Comparative assessment of the sealing capabilities of Biodentine, Mineral Trioxide Aggregates and Glass Ionomer Cement for the repair of furcal perforations in deciduous molar teeth: An In Vitro Study

Dr. Shemna M K [1*] ,Dr.Amith Adhyanthaya [2], Dr.Marium Raheema [3],Dr Vidhya Vijayan [4], Dr Hrishida P [5], Dr Laya Vijayaraj[6], Dr Nileena Balan [7], Dr Krishna N S [8], Dr Hanna Kizhakayil Hafiz [9]

Postgraduate Student [1,6,7,8, 9],Professor and HOD[2], Professor and HOD [3],Senior L ecturer[4,5], Department of Paediatric and Preventive Dentistry, KMCT Dental College, Calicut, Kerala.

CORRESPONDING AUTHOR - DR SHEMNA M K

KEYWORDS

Mineral Trioxide Aggregate, Furcal Perforation, Biodentine, Glass Ionomer Cement & Paediatric Dentistry.

ABSTRACT

Aim: This study aimed to investigate the sealing ability of biodentine, glass ionomer cement (GIC), and mineral trioxide aggregate (MTA) in furcal perforations in deciduous molar teeth.

Methods: Sixty primary mandibular molars were collected, cleaned, and then divided into three groups of twenty. Artificial furcal perforation were created and repaired using GIC, MTA, or Biodentine. 2% methylene blue was used for 48 hours to test each sample's ability to absorb the dye. To measure the amount of dye leakage, the teeth were dissolved in nitric acid and the supernatant was analyzed using a UV-visible spectrophotometer.

Results: The mean absorbance values for biodentine were 0.157 ± 0.01; for GIC, they were 0.406 ± 0.01; and for MTA, they were 0.205 ± 0.01. The statistical analysis using One-way ANOVA and Tukey HSD tests revealed significant differences ($p < 0.05$) between the groups. The group with the least amount of dye leakage was Biodentine, followed by MTA and GIC.

Conclusion: Biodentine exhibited superior sealing ability compared to MTA and GIC in the repair of molar furcal perforations. This suggests that it might be beneficial for clinical applications in pediatric dentistry.

Introduction

A common endodontic procedure complication that could compromise the outcome for the treated tooth is furcal perforation, especially in primary teeth. These perforations must be appropriately repaired in order to prevent bacterial leakage, which can irritate the tooth and eventually result in tooth loss[1]. Furcal Perforation have been sealed using a variety of materials, with differing degrees of success. In order to repair furcal perforations in deciduous molar teeth, this study aim to assess the sealing capabilities of three distinct materials: glass ionomer cement (GIC), mineral trioxide aggregate (MTA), and biodentine[2,3].

Because of its advantageous qualities, including chemical bonding to tooth structure, biocompatibility, and fluoride release, GIC is frequently utilised in paediatric dentistry.

However, because of its solubility and moisture sensitivity during setting, its capacity to seal furcal perforation has been questioned[4,5]. MTA has gained increased recognition since its introduction in the 1990s due to its exceptional sealing properties, biocompatibility, and ability to set in damp environments. It has been extensively studied and is considered the gold standard for many endodontic applications, including perforation repairs. In terms of handling convenience, biocompatibility, and sealing ability, the relatively new material biodentine has shown promising results. It has been marketed as a dentine substitute and utilized in a range of therapeutic contexts, including perforation repair[4,5,6,7].
This study was conducted to compare the sealing ablities of, GIC, MTA, and BIODENTIN for the purpose of sealing the furcal perforations in primary molars.

Methodology

This study protocol was approved by the Institutional Review Board and this randomized controlled in vitro trial was conducted at the Department of Paediatric and Preventive Dentistry at KMCT Dental College.

Preparation of specimen:

Extracted first and second human primary molars with no developmental defects, caries, white spot lesions, or those subjected were included in the study (Figure 1).

Sixty primary teeth that satisfied the inclusion requirements were first sterilized for thirty minutes in 3% sodium hypochlorite and then they were rinsed under running water to remove any debris further. The teeth were kept hydrated in normal saline after cleaning in order to prepare them for the following procedure.

A tapered diamond stone was used to amputate the root of each tooth 3 mm below the furcation area. This was done to ensure consistent dye immersion throughout the testing phase and to give stability when the teeth were set upright.

Access Cavity Preparation were done using a #2 round bur, a standardized access cavity created in each molar. The root canal orifices were identified, and endodontic files were used to remove pulp tissue. After that, the canals were debrided using saline and 3% sodium hypochlorite. Each canal's opening was covered with sticky wax, and to improve the marginal seal and stop leaks, two coats of varnish were added in succession.

The furcal area between the roots was marked externally with a black marker pen to guarantee accurate and uniform perforations. At the designated location, a #2 round carbide bur mounted on a high-speed handpiece with air-water coolant generated an artificial perforation with a diameter of 1 mm.

Procedure for Repair: Three groups of twenty teeth each were created by randomly selecting the teeth:

- Group I: Glass Ionomer Cement (GIC) was used to repair the perforation in this group.
- Group II: Mineral Trioxide Aggregate was used to repair the perforations in this group (MTA).
- Group III: Biodentine was used to seal the perforations in this group.

To guarantee that the components in the MTA and Biodentine groups were fully set, a moist cotton pellet was positioned between the pulp chamber and the furcal area outside.

For Dye Penetration test 2% methylene blue dye was added to individual Petri dishes containing each group of restored teeth. The samples were left in the dye for 48 hours so that any possible leaks could be evaluated. The teeth were taken out of the dye solution and rinsed under running water for forty minutes to get rid of any leftover dye after the dye penetration period. After that, a polishing disc was used to remove the varnish in order to guarantee precise dye penetration measurements (Figure 2)
Checking for Leakage of the dye: The teeth were put into vials with 1 milliliter of concentrated (65 weight percent) nitric acid and left there until they completely dissolved. After that, the vials were centrifuged for seven minutes at 9000 rpm in order to extract the dissolved tooth material from the residual fluid. A UV-visible spectrophotometer set at 545 nm wavelength was used to analyse 200 microliters (μl) of the supernatant from each sample, with concentrated nitric acid acting as a blank. The amount of dye that seeped into the perforation was shown by the measurements, which were expressed in absorbance units (AU).

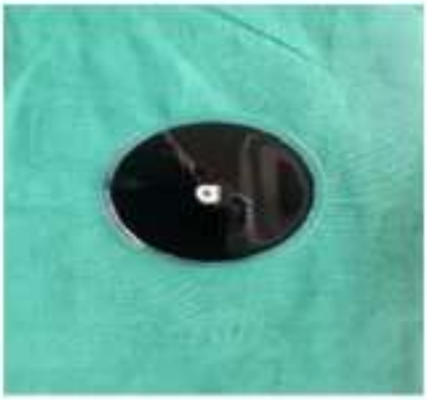
Outcome Measures

The amount of dye removed from each sample served as the key outcome measure for this study, which evaluated the sealing efficacy of the three materials. Based on the dye's emission of fluorescence, the dye penetration was measured and expressed in arbitrary units (AU). This offered a comparison of GIC, MTA, and Biodentine's sealing capacities for fixing furcal perforations in primary molars. The study sought to produce dependable and repeatable results by adhering to this meticulous and methodical process, which might direct clinical practice in paediatric dentistry, specifically in the selection of materials for furcal perforation repair.

Results

Table 1 & Graph 1 indicates that there were significant differences between the mean absorbance values of GIC, MTA, and Bio Dentine. The highest absorbance value was seen in Group, with mean absorbance of 0.4065 and lowest was seen in Group 3, with a mean absorbance of 0.1570. In intergroup comparison between experimental groups Biodentine followed by MTA was found to be the gold standard material was perforation repair(Table & Gaph 2).

Figure 1:
Figure :2



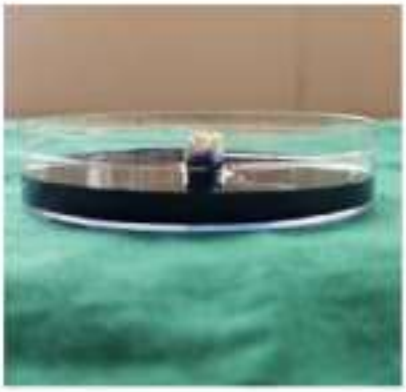


Table 1: Mean absorbance value of three experimental groups

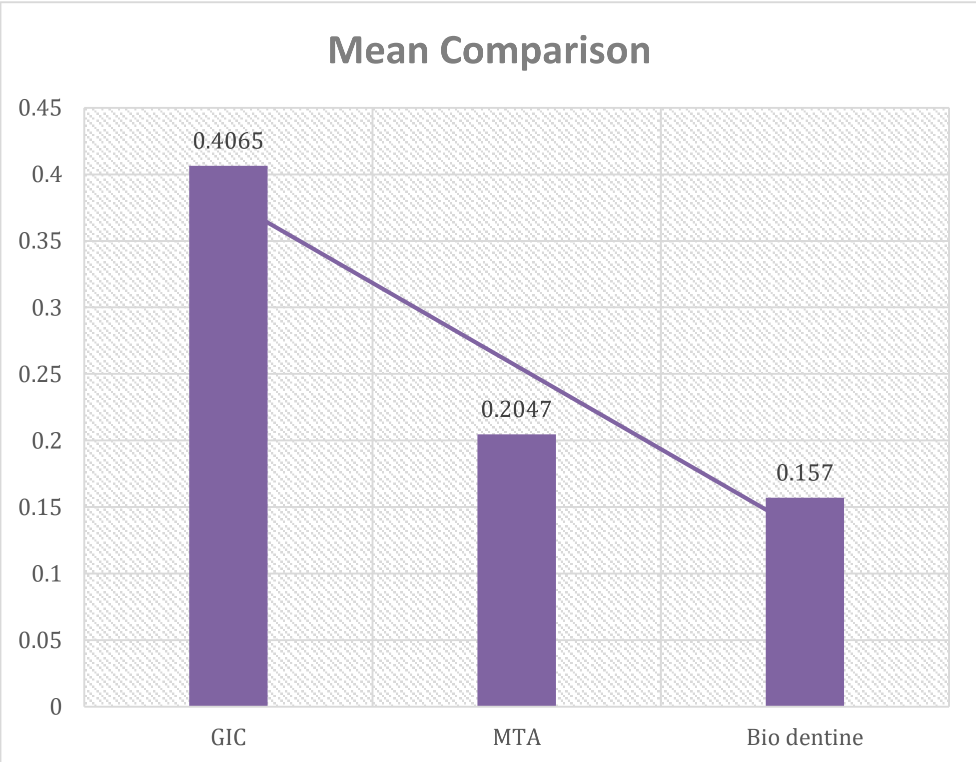
	N	Mean	Std. Deviation
GIC	20	.4065	.01468

MTA	20	.2047	.01002
Bio dentine	20	.1570	.01156
Total	60	.2561	.10968

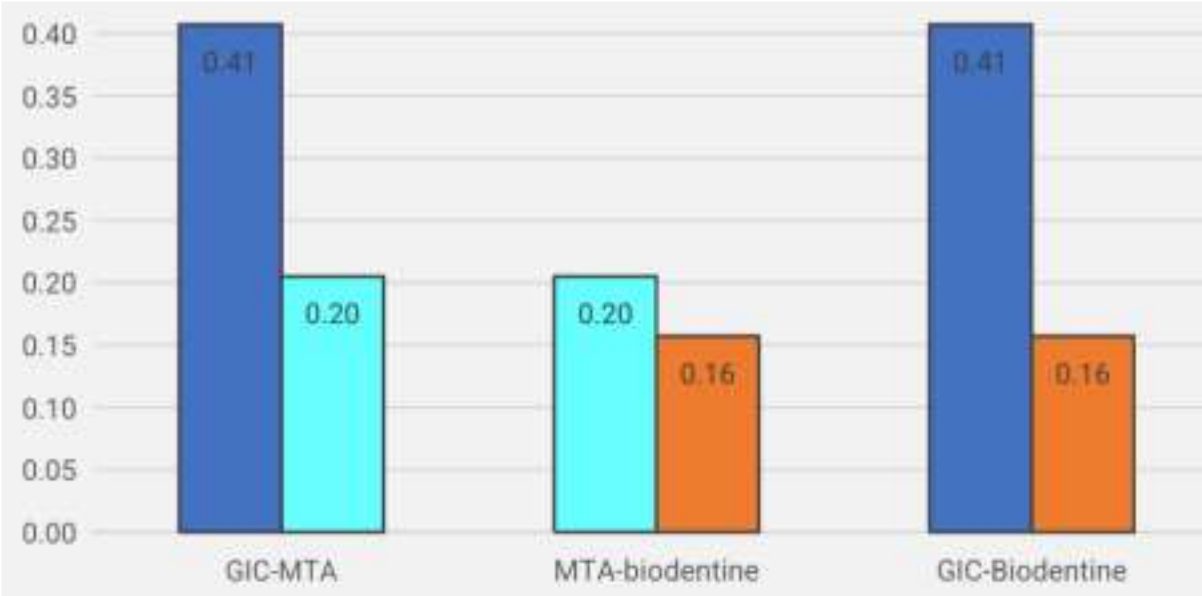
Table 2: Intergroup comparison of Mean absorbance value of three experimental group

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	p value	95% Confidence Interval	
					Lower Bound	Upper Bound
GIC	MTA	.20175*	.00387	.000	.1924	.2111
	Bio dentine	.24940*	.00387	.000	.2401	.2587
MTA	Bio dentine	.04765*	.00387	.000	.0383	.0570

Graph 1: Mean absorbance value of three experimental groups



GIC MTA Bio dentine



Discussion

The primary objectives of pulp therapy are to preserve oral structures, promote the healthy eruption of permanent teeth, and enhance the child's overall health. However, treating primary teeth with pulp involves several challenges, including the complexities of the procedures and behavioral issues in children, which can unintentionally result in furcal perforation[1,2]. Furcal perforation is an undesirable event that negatively impacts the prognosis of the treatment. It occurs when there is a connection between the periodontal ligaments and root canals through the pulp chamber. Various factors, such as severe decay, resorption, and improper bur placement during access cavity preparation, can contribute to this condition[4,5,6]. Studies indicate that the incidence of perforations ranges from 2% to 12%. If not addressed promptly, the perforation may become contaminated with bacteria, leading to inflammation, bone loss, necrosis, and epithelial proliferation into the perforation site, eventually resulting in tooth loss.[7,8,9,10.]

To repair perforation contemporary options like super EBA, IRM, gutta percha, Cavit, glass ionomer cement, and metal-modified glass to more conventional options like indium foil, amalgam, plaster of Paris, and zinc oxide eugenol Portland cement, calcium hydroxide, hydroxyapatite, ionomer cement, composite, dentin chips, Decalcified Freeze-Dried Bone, Tech Biosealer, and Tricalcium Phosphate Cement.[11,12] The objective of our study was to investigate the ability of biodentine, glass ionomer cement (GIC), and mineral trioxide aggregate (MTA) to seal furcal perforations in deciduous molar teeth.

The results showed that GIC had a mean absorbance of 0.4065 AU, with a 95% confidence interval of 0.3996 AU to 0.4133 AU, demonstrating moderate sealing ability(Table1&2). This result aligns with **Abraham S et al. (2023)**[13], who observed a perforation sealing ability of 0.2137.

MTA-Angelus demonstrated a mean absorbance of 0.2047 AU, with a 95% confidence interval ranging from 0.2000 AU to 0.2094 AU (Table 1 & 2),which is consistent with the results reported by **Ajas et al. (2018)**[14], a similar value of 0.205 ± 0.01 AU. The sealing ability of

MTA-Angelus is largely attributed to its antibacterial properties, radiopacity, and its ability to set in the presence of moisture, as highlighted in studies by **Patel et al. (2008)**[15] and **Takashi Komabayashi et al. (2008)**[16].

Despite these advantages, MTA-Angelus does have some limitations, including its slow setting time and handling difficulties. These challenges were particularly emphasized by **Girish CS et al. (2013)**[17], suggesting that while MTA-Angelus is effective in sealing, its clinical application can be hindered by these practical issues.AU, but is lower than the value of 0.550 ± 0.03 AU reported by **M Nepal et al. (2020)**[18].

In contrast, BioDentine exhibited a mean absorbance of 0.1570 AU, with a 95% confidence interval of 0.1516 AU to 0.1625 AU, and a standard deviation of 0.01156 AU(Table1&2). These results are in accordance with **Shaheen NA et al. (2018)**[19], who reported a perforation sealing ability of 0.025±0.009 AU for BioDentine, and **Kakani AK et al. (2020)**[20], who found a value of 0.120 AU. BioDentine's improved sealing ability is attributed to its mineral interaction zone with dentin, which enhances its sealing over time, and its favourable handling properties and shorter setting time. This makes it a promising alternative to MTA-Angelus. Overall, BioDentine offers advantages in terms of handling, faster setting time, and reduced microleakage. Further long-term studies are needed to confirm the clinical performance of these materials in preventing microleakage and ensuring the durability of perforation repairs.

In study it was concluded that Biodentine had the best sealing ability. The outcomes of this investigation are coherent with study conducted by **Kakani AK et al. (2020)**[21], that also concluded Biodentine has more superior properties as a perforation repair material in terms of microleakage. **Katge FA et al. (2016)**[22] in their experiment also concluded Biodentine had superior consistency, better handling characteristics, shortened setting time and perforation sealing performance. Another study conducted by **Attik et al. (2014)**[23] that compared biocompatibility of white ProRoot MTA and biodentine concluded that MTA and biodentine were equally biocompatible with bone cells.

Biodentine's improved marginal seal may be a result of its structural and chemical characteristics. Following mixing, a high pH solution including silicate ions, OH^-, and Ca2+ is produced when the calcium silicate particles in biodentine react with water. As saturation rises and calcium hydroxide nucleates, a calcium silicate hydroxide gel forms on the surface of unreacted calcium silicate grains. The calcium hydroxide raises the medium's alkalinity while the calcium silicate gel solidifies over time. Saliva and other biological fluids contain phosphate ions, which cause hydroxyapatite crystals to form around the substance and increase its sealing effectiveness[24,25]. In contrast, MTA-Angelus has a slower reaction rate and a more porous microstructure due to the coarse form of the powder components and reduced availability of tricalcium silicate.[26]

Conclusion

According to the study's findings, Biodentine was a more effective material for repairing furcal perforations in primary molars compared to Glass Ionomer Cement (GIC) and Mineral Trioxide Aggregate (MTA). The statistical analysis revealed significant differences between the materials, with Biodentine demonstrating the least dye leakage. These results support earlier research and provide further evidence for the use of Biodentine in pediatric dental practices.

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