Turkish Online Journal of Qualitative Inquiry (TOJQI)
Volume 12, Issue 8, July 2021: 271-280

An Invitro Evaluation of the Furcation Perforation Repair Ability of Silicate Cement Mineral Trioxide Aggregate (MTA Repair HP) and Biodentin

Vanishree H Shivakumar[a],Anand S Tegginamani[b]
[a]Lecturer, Paediatric dentistry, Faculty of Dentistry, SEGi University, Malaysia
[b]Associate Professor, Oral Diagnostic Sciences, Faculty of Dentistry, SEGi University, Malaysia

Abstract

One of the causes of endodontic failure is furcation perforation. Perforations have been repaired with a variety of materials. MTA Repair HP and biodentin are two additional materials that need to be evaluated for perforation repair. Using a stereomicroscope, compare and evaluate the sealing ability of two different materials when used to treat furcal perforations in permanent molars.In thirty-two extracted permanent molars, a standard access opening was made and perforated at the pulp chamber's centre with the standard diameter. Thirty teeth were randomly assigned to one of two experimental groups: MTA repair HP (15 teeth) and Biodentin (15 teeth). Two samples were used as positive controls, with perforated teeth that were not repaired. Dye was administered to the teeth. All the samples were directly sectioned buccolingually by using a diamond disc& observed under a stereomicroscope for microleakage.MTA repair HP &Biodentin, a novel high plasticity cement, were compared for perforation repair with minimal laboratory procedures. Perforations restored with Biodentin had good sealing ability compared to MTA repair HP, as per statistical analysis, with a statistically significant difference between the two groups. In vitro test indicated that Biodentin has a better sealing ability than MTA Repair HP.

Keywords: Biodentin, dye penetration, furcation repair, MTA Repair HP, perforation

1. Introduction

During endodontic treatment, mishaps or procedural accidents occur; a few are due to lack of attention, and others are unpredictable. Instrument-related endodontic errors might occur, during any steps of root canal treatment such as, diagnosis, access cavity preparation & obturation, of these the main concern is for furcal perforations, Mechanical or pathologic connections between the root canal system and the external tooth surface are defined as perforations, these can create a greater challenge in treating them**(Hashem AA, Hassanien EE, 2008; Al-Hezaimi K, 2005; Fida N, 2015; Rotstein I, Simon JH, 2008)**.Silver amalgam, Gutta-percha, glass ionomer cement (GIC), resin modified GIC, calcium hydroxide, zinc phosphate cement, super ethoxy benzoic acid, light cure calcium hydroxide, dentin chips, hydroxyapatite, and light cure composite resin have all been suggested for the nonsurgical repair of furcation perforation defects.But none of these materials were able to recover the originalarchitecture, suggesting its need for novel materials to be introduced**(AAE, 2003;Asgary S, 2010; Arens DE, Torabinejad M, 1996; Katge FA, Shivasharan PR, Patil D, 2016)**.According to a recent study, a favourable prognosis may be obtained by repairing the perforated root non-surgically, with an overall chance of success of about 80.9%, when using mineral trioxide aggregate (MTA) based material. However, MTA also has some disadvantages, like its consistency, the complexity of manipulating, the prolonged setting time, and the expensive material cost might make a placement at the repair site a test of one's capabilities. Additionally, its use can cause discoloration of the tooth**(Asgary S, 2010; Felman D, Parashos P, 2013)**.With the intent of enhancing some of those properties, a new material silicate cement mineral trioxide aggregate (MTA Repair HP) “High Plasticity” MTA (Angelus®, Brazil) was recently introduced **(Zanini M, Sautier JM, Berdal A, Simon S,2012)**.There is yet to be identified an ideal sealing material that can achieve optimal sealing, easy of manipulation, biocompatibility, and the potential to promote osteogenesis and cementogenesis(Juárez Broon N,2006).Bio-dentine, which was introduced in 2009 to resolve the drawbacks of filling materials and has a variety of uses including endodontic repair, could be an attractive material for dentin-pulp complex regeneration designed as a "dentine replacement" material. In recent years, it has gained popularity **(Malkondu Ö, 2014)**.In the present study, the sealing ability of MTA repair HP and Biodentine™ for furcal perforation repair in permanent molars was analyzed and compared using Stereomicroscope.

2. Methodology

The present study was conducted at SEGi Oral health center, Kota Damansara, Malaysia and the Institutional Ethical Clearance Committee has given their approval.A total of 32 extracted permanent human teeth were obtained. The maxillary and mandibular first and second molars were used in the study with minimal and no caries, restoration, and non-fused roots. The samples with cracks, open apices, root caries, and evidence of pathologic resorption were excluded from the study. Samples were stored in 10% formalin for 1 week**(Kumar M, Sequeira P S, Peter S, Bhat G K, 2005)**. Ultrasonic scaling was done to remove calculus and soft tissues. To remove the formalin, the teeth were rinsed with tap water and placed in saline until they were used again.

2.1 Preparation of the samples

All of the samples had a standard access cavity prepared with a round diamond bur and a #557 straight fissure carbide bur with a high-speed handpiece and water spray irrigation. Using a high-speed handpiece with water spray, perforations were made in the middle of the pulp chamber floor with a # 2 round carbide bur. The perforation width was standardized in all samples to the diameter of a # 2 round bur, although the depth of the perforation sites varied depending on the thickness of the dentin-cementum at the furcal area. Water was used to rinse the samples and air was used to dry them.

2.2 Perforation Repair

With 15 samples each, the samples were randomly allocated into two experimental groups: Group A (n=15) and Group B (n=15) (Figure:1). Two samples served as positive controls where the teeth were perforated but not repaired.

Group A: Repair of a group, A samples with MTA Repair HP (Angelus ®, Brazil) was done as per the manufacturer's guidelines. Powder and liquid were mixed on the non-absorbent pad until desired putty-like consistency was carried to the defect by using endodontic plastic instruments and also the endodontic pluggers. The material was gently condensed using a moist cotton pellet and an appropriately sized endodontic condenser with no air bubbles. On the pulp chamber, a moist cotton pellet was put.

Group B: Repair of a group B, samples with Biodentine (Biodentine™, Septodont®, France) was also done as per the manufacturer's guidelines.Powder and liquid were dispensed in a capsule and manipulated using amalgam trituration for 30 seconds. The material was scooped out into the tray provided by the manufacturer and applied to the perforation site by using endodontic pluggers. Condensation of the material was done similar to MTA repair

HP. After sealing the perforations on all of the samples, they were kept at 24 hours at room temperature to let the materials set.

2.3 Dye penetration

To prevent the dye from permeating, experimental samples were uniformly coated with two layers of nail varnish except for 2 mm around the area of the perforation site. All of the samples were soaked in a 2 percent methylene blue solution for 48 hours after they had dried for 48 hours. Teeth were properly cleaned with water and dried for 24 hours at room temperature. Without any further lab procedures, all the samples were directly sectioned buccolingually by using a diamond disc along with a water coolant. The sectioned samples exhibited the material between the two walls of perforation with one end towards the pulp chamber and the other end was towards the furcation. The perforation wall of the sectioned sample with more dye penetration was selected for the microleakage evaluation (Figure: 2&3).

3. Results

The collected data were analyzed using the software R-3.4.0. To compare the two groups, an independent sample t-test was used. Biodentin (494.5) has a lower mean dye absorbance than Mineral Trioxide Aggregate Repair HP (1001.1) as shown in Table:1& Graph:1. The sealing ability of these two groups differed statistically significant, with a p-value of 0.012. (Table: 2). All statistical analysis is carried at a 5% level of significance.

Figure. 1. Showing two experimental groups with 15 samples each

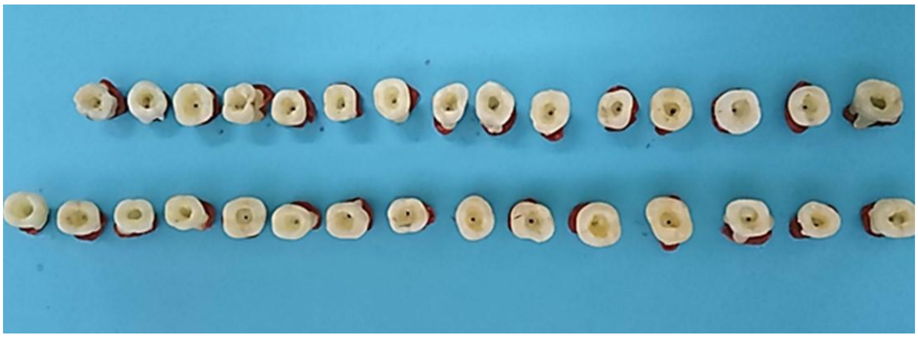


Figure. 2. Biodentin viewed under Stereomicroscope

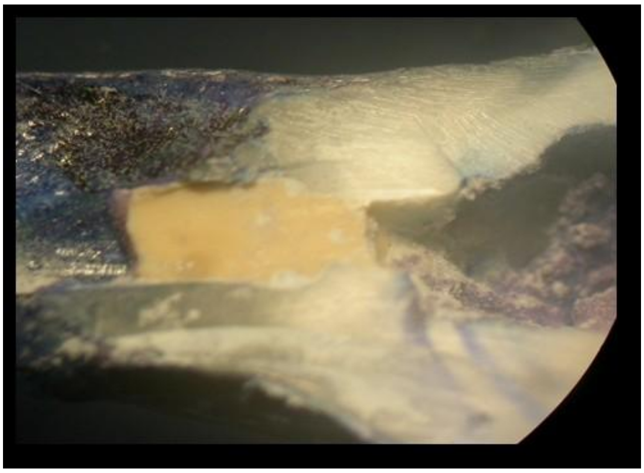


Figure.3.MTA Repair HP viewed under Stereomicroscope

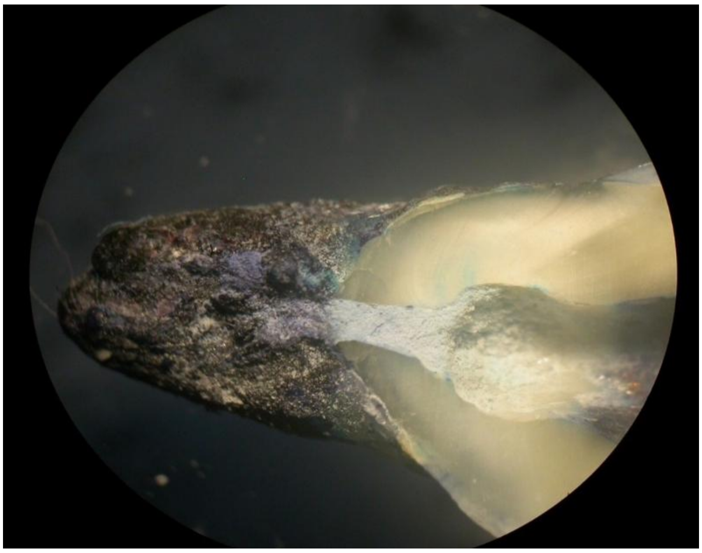


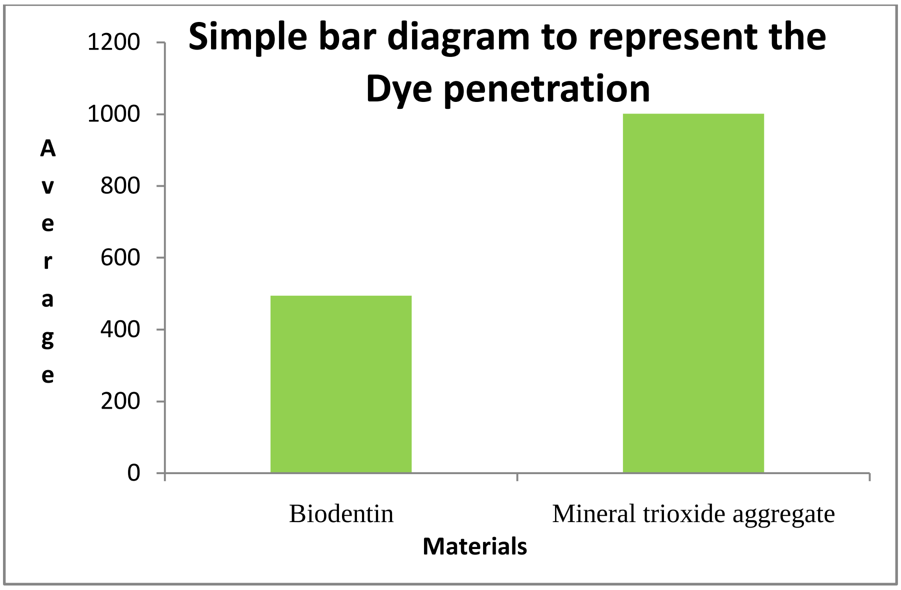
Table 1: Comparison between readings of two groups.

	Biodentin	**Mineral Trioxide Aggregate Repair HP**
Mean	494.5	1001.1
Standard Deviation	148.6	715.5

Interpretation of table -1.

It is showed from the above table that,Biodentin has a lower mean dye absorbance than Mineral Trioxide Aggregate Repair HP.

Graph. 1. Bar diagram representing the mean micro leakage of Biodentin& MTA Repair HP



Interpretation of graph 1.

Biodentin has lower dye penetration compared to Mineral Trioxide Aggregate Repair HP.

Table.2. Descriptive Statistical analysis

Test	**t- value**	**df**	**p-value**
Independent Sample t -Test	2.6868	28	0.012

Interpretation of table -2.

It is showedfrom the tablethat, the sealing ability of Biodentinand Mineral Trioxide Aggregate differed statistically significant.

4. Discussion

It's critical to stop the inflammatory reaction and the attachment loss at the perforation site while repairing furcal perforations **(Rotstein I, Simon JH,2008; AAE, 2003; Tsesis I, Fuss Z. 2006)**. Mineral trioxide aggregate (MTA) is a gold standard material that was first described in 1993 as cement for treating lateral root defects with respect to its biocompatibility, bioactivity hydrophilicity, radiodensity, sealing ability and low solubility, and desirable properties, commonly used material in treating both primary & permanent teeth**(Tawil PZ, Duggan DJ, Galicia JC,2015; Ha WN, Nicholson T, Kahler B, Walsh LJ, 2017).**.

MTA Repair HP has been shown to improve biological responses such as biocompatibility and biomineralization, while having no effect on dentin production and not promoting the inflammatory reaction **(Cosme-Silva L,2019; Cintra LTA, 2017; Barczak K, 2010)**.Biodentine (Septodont, Saint-Maur-des-Fossés, France) is another substance that is not advertised as MTA but is chemically identical. Calcium, silicon, and zirconium make up the elemental composition**(Ha WN, Nicholson T, Kahler B, Walsh LJ, 2017)**. This is developed to overcome some of the shortcomings of white MTA. Biodentine ^{TM} has a shorter setting time than MTA Plus^{TM}, therefore indicates there are fewer chances of bacterial contamination **(Jain P, Raj JD, 2015)**.It also provides a protective covering and long-lasting restoration, and it is recommended for reparative therapy methods where excellent sealing is essential. However, there are only a few studies that have looked into its potential to seal **(Övsay E, Kaptan RF, Şahin F,2018)**.

MTA PlusTM and BiodentineTM are both used to successfully treat furcal defects in primary molars **(Katge FA, Shivasharan PR, Patil D, 2016)**. When compared against Intermediate restorative material (IRM) and Biodentine, Pro Root MTA was found to be the most effective at preventing microleakage. In all materials, the amount of microleakage increased over time, and the size of the perforation also important, where microleakage was less in 2mm than 4 mm perforation **(Övsay E, Kaptan RF, Şahin F, 2018)**.

A recent study has shown that the Biodentine and Endosequence have a significantly better sealing ability compared to MTA-Angelus when utilized to treat severe furcal perforations, which are assessed with protein leakage model and also has a better handling property **(Kakani AK, Veeramachaneni C, 2020)**.

A proper repair material that is biocompatible, non-toxic, non-carcinogenic & convenient to use can ensure the success of the furcation repair**(Dazey S, Senia ES,1990)**.Microleakage and communication between the tooth and periodontal ligament should also be prevented. The present study demonstrated that Biodentine is a restorative material used for perforations and has shown significantly better sealing ability than MTA Repair HP. Dye penetration, dye extraction, fluid infiltration, electrochemical method, three-dimensional method, air pressure method, radioisotope method, bacterial leakage models and reverse diffusion method have all been used in studies to determine the ability of materials to seal furcation perforations**(Muliyar S, 2014; Sahebi S, 2013)**.

According to studies, the samples can be immediately seen under SEM for marginal adaptation evaluation without the need for resin replicas,because direct SEM evaluation of the samples did not result in the creation of a gap artificially. Hence, in the present study, by using the dye penetration method, samples were sectioned & examined directly under Stereomicroscope with minimal laboratory procedures(**Orosco FA, 2010)**. New alternative materials are introduced to overcome the shortcomings of many other materials previously utilized in dentistry. Numerous scientific studies have proved that MTA is a preferred material for all dentinal abnormalities and has a long history of usage in Endodontics due to its excellent clinical outcomes. However, due to its consistency, its manipulation & placement in the site of repair can be challenging. The study has shown that it can also cause discoloration of the tooth **(Felman D, Parashos P, 2013)**.

MTA Repair HP (High Plasticity MTA) is a novel formulation from ANGELUS® that maintains all of the chemical and biological features of the original MTA, ensuring treatment success. The MTA Repair HP's greater outcomes in contrast to White MTA could be explained by the replacement of bismuth oxide for calcium tungstate as a radiopacifier agent, which results in improved calcium release and provides better biomineralization. Furthermore, the high flexibility of MTA Repair HP may have a good impact on the marginal adaptation of the cement to the root walls, which is linked to the material's increased bond strength. **(Silva J M et al.,2016**). The inclusion of a radiopacifier ($CaWO_4$) that does not cause discoloration of the root or dental crown has been added

to a new formula whose particle size after hydration allows for greater handling and insertion into the dental cavity. It has a great biological root perforation sealing capacity to cause the production of periradicular cement, as well as the ability to be used in a moist medium without losing its qualities.**(Aggarwal V, Singla M, Miglani S, Kohli S, 2013)**. Biodentin offers better mechanical and physical qualities, as well as superior biocompatibility and bioactive behaviour, despite its composition being comparable to MTA.Biodentin has its own set of characteristics such as easy handling, quick setting time, and strong push-out bond strength, as well as its affordable price, which makes it the best choice for root canal and pulp chamber floor perforation repair. Biodentin possesses high push-out mechanical properties even after being exposed to different endodontic irrigation solutions, and blood contamination had no effect on the dentin's push-out bond strength, according to numerous in vitro investigations **(Priyalakshmi S, Ranjan M, 2014; Guneser MB, Akbulut MB, Eldeniz AU, 2013)**. Cementogenesis is a critical step in dentoalveolar development, according to studies, and the freshly created cementum acts as a biological barrier against the spread of microbial irritants within the root canal system. MTA and Biodentin are used in furcal perforation repairs because they can promote significant regrowth of surrounding dentoalveolar tissue in permanent teeth**(Silva J M et al., 2016; Baroudi K, Samir S, 2016)**.

When applied to heal extensive furcal perforations, a recent study found that Biodentine and Endosequence have a greater sealing ability than MTA-Angelus **(Kakani AK, Veeramachaneni C, 202**0**)**. It was also discovered that the new pulp-capping materials MTA Repair HP, NeoMTA Plus, and Biodentine have a high degree of cytocompatibility and cell migration rates with human dental pulp stem cells **(Tomas-Catala C J et al.,2018)**.According to other studies, the outcome of root perforation is mostly determined by the defect's size, location, period of contaminant exposure, repair material utilized, and access to the main canal **(Fuss Z, Tsesis I, Lin S, 2003)**.When employed as a root-end filling material, biodentine outperformed MTA in terms of sealing efficiency**(Tang JJ, Shen ZS, Qin W, Lin Z, 2019)**. Due to its low biocompatibility and marginal adaption, resin-modified calcium silicate-based material is unable to replace the MTA in the furcation perforation treatment **(Alazrag MA, Abu-Seida AM, El-Batouty KM, El Ashry SH, 2020)**. The contradicting assertion could be owing to the technology utilized to identify leakage; nonetheless, more research is needed to fully understand leakage in calcium silicate-based materials **(Malkondu Ö, KarapinarKazandağ M, Kazazoğlu E, 2014)**.

5. Conclusion

Based on the methodology used and the findings of this in vitro experiment, it can be stated that Biodentin has less microleakage and better handling properties than MTA Repair HP. However, the long term follows up studies with more samples & in vivo studies are required to evaluate these materials in the management of perforation repair.

References

[1]. Hashem, A. A., &Hassanien, E. E. (2008). ProRoot MTA, MTA-Angelus and IRM used to repair large furcation perforations: sealability study. *Journal of endodontics*, 34(1), 59–61.

[2]. Al-Hezaimi, K., Naghshbandi, J., Oglesby, S., Simon, J. H., &Rotstein, I. (2005). Human saliva penetration of root canals obturated with two types of mineral trioxide aggregate cements. *Journal of endodontics*, *31*(6), 453–456.

[3]. Fida N. Hassan1, Dunia Al Hadi2 and Saeed MH. (2015).Furcal Perforation Repair using mta&Biodentine™, an in Vitro Evaluation using dye Extraction Method. *Int. J. Recent Sci. Res*. 6:3172-3175.

[4]. Rotstein I, Simon JH. (2008). Endodontic‑ Periodontal interrelationships. In: Ingle JI, Bakland LK, Baumgartner JC, editors. Endodontics 6. 6th ed. Hamilton: BC Decker: p. 638‑ 59.

[5]. American Association of Endodontists. (2003). Glossary of Endodontic Terms. 7th ed. Chicago, IL: American Association of Endodontics.

[6]. Asgary S. (2010). Furcal perforation repair using calcium enriched mixture cement. *J Conserv Dent*.13(3):156-8

[7]. Arens DE, Torabinejad M. (1996). Repair of furcal perforations with mineral trioxide aggregate: two case reports. *Oral Surg Oral Med Oral Pathol Oral RadiolEndod.* 82(1):84-8.

[8]. Katge FA, Shivasharan PR, Patil D. (2016). Sealing ability of mineral trioxide aggregate Plus™ and Biodentine™ for repair of furcal perforation in primary molars: An in vitro study. *Contemp Clin Dent.*7(4):487-492.

[9]. Felman, D., &Parashos, P. (2013). Coronal tooth discoloration and white mineral trioxide aggregate. *Journal of endodontics*, 39(4), 484–487.

[10]. Zanini, M., Sautier, J. M., Berdal, A., & Simon, S. (2012). Biodentine induces immortalized murine pulp cell differentiation into odontoblast-like cells and stimulates biomineralization. *Journal of endodontics*, *38*(9), 1220–1226.

[11]. Juárez Broon, N., Bramante, C. M., de Assis, G. F., Bortoluzzi, E. A., Bernardineli, N., de Moraes, I. G., & Garcia, R. B. (2006). Healing of root perforations treated with Mineral Trioxide Aggregate (MTA) and Portland cement. *Journal of applied oral science: revista FOB*, *14*(5), 305–311.

[12].Malkondu, Ö., KarapinarKazandağ, M., &Kazazoğlu, E. (2014). A review on biodentine, a contemporary dentine replacement and repair material. *BioMed research international*, 2014, 160951.

[13]. Kumar, M., Sequeira, P. S., Peter, S., & Bhat, G. K. (2005). Sterilisation of extracted human teeth for educational use. *Indian journal of medical microbiology*, 23(4), 256–258.

[14]. Tsesis I, Fuss Z. (2006). Diagnosis and treatment of accidental root perforations. *Endod Topics*.13:95–107

[15]. Tawil, P. Z., Duggan, D. J., & Galicia, J. C. (2015). Mineral trioxide aggregate (MTA): its history, composition, and clinical applications. *Compendium of continuing education in dentistry* (Jamesburg, N.J : 1995), 36(4), 247–264.

[16]. Ha, W. N., Nicholson, T., Kahler, B., & Walsh, L. J. (2017). Mineral Trioxide Aggregate-A Review of Properties and Testing Methodologies. *Materials* (Basel, Switzerland), 10(11), 1261.

[17]. Cosme-Silva, L., Dal-Fabbro, R., Gonçalves, L. O., Prado, A., Plazza, F. A., Viola, N. V., Cintra, L., & Gomes Filho, J. E. (2019). Hypertension affects the biocompatibility and biomineralization of MTA, High-plasticity MTA, and Biodentine®. *Brazilian oral research*, 33, e060.

[18]. Cintra, L., Benetti, F., de Azevedo Queiroz, Í. O., de Araújo Lopes, J. M., Penha de Oliveira, S. H., Sivieri Araújo, G., & Gomes-Filho, J. E. (2017). Cytotoxicity, Biocompatibility, and Biomineralization of the New High-plasticity MTA Material. *Journal of endodontics*, 43(5), 774–778.

[19]. Barczak, K., Palczewska-Komsa, M., Lipski, M., Chlubek, D., Buczkowska-Radlińska, J., &Baranowska-Bosiacka, I. (2020). The Influence of New Silicate Cement Mineral Trioxide Aggregate (MTA Repair HP) on Metalloproteinase MMP-2 and MMP-9 Expression in Cultured THP-1 Macrophages. *International journal of molecular sciences*, 22(1), 295.

[20]. Jain P, Raj JD. (2015). Dentin substitutes: A Review. *Int J Pharm Bio Sci*.6:383–91.

[21].Övsay, E., Kaptan, R. F., &Şahin, F. (2018). The Repair of Furcal Perforations in Different Diameters with Biodentine, MTA, and IRM Repair Materials: A Laboratory Study Using an E. Faecalis Leakage Model. *BioMed research international*, 2018, 5478796.

[22]. Kakani, A. K., &Veeramachaneni, C. (2020). Sealing ability of three different root repair materials for furcation perforation repair: An in vitro study. Journal of conservative dentistry: JCD, 23(1), 62–65.

[23]. Dazey, S., &Senia, E. S. (1990). An in vitro comparison of the sealing ability of materials placed in lateral root perforations. *Journal of endodontics*, 16(1), 19–23.

[24]. Muliyar, S., Shameem, K. A., Thankachan, R. P., Francis, P. G., Jayapalan, C. S., & Hafiz, K. A. (2014). Microleakage in endodontics. *Journal of international oral health*: JIOH, 6(6), 99–104.

[25]. Sahebi, S., Moazami, F., Sadat Shojaee, N., &Layeghneghad, M. (2013). Comparison of MTA and CEM Cement Microleakage in Repairing Furcal Perforation, an In Vitro Study. *Journal of dentistry*(Shiraz, Iran), 14(1), 31–36.

[26]. Orosco, F. A., Bramante, C. M., Garcia, R. B., Bernardineli, N., & de Moraes, I. G. (2010). Sealing ability, marginal adaptation and their correlation using three root-end filling materials as apical plugs. *Journal of applied oral science: revista FOB*, 18(2), 127–134.

[27]. Silva, E. J., Carvalho, N. K., Zanon, M., Senna, P. M., DE-Deus, G., Zuolo, M. L., &Zaia, A. A. (2016). Push-out bond strength of MTA HP, a new high-plasticity calcium silicate-based cement. *Brazilian oral research*, 30(1), S1806-83242016000100269.

[28]. Aggarwal, V., Singla, M., Miglani, S., & Kohli, S. (2013). Comparative evaluation of push-out bond strength of ProRoot MTA, Biodentine, and MTA Plus in furcation perforation repair. *Journal of conservative dentistry*: JCD, 16(5), 462–465.

[29]. Priyalakshmi S, Ranjan M. (2014). Review on Biodentine-A Bioactive Dentin Substitute.*J Dent Med Sci.*13: 13-17.

[30]. Guneser, M. B., Akbulut, M. B., &Eldeniz, A. U. (2013). Effect of various endodontic irrigants on the push-out bond strength of biodentine and conventional root perforation repair materials. *Journal of endodontics*, 39(3), 380–384.

[31]. Baroudi, K., & Samir, S. (2016). Sealing Ability of MTA Used in Perforation Repair of Permanent Teeth, Literature Review. *The open dentistry journal*, 10, 278–286.

[32]. Tomás-Catalá, C. J., Collado-González, M., García-Bernal, D., Oñate-Sánchez, R. E., Forner, L., Llena, C., Lozano, A., Moraleda, J. M., & Rodríguez-Lozano, F. J. (2018). Biocompatibility of New Pulp-capping Materials NeoMTA Plus, MTA Repair HP, and Biodentine on Human Dental Pulp Stem Cells. *Journal of endodontics*, *44*(1), 126–132.

[33]. Fuss Z, Tsesis I, Lin S. (2003). Root resorption--diagnosis, classification and treatment choices based on stimulation factors. *Dent Traumatol*.19(4):175-82.

[34]. Tang, J. J., Shen, Z. S., Qin, W., & Lin, Z. (2019). A comparison of the sealing abilities between Biodentine and MTA as root-end filling materials and their effects on bone healing in dogs after periradicular surgery. *Journal of applied oral science: revista FOB*, *27*, e20180693.

[35]. Alazrag, M. A., Abu-Seida, A. M., El-Batouty, K. M., & El Ashry, S. H. (2020). Marginal adaptation, solubility and biocompatibility of TheraCal LC compared with MTA-angelus and biodentine as a furcation perforation repair material. *BMC oral health*, 20(1), 298.