analyzed in an ultraviolet–visible spectrophotometer at 550 nm using concentrated nitric acid as blank and readings were recorded as absorbance units. The obtained readings were statistically analyzed using one-way ANOVA and Scheffe multiple comparison test.

RESULTS

The least dye absorbance of the control group (0.0036 ± 0.0013) in contrast with the experimental groups clearly indicated the accuracy of the technique. Comparison of the mean microleakage among the three groups using one-way ANOVA test (p-value < 0.001) showed a significant difference (Table 1). Intergroup comparison with Scheffe multiple comparison test showed a statistically significant difference in the mean dye leakage values of Biodentine and MTA where Biodentine exhibited less leakage (Table 2).

DISCUSSION

Even though perforations at the middle and apical thirds of root have better prognosis, those occurring at the

Table 1: Mean dye absorbance values and comparison between groups

Group	*Mean*	*SD*	*n*	*F*	*Significance p-value*
I	0.089437	0.0505056	15		
II	0.173397	0.0780220	15	16.257	0.000*
III	0.003600	0.0013379	5		

*Significance p-value < 0.01: Statistically significant; n: Number of samples; SD: Standard deviation; F: Test statistic

Table 2: Intergroup comparison of dye absorbance values

Comparison groups	Mean difference (Comparison difference)	p-value
Biodentine *vs* MTA	−0.0839600	0.003
Biodentine *vs* Control	0.0858367	0.037
MTA *vs* control	0.1697967	0.000

p-value < 0.01: Statistically significant

furcal regions and coronal thirds are guarded due to their proximity to the gingival sulcus.[8] For an ideal perforation repair material, the prospect of microleakage must be nil so as to prevent the movement of bacteria and diffusion of bacterial products from the root canal system into the periodontal tissues and *vice versa*.[9] Several methods have been used to assess microleakage, which include dye penetration, fluid filtration, bacterial and protein leakage models, dye extraction method, scanning electron microscopy, and analysis with radioactive isotopes.[10] In the present study using dye extraction technique, the sealing ability of white MTA-Angelus and Biodentine as furcation repair materials was evaluated.

In the dye extraction method as reported by Camps and Pashley,[11] the actual volume of the dye absorbed can be calculated by dissolution of the samples in concentrated nitric acid. The optical density of the solution was recorded by the use of a spectrophotometer. Both dye extraction and fluid filtration are based on quantitative measurements. According to Camps and Pashley,[11] the dye extraction technique gave results similar to fluid filtration technique and it has the advantage of saving much laboratory time. On the contrary, commonly used dye penetration studies are easy to accomplish and do not require sophisticated materials, but also possess certain drawbacks. It only measures the deepest point reached by the dye and does not measure the actual volume of the dye absorbed by the sample. Torabinejad et al[12] stated that a material that is able to prevent the penetration of small molecules like dye should be able to prevent larger substances like bacteria and their by-products. The dye used in the present study was 2% methylene blue. Oppenheimer and Rosenberg[13] reported that the smaller sizes of methylene blue particles compared with bacteria made the dye test a more precise test than the bacterial leakage models.

Though originally introduced as a root-end filling material, due to its biocompatibility, MTA is now considered as a material of choice to seal perforations also. It has other advantages like good sealing capability, bactericidal activity, radiopacity, and ability to set in the presence of moisture.[14] Despite its good physical and biological properties, there are some disadvantages like slow setting kinetics, inferior compressive strength, and complicated handling properties.[6] The slow setting time of MTA might contribute to leakage, surface disintegration, and loss of marginal adaptation.[15] Hence, new formulations of MTA have been developed like MTA-Angelus in order to overcome the slow setting time. According to the manufacturer, there is a reduction in setting time from 3 hours for ProRoot MTA to 10 minutes for MTA-Angelus.[16] In the present study, the reason for selection of MTA-Angelus was to investigate whether the changes in the chemical composition had any influence in its sealing ability while having shorter setting time and being economical than ProRoot MTA.

Biodentine, introduced by Septodont in 2009, is specifically designed as a "dentin replacement material." It has a wide range of clinical applications including pulp capping, apexification, repair of root perforations and resorptive lesions, retrograde filling material, and as a dentin replacement material. Faster setting kinetics, superior compressive strength, and better handling properties of Biodentine compared with MTA have been reported in literarure.[17] Attik et al[18] compared the *in vitro* biocompatibility of Biodentine and white ProRoot MTA and concluded that the biocompatibility of Biodentine to bone cells was comparable to MTA. In order to qualify Biodentine as an ideal perforation repair material, it is necessary to compare the seal produced by Biodentine with that of MTA. The results of the present study showed that Biodentine had a less dye absorbance value (0.0894) compared with white MTA-Angelus (0.1733). One-way ANOVA and Scheffe multiple comparison test showed that the difference in the dye leakage was statistically significant. Clinically, this superior sealability of Biodentine over white MTA-Angelus has important implications, making it rather the first choice for repair of perforations.

The finer calcium silicate grains in Biodentine hydrates much faster, rendering a denser microstructure with a higher mechanical performance. The coarse nature of the powder components and less availability of tricalcium silicate of MTA-Angelus lead to a slower reaction rate and more porous microstructure.[19] Biodentine has more prominent biomineralization ability than MTA with wider calcium- and silicon-rich layer at material–dentin interface. This increased element uptake may be one of the reasons for better sealing ability.[20] Sinkar et al[21] compared the sealing ability of ProRoot MTA and Biodentine as furcation repair materials and concluded that Biodentine has superior sealing ability than that of ProRoot MTA.

From the result of the present study, it can be stated that Biodentine can be a better replacement to MTA-Angelus as a perforation repair material with regard to microleakage. Still further research with more number of samples along with the application of different techniques and clinical investigations would be helpful for stronger interpretations in terms of sealability and other clinically relevant properties of Biodentine.

CONCLUSION

Within the limitations of the present *in vitro* study, it can be concluded that Biodentine exhibited significantly less microleakage compared with white MTA-Angelus when used as a furcation perforation repair material. Biodentine is a calcium silicate-based material claiming better properties over MTA, and the result of the present study shows that Biodentine has the potential to seal perforations better than white MTA-Angelus. Still further research is necessary to investigate Biodentine as an ideal calcium silicate-based material that can replace MTA in the clinical applications.

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