Original Article

# Comparative evaluation of mineral trioxide aggregate, endoseal, and biodentine in furcation perforation repair: A bacterial leakage study

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**ABSTRACT**

**Objectives:** The aim of this study is a comparative evaluation of the sealing ability of mineral trioxide aggregate (MTA) Angelus, pozzolan-based Endoseal MTA, and Biodentine when used as sealing materials for furcation perforation. This was done with a bacterial leakage model.

**Materials and Method:** Sixty-four permanent mandibular molars were selected and horizontally sectioned at middle third of the root. Cavities of 2 mm depth were prepared at the root ends. Access cavities were prepared, and the canal orifices and the root end cavities were restored with light cured resin. Perforations of diameter 1.6 mm were created in the center of the pulpal floor using a round bur in a low-speed handpiece. The teeth were randomly assigned to three experimental groups ($n = 20$). The perforation sites in Groups 1, 2, and 3 were repaired with MTA Angelus, EndoSeal MTA, and Biodentine, respectively. The teeth were inserted individually in an Eppendorf vial which was then placed in a McCartney's bottle containing nutrient broth. The reservoirs were filled with 0.5 ml of *Enterococcus faecalis*. The system was incubated at 37 C and checked for appearance of turbidity in the nutrient broth for 30 days, and these findings were noted. Level of significance was fixed at $P = 0.05$, and statistical analysis was done with Chi-square analysis using IBM SPSS statistics 20.0 (IBM Corporation, Armonk, NY, USA).

**Results:** In the time interval of 30 days, all the materials showed contamination to varying degrees (MTA Angelus 8/20 samples, Endoseal MTA 10/20 samples, and Biodentine 7/20 samples). There was no significant difference between the three groups ($P > 0.05$).

**Conclusions:** MTA Angelus, Endoseal MTA, and Biodentine showed contamination in a 30-day incubation period when used as furcation perforation seal materials.

**Keywords:** Bacterial leakage, biodentine, endoseal, furcation perforation, mineral trioxide aggregate

## INTRODUCTION

Studies have demonstrated that bacteria have the ability to remain entrenched deep in dentinal tubules and complexities of the root canal systems even after application of bactericidal irrigants and disinfectants.[1] The objectives of cleaning and shaping are multiple; remove infected hard and soft tissue, enhance access of apical third region to irrigants, and create space for the delivery of medicaments to the root canal system to subsequently obtain a 3-D obturation.[2]

Endodontic treatment involves three basic steps: access opening, cleaning and shaping, and obturation. Perforations are endodontic mishaps that affect the prognosis of

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the treatment. It leads to seepage of bacteria and toxic by-products into periodontal and periapical tissues.[3,4] Furcal perforation (FP) is commonly encountered during access opening. It could be as a result of extensive caries, resorption, or iatrogenic error.[5] Long-term effects of FP include gingival epithelial downgrowth, inflammation, bone resorption, necrosis, and eventually tooth loss.[5]

Materials which have been used for FP repair include silver amalgam, IRM, gutta-percha, Cavit, Super EBA, light cured GIC, composites, and so on.[4] The principal obstacles to a proper repair are the lack of isolation, presence of soft tissues, and lack of a wall against which the material can be condensed. Mineral trioxide aggregate (MTA) was introduced by Torabinejad in 1993 as a retrograde filling material. It is a mixture of tricalcium silicate and aluminate with tetra calcium aluminoferrite.[5] It has the ability to induce hard tissue formation by differentiation and migration of blastic cells. MTA Angelus (Angelus, New Milford, CT) has been used in this study.

Biodentine (Septodont, Saint-Maur-des-Fosses, Cedex, France) is a tricalcium silicate-based restorative cement introduced in 2011.[6] Indications for use are similar to that of MTA and it has the added advantage of fast set and easier manipulation.

Endoseal MTA (Maruchi, Wonju, Korea) is a newer variety of MTA-based sealer. It has a siliceous and luminous material which gets cement-like properties after setting with calcium hydroxide and water. This enables flow of premixed substrate through the delivery tip with adequate working consistency.[7] It is indicated for perforation repair, as a sealer, pulp revascularization among other uses.

Microleakage can be defined as a seepage of fluids, debris, microbes, or ions along the interface between a filling material and wall of tooth.[8] Leakage assessment methods include dye leakage, radioactive isotopes, air pressure methods, fluid or glucose filtration, and bacterial leakage.[9] The present study evaluated the sealing ability of MTA Angelus, Endoseal, and Biodentine in FP repair using a bacterial leakage model. The null hypothesis was taken as there was no difference in the sealing ability between the 3 materials.

## MATERIALS AND METHOD

The study protocol was approved by the Institutional Ethics Committee, and consent was taken from the patients whose extracted teeth were used. Sixty-four human permanent mandibular molars were selected. The teeth were placed in 5.25% solution of sodium hypochlorite for 24 h to remove residual tissue tags and then were washed with tap water. The roots were horizontally sectioned with carborundum disc (Unident Denmed, New Delhi, India) with a slow speed micromotor handpiece in the middle third to facilitate their manipulation. Cavities with 2 mm depth were prepared at root ends (BR49, Mani, Japan). Standardization of the depth of the cavities was done using a graduated periodontal probe. Access cavities were prepared with a round bur (BR31, Mani, Japan) using a high-speed handpiece with constant coolant. The canal orifices and the apical end of each root of all specimens were etched with 37% phosphoric acid gel (Etch-Rite, Pulpdent, Watertown, MA, USA) for 30 s. Fifth-generation bonding agent (Tetric N Bond, Ivoclar Vivadent, Liechtenstein) was then applied to the canal orifices and the apical end and then photo-polymerized for 20 s with an light-emitting diode source. A resin composite Z100 (3M ESPE, St Paul, MN, USA) was then used to fill the root canal orifices and the apical ends and then they were photopolymerized for two curing cycles of 20 s each.

Perforations of diameter 1.6 mm were created in the center of the pulpal floor using a round bur (BR40, Mani, Japan) in a low-speed handpiece. The teeth were embedded in putty elastomeric material till the level of the CEJ to simulate the periodontal apparatus. The teeth were randomly assigned into three experimental groups ($n = 20$). MTA Angelus (Angelus, Londrina, PR, Brazil) and Biodentine (Septodont, St. Maur-des-Fosses, France) were prepared according to the manufacturer's instructions. EndoSeal MTA is a premixed paste which was delivered through a syringe. The perforation site in Groups 1, 2, and 3 received MTA Angelus, EndoSeal MTA, and Biodentine, respectively. Two teeth were perforated but not repaired which served as positive controls. Another two teeth were not perforated and served as negative controls.

The teeth were then removed from the putty elastomeric mold. Two coats of different colored nail varnish were applied on the external surface of all teeth in each group, except on the perforation site, in order to prevent bacterial leakage through lateral canals or other discontinuities in the cementum. Group 1 (MTA Angelus) was coated with purple varnish, Group 2 (EndoSeal MTA) was coated with pink varnish, and Group 3 (Biodentine) was coated with fluorescent pink to distinguish between the groups.

The teeth were inserted individually in an Eppendorf vial (5 ml) with the region containing the perforation protruding through the end. The Eppendorf vial was used to create the bacterial reservoir. The interface between the crown and the tube was sealed with cyanoacrylate adhesive. The system was then placed in a McCartney's bottle containing nutrient broth. The interface between the tube and the bottle was sealed with cyanoacrylate adhesive.

To verify the efficiency of the cyanoacrylate seal, 2 ml of methylene blue dye was placed into the tube, leading to the coronal portion of each sample. If the medium turns blue, this meant that the seal was defective, and the specimen was discarded. All the specimens were found to have an effective seal after checking with this method. The entire system was then placed in an autoclave for sterilization.

The reservoirs were filled with 0.5 ml of *Enterococcus faecalis* using a micropipette. The system was incubated at 37°C and was checked daily for appearance of turbidity in the nutrient broth for 30 days and these findings were noted.

### Statistical analysis

Descriptive and inferential statistical analyses were carried out in the present study. Level of significance was fixed at ($P = 0.05$) and any value $\leq 0.05$ was considered to be statistically significant. Chi-square analysis was used to find the significance of study parameters on categorical scale. The Statistical software IBM SPSS statistics 20.0 (IBM Corporation, Armonk, NY, USA) was used for the analyses of the data, and Microsoft word and Excel were used to generate graphs, tables etc.

## RESULTS

The negative control group, in contrast to the positive control group, showed no turbidity during the experimental period. 8/20 samples in the MTA Angelus group, 10/20 samples in the EndoSeal MTA group, and 7/20 samples in Biodentine group showed contamination during 30-day incubation period [Table 1]. There was no significant difference between three groups ($P > 0.05$).

## DISCUSSION

Fuss and Trope[10] have classified perforations as cervical, crestal, and apical based on the location. Perforations by themselves need not cause deleterious sequelae. When bacterial infection or an irritative restorative material is superimposed on the area of perforation, healing may get delayed. Factors affecting prognosis and treatment of perforations are:

A. Time between occurrence and treatment – sooner the sealing of the defect happens, better the prognosis.[11,12] In this study, the defects were sealed within 24 h
B. Size of the defect – smaller defects have better chance of healing due to the improved sealing ability.[12] In this study, perforations were made with a standard size of 1.6 mm
C. Location of defect – proximity of perforations to the gingival sulcus can lead to contamination through the sulcus with bacteria.[12] FPs are considered as Crestal perforations due to the proximity of epithelial attachment and sulcus.

If the perforation is small and sealed soon and strict asepsis is maintained throughout, there is a very high chance of success.[12] Ideally, there should be stimulation of formation of new bone, periodontal ligament, and cementum with the use of the sealing material. In this study, the size of the perforation was standardized. The orifices and the apical root ends were sealed with composite resin to negate the chances of any leakage from those areas.

For estimating micro leakage, dye methods are most commonly employed. Methylene blue, basic fuchsin, rhodamine B, and India ink are the dyes routinely used. Dye leakage studies are not clinically relevant as they have a small particle size, and the permeability of dentin tubules may lead to over estimation.[13] Furthermore, a potential error exists with certain dyes such as basic fuchsin which tend to bind with tooth substance or restorative material. Some dyes which are not color stable lead to wrong interpretation such as aniline blue that turns colorless in alkaline medium.

Bacterial leakage studies have more relevance than others mainly due to the fact that they are biologically more relevant. It is found to be more accurate than dye or isotope

**Table 1: Comparison of the sealing ability of Biodentine, mineral trioxide aggregate, and EndoSeal mineral trioxide aggregate at day 30 using Chi-square test**

| | Turbidity | | Total |
|---|---|---|---|
| | Present | Absent | |
| Sealing ability | | | |
| Biodentine | | | |
| Count | 7 | 13 | 20 |
| Percentage within group | 35.0 | 65.0 | 100.0 |
| MTA | | | |
| Count | 8 | 12 | 20 |
| Percentage within group | 40.0 | 60.0 | 100.0 |
| EndoSeal MTA | | | |
| Count | 10 | 10 | 20 |
| Percentage within group | 50.0 | 50.0 | 100.0 |
| Total | | | |
| Count | 25 | 35 | 60 |
| Percentage within group | 41.66 | 58.33 | 100.0 |

$\chi^2$: 0.96, $P$: 0.618. MTA: Mineral trioxide aggregate penetration studies *in vitro*.[14] There are certain drawbacks of this method as in the results would be qualitative and they do not take into account the gaps that are smaller than the size of the bacteria.[15]

Sjögren *et al*. reported that bacterial presence was seen in the cases of apical periodontitis in treated cases in 32% of cases after 5 years.[16] Persistent periapical lesions have been associated with bacteria in treated teeth.[17] *E. faecalis* is commonly seen in persistent root canal infections and is most often found in failed endodontic treated teeth. It has properties such as adaptation to oxygen depleted environs, intrinsic resistance to antibiotics, and quorum sensing which makes it ideal to be used to evaluate leakage of FP repair material.[18]

Studies have shown that cementogenesis is vital for dentoalveolar formation and the newly formed cementum acts as a barrier.[19] MTA and BD can cause regeneration of dentoalveolar tissues. MTA Angelus has 80% Portland cement and 20% bismuth oxide with faster setting time of 10 min.[5] However, the handling is difficult due to its pasty consistency and may cause discoloration in some cases. BD is similar to MTA in its basic composition. Addition of setting accelerators and predosed capsule formation improves the physical properties significantly. Endoseal MTA is an injectable calcium silicate-based sealer and perforation repair material. It can be applied by directly injecting into the area.[20]

In this study, there were no significant differences between the sealing ability of all three materials. BD was slightly better with only 35% of samples showing turbidity after 30 days. This could be because BD has a triclinic form of tricalcium silicate, while MTA has the monoclinic form. The triclinic form has higher specific surface area of 2.811 $m^2/g$ in comparison to that of monoclinic form which is 1.0335 $m^2/g$. This allows more powder to be mixed with the liquid hence reducing porosity and decreasing the microleakage.[21]

In the pozzolan-based Endoseal MTA, 50% of samples showed leakage at the end of 30 days. This could be due to its high solubility of 0.7%. The setting of these materials depends on the moisture or blood present in the perforation area which alternatively may have an effect on the stability of the set matrix.[22]

## CONCLUSIONS

MTA Angelus, Biodentine, and Endoseal MTA can be used as FP repair materials. Biodentine showed lesser bacterial leakage compared to MTA Angelus and Endoseal MTA at different time intervals, but this was not statistically significant.

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### Conflicts of interest

There are no conflicts of interest.

## REFERENCES

1. Matsumiya S, Kitamura H. Histopathological and histobacteriological studies of the relation between the condition of sterilization of the interior of the root canal and the healing process of periapical tissues in experimentally infected root canal treatment. Bull Tokyo Dent Coll 1960;1:1-19.
2. Suresh Chandra B, Gopikrishna V, editors. Rationale of endodontic treatment. In: Grossman's Endodontic Practice. 13th ed. Gurgaon, Haryana. Wolters Kluwer; 2014. p. 79.
3. Kaya S, Ayaz SG, Dogan MS, Aydin H. Comparing MTA and Ketac Molar Easymix for furcation perforation repair using a volumetric method. Int Dent Res 2011;1:13-7.
4. Roda RS. Root perforation repair: Surgical and nonsurgical management. Pract Proced Aesthet Dent 2001;13:467-72.
5. Hashem AA, Hassanien EE. ProRoot MTA, MTA-Angelus and IRM used to repair large furcation perforations: Sealability study. J Endod 2008;34:59-61.
6. Ferris DM, Baumgartner JC. Perforation repair comparing two types of mineral trioxide aggregate. J Endod 2004;30:422-4.
7. Abu Zeid ST, Alothmani OS, Yousef MK. Biodentine and mineral trioxide aggregate: An analysis of solubility, pH changes and leaching elements. Life Sci J 2015;12:18-23.
8. Yoo YJ, Baek SH, Kum KY, Shon WJ, Woo KM, Lee W. Dynamic intratubular biomineralization following root canal obturation with pozzolan-based mineral trioxide aggregate sealer cement. Scanning 2016;38:50-6.
9. Muliyar S, Shameem KA, Thankachan RP, Francis PG, Jayapalan CS, Hafiz KA. Microleakage in endodontics. J Int Oral Health 2014;6:99-104.
10. Fuss Z, Trope M. Root perforations: Classification and treatment choices based on prognostic factors. Endod Dent Traumatol 1996;12:255-64.
11. Asgary S, Verma P, Nosrat A. Periodontal healing following non-surgical repair of an old perforation with pocket formation and oral communication. Restor Dent Endod 2018;43:e17.
12. Estrela C, Decurcio DA, Rossi-Fedele G, Silva JA, Guedes OA, Borges ÁH. Root perforations: A review of diagnosis, prognosis and materials. Braz Oral Res 2018;32:e73.
13. Wu MK, Wesselink PR. Endodontic leakage studies reconsidered. Part I. Methodology, application and relevance. Int Endod J 1993;26:37-43.
14. Jafari F, Jafari S. Importance and methodologies of endodontic microleakage studies: A systematic review. J Clin Exp Dent 2017;9:e812-9.
15. Fabianelli A, Pollington S, Davidson CL, Cagidiaco MC, Goracci C. The relevance of microleakage studies. Int Dent SA 2007;9:66-74.
16. Sjögren U, Figdor D, Persson S, Sundqvist G. Influence of infection at the time of root filling on the outcome of endodontic treatment of teeth with apical periodontitis. Int Endod J 1997;30:297-306.
17. Nair PN, Sjögren U, Krey G, Kahnberg KE, Sundqvist G. Intraradicular bacteria and fungi in root-filled, asymptomatic human teeth with therapy-resistant periapical lesions: A long-term light and electron microscopic follow-up study. J Endod 1990;16:580-8.
18. Tabassum S, Khan FR. Failure of endodontic treatment: The usual

suspects. Eur J Dent 2016;10:144-7.

19. Samuel A, Asokan S, Geetha Priya PR, 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. Contemp Clin Dent 2016;7:322-5.
20. Silva EJ, Carvalho NK, Prado MC, Zanon M, Senna PM, Souza EM, *et al*. Push-out bond strength of injectable pozzolan based root canal sealer. J Endod 2016;42:1656-9.
21. Kokate SR, Pawar AM. An *in vitro* comparative stereomicroscopic evaluation of marginal seal between MTA, glass inomer cement and BIODENTINE as root end filling materials using 1% methylene blue as tracer. Endodontology 2012;2:36-42.
22. Lim ES, Park YB, Kwon YS, Shon WJ, Lee KW, Min KS. Physical properties and biocompatibility of an injectable calcium-silicate-based root canal sealer: *In vitro* and *in vivo* study. BMC Oral Health 2015;15:129.