ORIGINAL RESEARCH

In Vitro Assessment of Sealing Ability of Various Materials Used for Repair of Furcal Perforation: A SEM Study

Maneesha Das[1], Ahmed Abdullah Al Malwi[2], Abinash Mohapatra[3], Mohammed Abdul Kader M[4], Ahmed Babiker Mohamed Ali[5], Shriya C Shetty[6], Mirza Muzaamill Baig[7]

Abstract

Aim: The aim of the current *in vitro* research was to evaluate the sealing capacity of three different agents employed for the repair of perforations at the furcation area.

Materials and methods: Recently 60 extracted human mandibular permanent molars having well apart plus fully formed roots, and intact furcation were chosen. The 60 samples were allocated at random to three groups of 20 samples: Group I: Furcation perforation repair by means of mineral trioxide aggregate (MTA)-Angelus, Group II: Furcal perforation repair using Biodentine, Group III: Furcal perforation repair by EndoSequence. The specimens were subjected to sectioning with a hard tissue microtome and the sectioned parts of the samples were then examined. The specimens were subjected to gold sputtering and visualizing beneath scanning electron microscope (SEM) at 2000× magnification for assessing the sealing capacity of the agents.

Results: The highest sealing capacity was noted with the use of Biodentine at 0.96 ± 0.10, in pursuit by EndoSequence use at 1.18 ± 0.14 and MTA-Angelus use at 1.74 ± 0.08. The disparity amid the three groups was statistically significant with $p < 0.001$.

Conclusion: In conclusion, it may be inferred that Biodentine exhibited the finest sealing capacity than EndoSequence and MTA- Angelus. It may thus be given consideration as a substance of preference for the repair of furcal perforation.

Clinical significance: Using biologically compatible substances may be suggested to amend perforations thereby decreasing the occurrence of inflammatory response in the neighboring tissues. The sealing capacity is a significant feature in supporting the result of a root canal treatment of a tooth.

Keywords: Furcal perforation, Root repair material, Scanning electron microscope, Sealing ability.

The Journal of Contemporary Dental Practice (2022): 10.5005/jp-journals-10024-3425

Introduction

The veracity of the natural teeth is crucial for maintaining normal esthetics as well as the complete functionality of the dentition. A disruption in such synchronization necessitates dental management particularly endodontic treatment. During endodontic treatment, a clinician may face many procedural accidents which can affect the prognosis of the treatment, and among them; perforation of the root canal system is also one. Perforations can come about at any phase either through access cavity making, resulting in lateral surface or furcation perforation, or at the time of instrumentation causing canal perforation at the cervical, middle, or apical areas.[1]

Perforation by definition is a non-natural communication amid the radicular canal space as well as the adjoining periodontal tissues or oral atmosphere. Such perforations may be a result of pathologies (as a result of radicular resorption/caries) or iatrogenic (from dental events through access cavity making, canal instrumentation, or post-space creation). A variety of factors, like the duration prior to fixing this perforation, the place or dimensions of the perforation, the repair agent employed, as well as the familiarity of the clinician in handling such mishaps, could influence the therapy results.[2]

Unintentional perforation of the pulp floor in course of root canal therapy influences the therapeutic prognosis. The prognosis is also influenced by numerous other parameters like the dimensions, site, and time of perforation and the capability of the agent employed to close this flaw. Such perforations can be amended by non-surgical means using appropriate biocompatible, harmless, radiopaque, non-absorbent substances, consequently averting infectivity from bacteria. In the permanent dentition, numerous agents have been recommended for perforation-mending like amalgam, calcium hydroxide, reinforced zinc oxide-eugenol cement, MTA, calcium-enriched mixture (CEM) cement, in addition to Biodentine™.[3]

[1]Department of Conservative Dentistry and Endodontics, Institute of Dental Sciences, Siksha 'O' Anusandhan (Deemed to be University), Bhubaneswar, Odisha, India

[2,4,5]Department of Restorative Dental Sciences, King Khalid University, Abha, Saudi Arabia

[3]Department of Pedodontics and Preventive Dentistry, Kalinga Institute of Dental Sciences KIIT (Deemed to be University), Bhubaneswar, Odisha, India

[6]Central Research Laboratory, KS Hegde Medical Academy, NITTE (Deemed to be University), Mangaluru, Karnataka, India

[7]Department of Conservative Dentistry and Endodontics, Sri Balaji Dental College & Hospital, Moinabad, Telangana, India

Corresponding Author: Mirza Muzaamill Baig, Department of Conservative Dentistry and Endodontics, Sri Balaji Dental College, Moinabad, Telangana, India, Phone: +91 9177231919, e-mail: Mozzybaig05@gmail.com

How to cite this article: Das M, Al Malwi AA, Mohapatra A, *et al. In Vitro* Assessment of Sealing Ability of Various Materials Used for Repair of Furcal Perforation: A SEM Study. J Contemp Dent Pract 2022;23(11): 1136–1139.

Source of support: Nil

Conflict of interest: None

The utility of MTA has been evidently recommended by the majority of dental practitioners owing to its sealing capacity, marginal adjustment plus biocompatibility on the basis of cytotoxicity as well as genotoxicity investigations on cellular cultures, implantation, and usage analysis in animal studies.[4] Biodentine is a novel substance, that is the foremost all-in-one bioactive plus biocompatible dentin alternate, created on the base of a distinctive Active Biosilicate Technology, as well as planned to take care of injured dentine together for restorative as well as endodontic implications.[5] Lately, EndoSequence root repair agent has been built-up as a ready-to-use, premixed bioceramic agent suggested for perforation mending, apical surgery, apical plug, plus pulp capping.[6]

There is an array of agents accessible to close the furcation perforations. The idyllic repair substance should offer a sufficient seal, must exhibit biocompatibility, and have the capacity to promote osteogenesis along with cementogenesis. Bearing this in mind, the current research was performed to assess the effectiveness of the sealing capacity of MTA, Biodentine, and EndoSequence agents employed for mending perforation in the furcation area.

Materials and Methods

The current *in vitro* research was performed in the Department of Conservative Dentistry and Endodontics. There are 60 human mandibular permanent molars extracted due to periodontal disease and having well apart plus fully formed roots, and intact furcation were chosen. Every specimen was scrutinized to get rid of those having cracks, radicular caries, restoration, fracture, as well as open apices in accordance with the exclusion criteria. The samples were subjected to sterilization in 10% formalin for 14 days. Subsequent to the elimination of calculus plus soft tissues via ultrasonic scaling, the samples were subjected to storage at 40°C in a normal saline solution prior to utilizing in the research.

Preparation of Samples

Access cavities were made using a round diamond bur with a high-speed handpiece beneath abundant irrigation by means of water spray. The radicular canal system was subjected to cleaning and shaping as per the Step-back technique with K-files along with Gate Glidden drills. Irrigation was performed with a 3% sodium hypochlorite solution (NaOCl). The radicular canals thus prepared were subjected to drying with paper points. After positioning the AH Plus sealer (Densply-De Trey, Konstanz, Germany) inside the canals, they were packed with Gutta-percha by means of the lateral condensation method. The external radicular surfaces were enclosed in two coats of nail varnish to avoid dye diffusion from open tubules, slight dentine imperfections, or lateral canals, with enormous attention to the furcal region. The pulpal floor was perforation in the center with a number four round bur using a slow- speed handpiece along with steady water spray irrigation. The samples were then subjected to rinsing and airdrying. The width of the perforation matched the bur diameter while the depth was influenced by dentine-cementum thickness from the pulpal floor to the furcal region.

The 60 samples were allocated at random to three groups of 20 samples. For replicating oral clinical circumstances all samples were implanted roughly to the level of cemento-enamel junction (CEJ) into dampened distilled water, a flower sponge.

Group I: Furcal Perforation Repair with MTA-Angelus

MTA-Angelus was subjected to mixing as per the recommendations of the manufacturer to create a homogeneous paste. With the Master Apical Placement (MAP) system, the material was placed in the perforation and compressed using Schilder pluggers (Hu-Friedy, Chicago, Illinois, United States). A cotton ball that had been moistened with saline was placed in the pulpal chamber above the MTA surface. Following this time, the cotton ball was removed, and intermediate restorative material (IRM) was used to pack the access cavity.

Group II: Furcal Perforation Repair with Biodentine

Biodentine (Septodont, Saint-Maur-des-Fosses Cedex, France) was subjected to mixing to attain a suitable consistency. The substance in the capsule was subjected to transfer within the perforation spot with a spatula following which amalgam pluggers were employed for gentle condensation of the agent. The subsequent 12 minutes were given to allow the setting of the agent. The access cavity was then packed using IRM.

Group III: Furcal Perforation Repair with EndoSequence

This agent is a ready-to utilize, premixed paste therefore, it was not mixed. Setting reaction is initiated when the agent makes contact with damp surroundings, rendering a working duration greater than 30 minutes. The paste was positioned in place of the perforation and condensation was performed with pluggers. In the end, the access cavity was packed using IRM.

Evaluation of the Efficacy of Furcal Perforation Repair using SEM

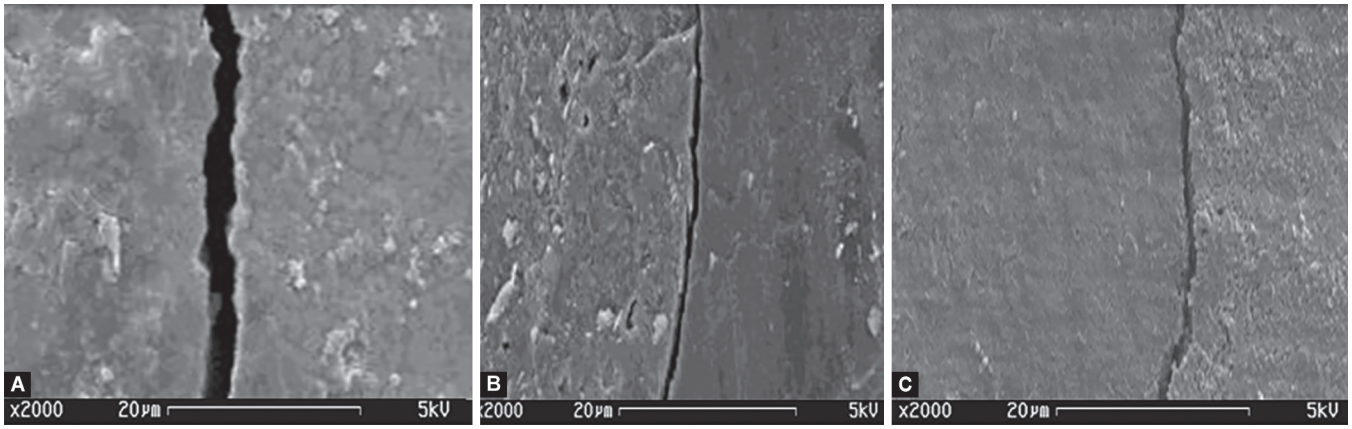
All the sealed holes were subjected to compaction with a damp cotton ball. The specimens were subjected to storage in a clogged container for 24 hours to permit the complete set of the repair resources. Following 24 hours, the specimens were subjected to longitudinal sectioning with a hard tissue microtome. The two sectioned parts of the samples were then examined. The specimens were subjected to gold sputtering and visualizing beneath SEM at 2000× magnification for assessing the sealing capacity of the agents (Fig. 1). SEM photomicrographs were taken at the four corners of every specimen. The distance of the dentinal walls of the perforated area as well as the agents were calculated at four equally distant points of every micrograph.

Statistical Analysis

The data thus obtained was analyzed using SPSS 20.0 statistics program (SPSS Inc. Chicago, Illinois). Descriptive statistics (mean, standard error, standard deviation) were employed to assess the agent's gap dimensions. The consequences were also subject to analysis of variance (ANOVA) test for estimating the effectiveness of individual agents. The significance of disparity amid the three groups was measured at a p-value < 0.05.

Results

Table 1 depicts the mean sealing capacity of three different agents employed in repairing perforation at the furcation area. The mean sealing capacity of the MTA-Angelus group was 1.74 ± 0.08, for the Biodentine group 0.96 ± 0.10, and for the EndoSequence group



Figs 1A to C: Scanning electron microscope images of (A) MTA-Angelus; (B) Biodentine; (C) EndoSequence groups

Table 1: Mean sealing ability of three different materials used for repair of furcal perforation

Study groups	*Samples*	*Mean ± SD*
Group I: MTA-Angelus	20	1.74 ± 0.08
Group II: Biodentine	20	0.96 ± 0.10
Group III: EndoSequence	20	1.18 ± 0.14

Table 2: Comparison of mean sealing ability of three different materials used for repair of furcal perforation

Study groups	*Mean ± SD*	*Std error*	*F-value*	*p-value*
Group I: MTA-Angelus	1.74 ± 0.08	0.024	18.128	0.001**
Group II: Biodentine	0.96 ± 0.10	0.018		
Group III: EndoSequence	1.18 ± 0.14	0.090		

**Highly significant

Table 3: Multiple comparison of sealing ability of three different materials used for repair of furcal perforation using Tukey HSD

Study groups	*Comparison with*	*Mean Difference (I-J)*	*Significance*
Group I	Group II	0.78	**0.001****
	Group III	0.56	0.624
Group II	Group I	–0.78	**0.001****
	Group III	–0.22	0.788
Group III	Group I	–0.56	0.624
	Group II	0.22	0.788

**Highly significant

1.18 ± 0.14. Table 2 delineates the contrast assessment of the mean sealing capacity of three different agents employed in repairing perforation at the furcation area. The highest sealing capacity was noted with the use of Biodentine at 0.96 ± 0.10, in pursuit by EndoSequence use at 1.18 ± 0.14 and MTA-Angelus use at 1.74 ± 0.08. The disparity amid the three groups was statistically significant with $p < 0.001$.

Multiple contrast assessment of the mean sealing capacity of three dissimilar agents employed in repairing perforation at the furcation area by means of Tukey honestly significant difference (HSD) is depicted in Table 3. A statistically significant dissimilarity was noted amid the Biodentine group (0.96 ± 0.10) as well as the MTA- Angelus group (1.74 ± 0.08).

Discussion

Efficient as well as punctual management of perforations significantly influences the prognosis of the affected teeth. Of all the failed treatments, 9.62% are owing to perforations which account for the second chief reason for failure. As a result, this communication amid the radicular canals as well as the surrounding periodontal tissues should be subjected to sealing with a biologically compatible substance as quickly as feasible. The perforation at the furcation area can be treated by surgical or non-surgical means as affected by the clinical as well as radiological results. If the problem is appropriately diagnosed and the defect is correctly mended by an agent that offers good sealing capacity plus biocompatibility, the prognosis is usually outstanding.[7]

An appropriate substance should cease the microleakage as well as stop communication amid between the tooth and periodontium. To attain victory, the perforation repair substance should idyllically produce fresh bone, periodontal ligament plus cementum. Preceding research indicated that cementogenesis is an imperative course in dentoalveolar development and the newly produced cementum behaves as a biological hurdle in opposition to the spread of microorganisms within the radicular canals. MTA and Biodentine™ are able to lead to the entire regeneration of the neighboring dentoalveolar tissues in permanent dentition and are therefore employed for repairing furcal perforations.[8]

Different methods like bacterial leakage, fluid filtration technique with radioisotopes, as well as dye infiltration were employed in measuring the sealing capacity of repairing substances.[9] Orosco et al.[8] have noted that for assessment of marginal adaptation, the specimens can be straightforwardly visualized beneath SEM subsequent to gold sputtering in addition to eliminating the requirement for creating resin imitations as direct SEM assessment of the specimens did not cause artificial space creation; therefore, in the present study sectioned the samples and observed its edge directly beneath the SEM.

In the current research, the highest sealing capacity was noted with the use of Biodentine pursued by EndoSequence and MTA-Angelus. Likewise, Aggarwal et al.[10] elucidate that Biodentine showed the least microleakage and sealing capacity since Biodentine is a calcium silicate-based substance that has a polycarboxylate-based hydro-soluble polymer structure depicted as a water-reducing substance to decrease the water content of the mix in general, plus calcium chloride as a setting enhancer. As

per research conducted by Pathak,[11] the bonding occurs chemo-mechanically with the tooth beside the creation of tag-shaped areas made up of calcium/phosphate affluent crystalline accretions that enhance with time and minimize the space amid the tooth and Biodentine. Girish et al.,[12] Kokate and Pawar[13] infer that Biodentine is better than MTA since Mineral Trioxide Aggregate has a few shortcomings like the complexity of handling plus extremely slow setting response, which may add to the leakage, surface breakdown, failure of marginal adjustment and interruption in the stability of the substance leading to an increased peril of microbial contamination.

Han and Okiji[14] depicted that calcium and silicon ion take-up by dentin leads to the development of tag shaped areas in Biodentine that was greater than in MTA. Superior seal with Biodentine can also be ascribed to its altered powder constitution which is the addition of setting enhancers plus softeners. Camilleri[15] elucidated that a novel pre-dosed capsule constitution for utilization in an amalgamation apparatus mainly enhances the physical characteristics such as the sealing capacity of the agent. The smaller particle size of Biodentine leads to sealing interface porosity and pore volume in set Biodentine substance being lesser than MTA, which can potentially contribute to a superior sealing capacity.

In the current research superior sealing capacity was noted in the EndoSequence group vs MTA-Angelus group. Shokouhinejad et al.[16] investigated the bioactivity of EndoSequence by revealing the set substance on phosphate-buffered saline. Apatite crystals were precipitated implying its bioactivity. Apatite crystals precipitation could be regarded as a cause accountable for decreased leakage as well as enhanced sealing capacity in the EndoSequence group.

The limitations of the current research are that the findings are documented with regard to the sealing capacity in relation to the walls of the perforation since the perforation depth of the cavities is an unrestrained factor that relies on the thickness of the cementum and dentine of every tooth. Moreover, in clinical circumstances, such disparities in depth may be even greater assuming that perforations are commonly resulting from excessive grinding of the pulpal floor in an effort to locate calcified root canal orifices. Nevertheless, additional in vivo research is suggested to verify and associate the conclusion of this research with a clinical situation.

Conclusion

In conclusion, it may be inferred that Biodentine exhibited the finest sealing capacity than EndoSequence and MTA-Angelus. It may thus be given consideration as a substance of preference for the repair of furcal perforation.

References

1. Mohan TM, Sudha K, Shoba C, et al. Comparative evaluation of sealing ability of ProRoot MTA, Biodentine, and bone cement in the repair of furcation perforation–an in vitro study.Indian J Dent Adv 2019;10(4):176–180. DOI: 10.5866/2018.10.10176.
2. Tsesis I, Rosenberg E, Faivishevsky V, et al. Prevalence and associated periodontal status of teeth with root perforation: A retrospective study of 2002 patients' medical records. J. Endod 2010;36:797–800. DOI: 10.1016/j.joen.2010.02.012.
3. Haghgoo R, Arfa S, Asgary S. Microleakage of CEM cement and ProRoot MTA as furcal perforation repair materials in primary teeth. Iran Endod J 2013;8:187–190. PMID: 24171027.
4. Torabinejad M, Parirokh M. Mineral trioxide aggregate: A comprehensive literature review—Part II: Leakage and biocompatibility investigations. Journal of Endodontics 2010;36: 190–202. DOI: 10.1016/j.joen.2009.09.010.
5. Dimitrova I, Kouzmanova Y. Marginal adaptation of calcium silicate-based materials used in furcal perforation repair: A comparative *In Vitro* study. International Journal of Science and Research (IJSR) 2015;4(8):750–755. Corpus ID: 37824990.
6. Farzaneh M, Abitbol S, Friedman S. Treatment outcome in endodontics: The toronto study. Phases I and II: Orthograde retreatment. J Endod 2004;30:627–633. DOI: 10.1097/01.don.0000129958.12388.82.
7. Ajas A, Anulekh B, Nasil S, et al. Comparative evaluation of sealing ability of biodentine and white MTA-Angelus as furcation repair materials: A dye extraction study. International Journal of Oral Care and Research 2018;6(1):54–57. DOI: 10.5005/jp-journals-10051-0149.
8. Orosco FA, Bramante CM, Garcia RB, et al. Sealing ability, marginal adaptation and their correlation using three root-end filling materials as apical plugs. J Appl Oral Sci 2010;18:127134. DOI: 10.1590/S1678-7757 2010000200006.
9. Sahebi S, Moazami F, Sadat Shojaee N, et al. Comparison of MTA and CEM cement microleakage in repairing furcal perforation, an *in vitro* study. J Dent (Shiraz) 2013;14:31–36. PMCID: PMC3927668.
10. Aggarwal V, Singla M, Miglani S, et al. Comparative evaluation of push-out bond strength of ProRoot MTA, Biodentine, and MTA Plus in furcation perforation repair. J Conserv Dent 2013;16:462–465. DOI: 10.4103/0972-0707.117504.
11. Pathak S. Comparative evaluation of sealing ability of root end filling materials: an *In-Vitro* Study. Int J Dent Med Res 2015;1(5):48–52. https://www.google.com/search?q=Pathak+S.+Comparative+evaluation+of+sealing+ability+of+root+end+filling+materials%3A+An+in+vitro+study.+Int+J+Dent+Med+Res+2015%3B5%3A48-52.&oq=Pathak+S.+Comparative+evaluation+of+sealing+ability+of+root+end+filling+materials%3A+An+in+vitro+study.+Int+J+Dent+Med+Res+2015%3B5%3A48-52.&aqs=chrome..69i57.906j0j4&sourceid=chrome&ie=UTF-8.
12. Girish CS, Ponnappa K, Girish T, et al. Sealing ability of mineral trioxide aggregate, calcium phosphate and polymethylmethacrylate bone cements on root ends prepared using an Erbium: Yttriumaluminium garnet laser and ultrasonics evaluated by confocal laser scanning microscopy. J Conserv Dent 2013;16:304–308. DOI: 10.4103/0972-0707.114355.
13. Kokate SR, Pawar AM. An in vitro comparative stereomicroscopic evaluation of marginal seal between MTA, Glass Inomer Cement & Biodentine as root end filling materials using 1% methylene blue as tracer. Endod 2012;2:36–42. DOI: 10.4103/0970-7212.352091.
14. Han L, Okiji T. Uptake of calcium and silicon released from calcium silicate-based endodontic materials into root canal dentine. Int Endod J 2011;44:1081–1087. DOI: 10.1111/j.1365-2591.2011.01924.x.
15. Camilleri J. The chemical composition of mineral trioxide aggregate. J Conserv Dent 2008;11:141–143. DOI: 10.4103/0972-0707.48834.
16. Shokouhinejad N, Nekoofar MH, Razmi H, et al. Bioactivity of endosequence root repair material and bioaggregate. Int Endod J 2012;45:1127–1134. DOI: 10.1111/j.1365-2591.2012.02083.x.