

## Original Article

# Sealing Ability Of Biodentine Versus Mineral Trioxide Aggregate In Extracted Primary Molars With Furcal Perforation: In Vitro Study

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## Abstract

**Aim:** This study aimed to assess the sealing ability of biodentine versus Mineral Trioxide Aggregate (MTA) in extracted primary molars with furcal perforation.

**Materials and methods:** Forty-two extracted primary molars were collected, cleaned and then divided randomly into two equal groups (n = 21). The teeth were embedded in wax blocks. Preparing the access cavity in the typical manner was done, and each tooth's pulpal floor was purposefully perforated with a 0.5 mm round bur. The perforations were sealed in Group A with MTA and in Group B with biodentine. After 24 hours, the samples underwent longitudinal sectioning, and the spaces between the perforation walls and the repair material were measured in microns using scanning electron microscope at magnification 1000x to assess sealing ability.

**Results:** Biodentine has a significantly lower gap distance (highest sealing ability) ( $2.72 \pm 0.67$ ) ( $\mu\text{m}$ ) in comparison to MTA ( $3.69 \pm 0.82$ ) ( $\mu\text{m}$ ) ( $p < 0.001$ ).

**Conclusion:** With superior sealing capabilities, biodentine can act as a substitute for MTA.

**Keywords:** Primary molars, furcal perforation, sealing ability, Mineral trioxide aggregate, biodentine.

## Introduction

Preserving primary teeth has a major impact on maintaining the structural integrity of the oral cavity, guiding the correct eruption of permanent teeth, and ultimately ensuring the overall health of children. Due to the complexity of treatment and the behavioral challenges of children, perforation is a common procedural incident, especially the creation of artificial openings in bifurcation area (Ramazani and Sadeghi, 2016 and Abdelmotelb et al., 2021).

Furcal perforation is defined as an artificial communication between pulp cavity and the periodontal tissue and this may occur due to iatrogenic or non-iatrogenic causes (Al-Nazhan, S. et al., 2022).

The key to effective perforation management is to promptly seal the perforation with the appropriate material. When sealing a perforation, the material should be radiopaque, non-absorbent, bactericidal or bacteriostatic, non-toxic, non-carcinogenic, not affected by blood contamination and maintaining a good

seal. Furthermore, it ought to be able to stimulate osteogenesis and cementogenesis and easy in manipulation and placement (*Subbarao et al., 2017 and Alazrag et al., 2020*).

**Mahmoud Torabinejad** first introduced mineral trioxide aggregate (MTA) in **1993** and since then it gained a wide role for various purposes in the dental field. MTA is considered as “hydraulic silicate cement” composed of tricalcium silicate, tricalcium aluminate, tricalcium oxide, and bismuth oxide. MTA has an excellent sealing capacity when utilized in perforation repair because of its biocompatibility with periradicular tissues and its ability to stimulate cementoblasts to create the matrix for cementum formation (*Kakani et al., 2015 and Alla et al., 2020*).

Though this excellent cement has a high clinical efficacy, its long setting time and challenging manipulation were two of its main shortcomings (*Stringhini Junior et al., 2019*).

Biodentine is another calcium silicate-based material introduced to the market in **2011**. Its main constituents are calcium chloride (setting accelerator), zirconium dioxide (radiopacifier), calcium carbonate (filler), water reducing agent (superplasticizer) and tricalcium silicate, which controls the setting reaction (*Arandi and Thabet, 2021*).

Biodentine is considered as a dentin substitute due to its capability to pierce through open dentinal tubules, interlock with dentin, and possess mechanical properties (*Sinkar et al., 2015 and Kaur et al., 2017*).

Therefore, this study's goal was to compare biodentine in treating furcal perforations of primary molars with MTA concerning their sealing ability.

## Materials and Methods

### Study Settings and Study Design:

This is an in-vitro study that was conducted in the Pediatric Dentistry Department, Faculty of Dentistry. The Faculty Research Ethics

Committee reviewed the study proposal and gave its approval on 26/7/2022 with an approval number (35-7-22).

### Sample Size Calculation:

Based on the previous research by **Samuel et al., (2016)**. Sample size calculation with 95% confidence and 80% power.

The equation is 
$$N = \frac{16}{\text{Standardised difference}}$$

$$\frac{\text{Standardized difference}}{\text{Mean group 1} - \text{Mean group 2}} = \frac{16}{(\sqrt{\text{Standard deviation group 1}} + \sqrt{\text{Standard deviation group 2}})^2}$$

Sample size (n) was found to be a total of forty-two samples. The website Random.org was used by the co-supervisor to generate random sequences as the forty-two samples were split into two equal groups at random (n=21).

### Sample collection:

Freshly extracted primary molars with intact furcation (no caries, no perforation) and with physiologic root resorption not more than two-thirds of root length were collected from the Outpatients' Clinic of Pediatric Dentistry and Dental Public Health Department, Faculty of Dentistry, Cairo University. The reasons for the extraction of primary molars are carious lesions with bad prognosis, recurrent pathological infections, and orthodontic purposes. Only teeth discarded by patients, and guardians, were collected. All cracked teeth were excluded from this study. Following that, teeth were kept for a full day in 5.25% sodium hypochlorite to eliminate any remaining tissue. Following a 24-hour period, the specimens underwent a tapwater wash and were subsequently preserved in saline within separate dark containers, and numbered from 1 to 42.

### Sample preparation:

At the time of the preparation, teeth were removed from the saline and dried with oil free compressed air, then mounted in modeling. Using a 0.5mm round bur with high-speed

handpiece (W&H, Austria) and water coolant, a standardized access cavity was prepared. A round bur, 0.5 mm, was used to standardize the size of the furcal perforation, which was made in the middle of the pulpal floor. The pulp chamber and perforation were then flushed with water and dried with oil free compressed air. Each tooth was placed in a separate container. Containers were then randomly allocated either to the control or intervention groups.

#### Group A: (MTA group)

It included teeth with perforations sealed with MTA. The powder and liquid were distributed and mixed on a glass slab in a circular motion in line with the guidelines provided by the manufacturer. Using an amalgam carrier, the material was carried and placed in the furcation site to seal the perforation.

#### Group (B): (biodentine group)

It included teeth with perforations sealed with biodentine. Using a triturator (HI-Ah G10 amalgamator, China), the liquid and powder inside the capsule were mixed for 30 seconds in line with the guidelines provided by the manufacturer. The material was then scooped and applied in the perforation site.

To enable the repair materials to fully set, a wet cotton pellet was used to compact each sealed perforation, and the samples were stored in a closed container for a full day. A diamond disk, size 22mm, mounted in a low speed hand piece (W&H, Austria) was used to section the teeth in a longitudinal direction into two halves (*Nagesh et al., 2016 and Mohan et al., 2021*).

Then the teeth of both groups were examined using a scanning electron microscope (FEI inspect S, Netherland) at magnification 1000x for evaluating the sealing ability by measuring the gap at the dentin–furcation repair material interface. The microleakage was evaluated by measuring the gaps between the repair material and perforation walls in both

groups in microns at four points on the left and right sides (*Rajablou and Azimi., 2001*), as shown in figures 1 and 2.

Then the maximum gap size was used for calculations (*Bolbolian et al., 2020*).

#### Statistical analysis:

The chi square test was used to analyze the frequency and percentage values of the categorical data. The means with 95% confidence intervals (CI), standard deviation (SD), minimum (min.) and maximum (max.) values were used to present numerical data. They underwent Shapiro-Wilk's test analysis to determine their normality. With a normal distribution of data, the independent t-test was used for analysis. For every test, the significance threshold was set at  $p < 0.05$ . R statistical analysis software, version 4.3.2 for Windows, was used to conduct the statistical analysis.

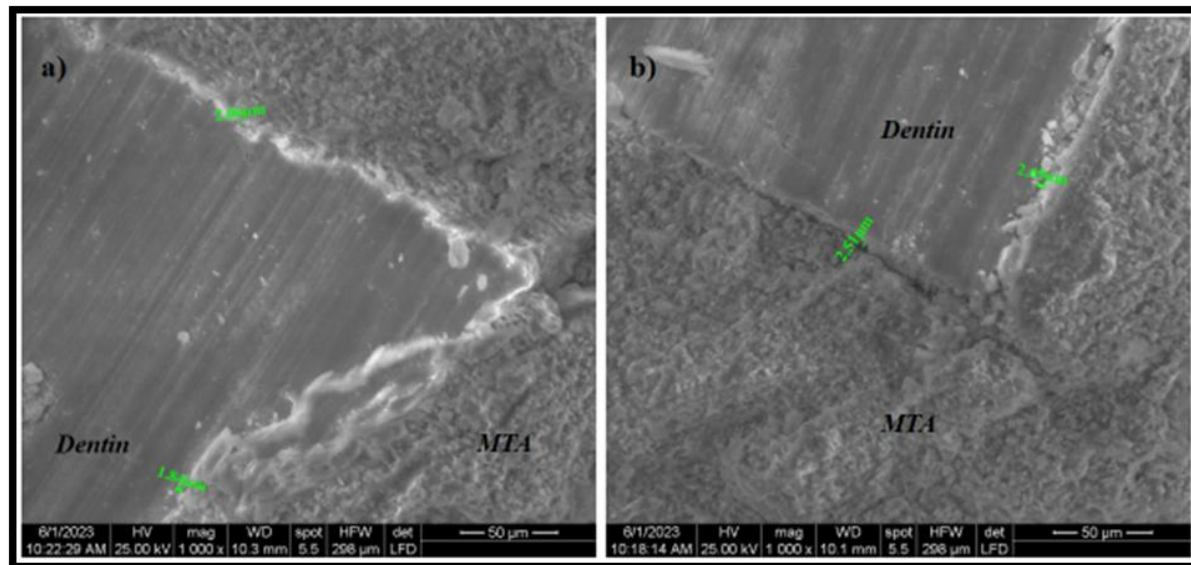
### Results

#### Descriptive statistics:

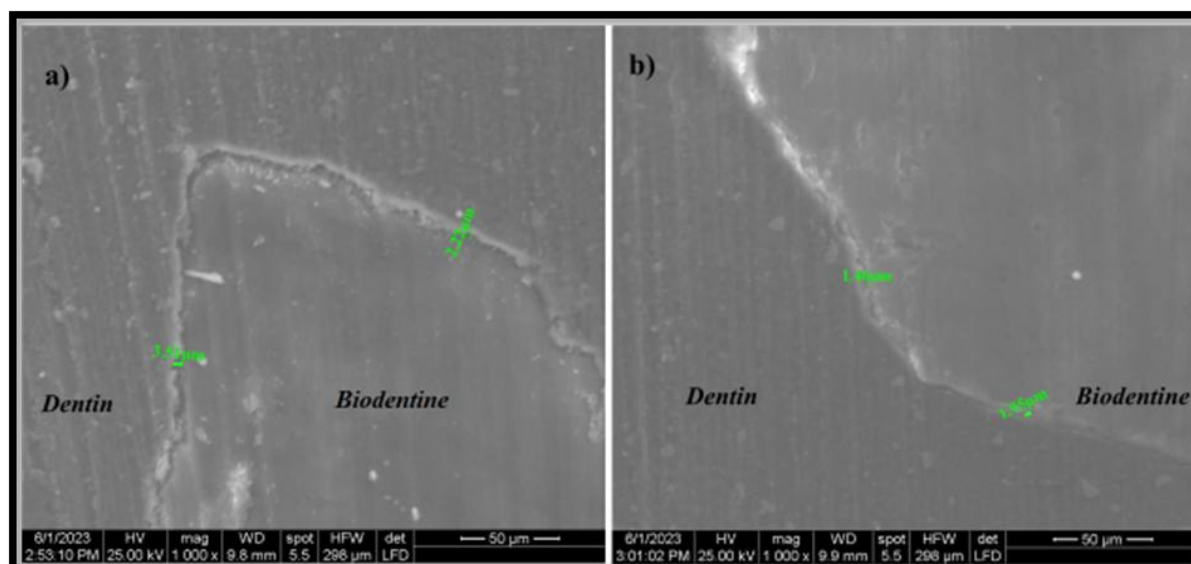
For MTA group, the mean was (3.69) with 95% confidence interval of (3.34:4.05), standard deviation was (0.82), minimum value was (2.45), and the maximum value was (5.28). While for biodentine group, the mean was (2.72) with 95% confidence interval of (2.43:3.01), standard deviation was (0.67), minimum value was (1.46), and the maximum value was (3.96), as presented in table (1).

#### Intergroup comparison:

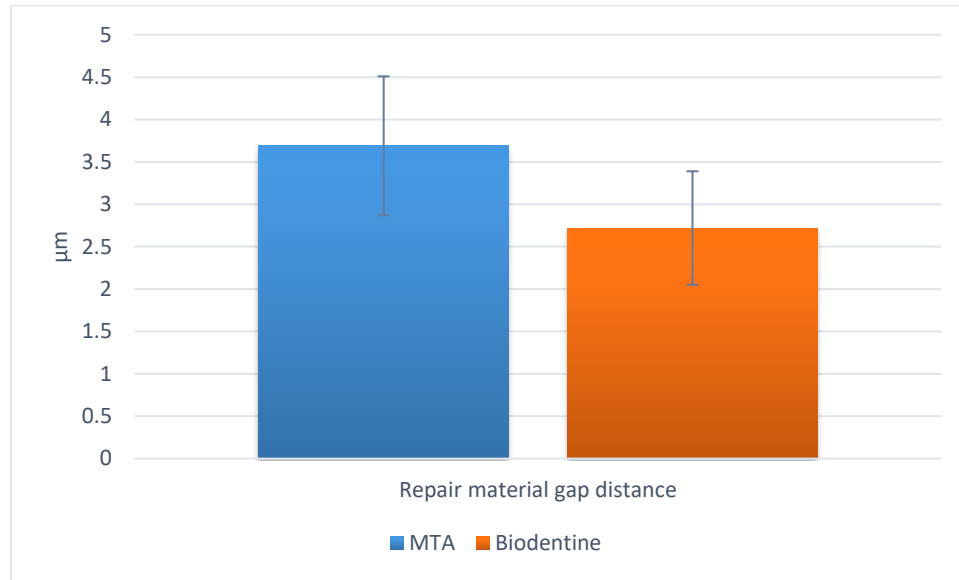
MTA ( $3.69 \pm 0.82$ ) ( $\mu\text{m}$ ) had a significantly higher gap distance (lower sealing ability) than biodentine ( $2.72 \pm 0.67$ ) ( $\mu\text{m}$ ) ( $p < 0.001$ ), as presented in table (2) and in figure (3).



**Figure (1):** Measuring the gaps between MTA and perforation walls,  
**a:** Right side.  
**b:** Left side.



**Figure (1):** Measuring the gaps between biodentine and perforation walls,  
**a:** Right side  
**b:** Left side.



**Figure (3):** Bar chart showing mean and standard deviation values of repair material gap distance (µm)

**Table (1):** Descriptive statistics for repair material gap distance (µm)

| Group      | Mean | 95% CI |       | SD   | Min. | Max. |
|------------|------|--------|-------|------|------|------|
|            |      | Lower  | Upper |      |      |      |
| MTA        | 3.69 | 3.34   | 4.05  | 0.82 | 2.45 | 5.28 |
| Biodentine | 2.72 | 2.43   | 3.01  | 0.67 | 1.46 | 3.96 |

**Table (2):** Intergroup comparisons, mean and standard deviation (SD) values for repair material gap distance (µm).

| Repair material gap distance (µm) (Mean±SD) |            | Test statistic | p-value |
|---------------------------------------------|------------|----------------|---------|
| MTA                                         | Biodentine |                |         |
| 3.69±0.82                                   | 2.72±0.67  | 4.21           | <0.001* |

\*, significant ( $p < 0.05$ )

The test used is independent t-test

## Discussion

Pulp therapy is an important approach that can assist in avoiding pain and infection in primary teeth, but the tiny size of the teeth and restricted access may make it difficult sometimes. The worst outcome of access cavity pulpotomy procedures is iatrogenic perforation of the furcation area (*Abdelmotelb et al., 2021 and Baby et al., 2023*).

In the current study, sealing ability was assessed because the prognosis of the furcation perforation is often excellent if it's correctly identified and the defect is repaired with a material that has strong sealing ability. By sealing the perforation with a non-irritating material, periodontal defects and future epithelium breakdown will be avoided (*Das et al. 2022 and Zarzour et al., 2021*).

MTA was used as the control group in the current study, as the tissue healing, biocompatibility, and sealing adaptability of MTA have all been validated by several investigations and MTA is considered a gold standard material in sealing perforations. Despite the previously described characteristics, MTA can be challenging to manipulate and apply, necessitating appropriate skills and training. Other significant clinical limitations of MTA include its long setting time and the discoloration of teeth caused by the interaction of bismuth oxide and sodium hypochlorite (*de Sousa Reis et al., 2019*).

Biodentine has similar features to MTA but also has the advantage of a faster setting time and better manipulation. It bonds with the dentin in chemo-mechanical manner, forming a tag-like structure at its interface with the tooth structure. In addition, its smaller particle size results in lower pore volume and sealing interface porosity in set biodentine material compared to MTA, which could be a reason for better sealing ability (*Nagmode et al., 2023 and Grover et al., 2020*).

In the current study, eligibility criteria were in accordance with *Nagmode et al., (2023)*, including freshly extracted primary molars with intact furcation and excluding cracked teeth, and teeth with root resorption more than two-thirds of the root length to stabilize teeth properly in blocks (*Abdelmotelb et al., 2021*).

Teeth were immersed in a 5.25% solution of sodium hypochlorite for twenty-four hours for disinfection and removal of tissue remnants, then cleaned with tap water and preserved in saline to wash out residual sodium hypochlorite solution. (*Lodiene et al., 2011 and Baralay and Raghavendra, 2022*).

*Bansal et al., (2019)*, clarified that the most popular technique for identifying sealing ability is dye penetration; however, this approach has drawbacks as well, including dye dissolution, random sectioning that does not demonstrate deep dye penetration, dentinal tissue loss with dye, demineralization, and dehydration. On the other side, SEM's great magnification and depth of focus allow it to visualize how restorative materials adapt to cavity borders.

In this study, the gap (measured in  $\mu\text{m}$ ) between the furcal repair material and the pulpal floor was used to assess the sealing adaptability. A characteristic's determining factors are its marginal adaption and its close contact with the surrounding material (dentin and dental material). The gap in ( $\mu\text{m}$ ) was therefore used to measure the sealing adaptation (*Nagmode et al., 2023*).

The results of this study were consistent with a study conducted by *Das et al. (2022)* using SEM at 2000x magnifications to assess three distinct materials: MTA-Angelus, biodentine and Endosequence and discovered that biodentine had the greatest sealing ability, while MTA-Angelus had the lowest. In line with previous studies, *Kakani and Veeramachaneni, (2020)*, used the protein leakage technique. All groups' mean protein leakage varied in a way that was statistically significant. MTA leaked more than any other

substance, whereas biodentine leaked the least, followed by endosequence.

Also, the findings of this study agreed with those of a study conducted by **Krikor Kaloustian et al., (2020)** who used the methylene blue dye penetration technique to assess sealing ability and elucidated that biodentine demonstrated superior seal strength and is the preferred biomaterial for the treatment of furcal perforations, in contrast to MTA Angelus, despite the fact that both materials have positive attributes and can considerably improve the prognosis of teeth with weakness as a result of perforations.

On the other hand, these results disagree with **Mulla et al., (2020)**, who conducted a study using SEM at magnification 500x to assess sealing ability and found that there was no statistically significant difference between proRoot MTA and biodentine. This conflict may be attributed to the difference in sample size for each group between both studies, as well as the difference in storage time of samples after repairing material application; they stored the samples in a wet sponge for 7 days, while in our study, Samples were compacted using a wet cotton pellet following the application of repair material, and they were only kept in a closed container for a twenty four hours.

Another study conducted by **Baralay and Raghavendra, (2022)**, and showed that there was no significant difference between MTA, biodentine and endoseal repair material. The explanation of the conflict here may be related to the bacterial leakage model used for assessment of the sealing ability, as there are several limitations with this approach, such as qualitative results that fail to account for gaps smaller than the size of the bacteria.

### Limitations of the study

This study is an in-vitro study that didn't capture the oral environment's complications and didn't give a true mimic of in vivo settings.

### Conclusion

Based on the results of the current study, the followings could be concluded:

- Biodentine can be more effective and can be an alternative to MTA in repairing furcation perforation in primary molars.
- There was a significant difference between biodentine and MTA. Biodentine has better sealing ability with less gap between dentin-material interface.

### Conflict of Interest:

The authors declare no conflict of interest.

### Funding:

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

### Ethics:

This study protocol was approved by the ethical committee of the faculty of dentistry- Cairo University on 26/7/2022, approval number (35-7-22).

### Data Availability:

Data will be available upon request

### CRedit statement:

Author 1: Data curation, Writing - review & editing, Writing - original draft, Methodology, Conceptualization, Resources.

Author 2: Data curation, Conceptualization, Project administration, Supervision, Methodology, Writing - review & editing, Writing - original draft.

Author 3: Methodology, Writing - original draft, Writing - review & editing, Investigation, Formal analysis, Supervision, Data curation.

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