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# A Comparative study to evaluate marginal adaptation of Bioceramic, MTA in vital pulpotomy on primary teeth (an in vitro study)

**Rama Awad[1*], Abdul Wahab Nourallah[1]**

[1]Department of Pediatric Dentistry, Faculty of Dentistry, Tishreen University, Latakia, Syria

*Corresponding Author: Email: rama.awad@tishreen.edu.sy

**Abstract**

**Aim**: The main goal of this study was to compare the microleakage of MTA and Bioceramic, using Scanning Electron Microscopy in pulpotomized primary molars.

**Materials and Methods**: Study design: 10 extracted primary molars (caries-free or not) were used and randomally distributed among two groups of study (n=5). Pulpotomy was conducted using either MTA or Bioceramic, the teeth were then restored with composite resin. The crowns were resected longitudinally (bucco-lingual direction) into two halfes. The teeth were thermocycled to 200 rounds between 5° and 55°C in distilled water, with 30s dwell time in each bath, The samples were mounted on an aluminum stub and marginal gaps were examined and recorded in micrometer using Scanning Electric Microscopy (SEM)

**Results**: Variable gaps were observed between the materials and dentinal walls. MTA had the largest mean gaps (mean 6.716), whereas BC had the smallest mean gaps (1.428).

Statistic: The study results were analysed using an independent sample t-test.

**Conclusion**: This study showed that Bioceramic was comparable to MTA in marginal adaptation. there has been a superior behavior of Bioceramic than white MTA and it adapts better with the adjacent dentin. It is worth saying that this study differs from other studies measured the marginal adaptation with dentin by using SEM on filled primary teeth.

**Keywords:** Microleakage, Bioceramic, MTA, Primary molars, Scanning electron microscopy



## INTRODUCTION

Micro leakage in dentistry can be categorized as passing the iones and molecules or fluids and bacteria through the inter face tooth- filling material (Amaireh et al 2019). The cause of the early fail after restoring teeth may be the treatment itself which serve as a bath of bacterial contamination or the new formed hard tissues do not fully protect against bacterial leakage, so, developing new biomaterials with its biocompatibility and sealing ability changes the attitude (Amaireh et al 2019).

Mineral trioxide aggregate(MTA), is a bioactive and bioinductive material that has been investigated for endodontic applications since the early 1990s (Tawil et al 2009). It has

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several desirable properties. The most important of these properties in dentistry are its biocompatibility and sealing ability. High biocompatibility encourages optimal healing responses. The seal achieved is due to its expansion and contraction properties being very similar to dentin which results in high resistance to marginal leakage and to bacterial migration into the root canal system (Tawil et al 2009). (Bidar et al 2007) compare the marginal adaptation of Gray Mineral Trioxide Aggregate (GMTA) – White Mineral Trioxide Aggregate (WMTA) – Portland Cement (PC) using Scanning Electron Microscopy (SEM) and 75 single rooted extracted human teeth, the canals filled with gutta-percha and cavities were prepared and filled with the studied materials then root were longitudinally sectioned into two halves, under SEM the marginal gaps of the GMTA – WMTA – PC were 211,6 – 349 – 326,3um respectively and the gaps were smaller for GMTA, the results indicate that there were no significant differences between the tested materials.

Since the introduction of MTA, Bioceramic materials have increasingly started to fill the gap that has existed in demanding endodontic situations with regard to suitable materials (Haapasalo et al 2015 )

Bioceramics (BC) are ceramic materials designed to be used in medical and dental filed, During the 1960s and 1970s (Ree et al 2014). Bioceramics are inorganic, non- metallic, biocompatible materials that include alumina and zirconia, bioactive glass, coatings and composites, hydroxyapatite and resorbable calcium phosphates and radiotherapy glasses (Best et al 2008). They are chemically stable, non – corrosive, and interact well with organic tissue

**Bioceramics in endodontics:**

They can be categorized by composition, setting mechanism, and consistency. There are sealers and pastes, developed for use with gutta- percha, and putties, designed for use as sole material, comparable to MTA. Some are powder/liquid systems that require manual mixing which is a very sensitive technique and produce considerably waste. Premixed bioceramics require moisture from the surrounding tissues to set. The premixed sealer, paste, and putty have the advantage of uniform consistency and lack of waste. They are all hydrophilic,They are dimensionally stable and expand slightly(Debelian et al 2016). When set, they are hard , allowing full compaction of a final restoration, and they are insoluble over time, ensuring a superior long – term seal. When setting, the PH reaches above 12 due to the hydration reaction (SOUZA et al 2015). Therefore when unset, the material has antibacterial properties. When fully set, it is biocompatible and even bioactive (Debelian et al 2016). (Patri et al 2020) demonstrated a significant and better sealing ability and marginal adaptation by Bioceramic when compared to ProRooyMTA sealer. (Leal et al 2011) studied the apical sealing capacity of Bioceramic and compared it with WMTA in preventing glucose leakage which has a high molecule weight through root-

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end fillings after preparation a 3 mm in depth cavity and filled with studied materials and found no differences between it in apical sealing. (Chisnoiu et al 2019) prepared twenty mandibular teeth endodontically, the radicular filling was performed using gutta-percha in association with a sealer, ten teeth were filled with consecrated endodontic filling material and the residual with the experimental BC based sealer they did not find important statistical differences between the size of marginal gaps of BC materials measured in three areas. (Nair et al 2011) instrumented 40 single-rooted teeth and obturated them with gutta-percha, 15 teeth were retrofilled with WMTA and (Bioceramic Root Repair Material) BCRRM (n=15). Unfilled specimens (n=10) received no retrofilled and were used as controls. All groups receives E.faecalis in a created reservoir coronal to the root filling, and evaluated the presence of micro leakage by counting the colony-forming units from each specimen, they noticed that BC presents the same sealing capacity of MTA when it is used in root opturation. (Hirschberg et al 2013)(2) compared the sealing ability of MTA with EndoSequence bioceramic RRM(ES-BCRRM) by using 60 single-rooted extracted teeth and the apical 3 mm of each root was sectioned at 90 degrees to the long axis of the root, teeth were equally divided into four groups group 1 MTA group 2 ES-BCRR putty group 3 and 4 positive and negative control respectively, teeth were inoculated with E. faecalis through the occlusal openings, samples were observed up to 28 days and concluded that samples in the ES-BCRR group leaked significantly more than samples in the MTA group.

(Antunovic et al 2021) compared the sealing ability of TotalFill BC with MTA plus when used in root opturation using ninety-four single-rooted human teeth with one round root canal which were instrumented and randomly divided into five experimental groups, the prepared samples were fixed in a model designed for the E.faecalis leakage evaluation. The bacterial penetration through the filled root canals was checked by the color change in the lower tube during 60 days, SEM was used to check the bond between the sealer and dentine wall, to find better results for TotalFill BC. (Polineni et al 2016) compared the marginal adaptation of three newer root canal sealer (group 1 epoxy resin sealer- group 2 MTA Fillapex – group 3 EndoSequence BC sealer) to root dentin, by using 30 freshly extracted human single-routed with completely formed apices teeth, teeth were decoronated and root canals were instrumented, the specimens were randomly divided into three groups (n=10) based upon the sealer used, later, samples were vertically sectioned and marginal adaptation of sealers to root dentin was evaluated under coronal and apical halves using SEM, they found the lowest marginal gap in group 1 and the highest marginal gap in group 2 and noticed that the coronal halves showed better adaptation compared to apical parts in all the groups under SEM. (Patri et al 2020) used sixty human extracted lower premolars and removed the visible debris and calculus ultrasonically and sectioned all the teeth samples at the cementoenamel junction the

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canals were cleaned and shaped. According to the sealer used , the samples were divided randomly into three groups: group 1 BC sealer group 2 resin- based sealer group 3 MTA-based sealer and were visualized ender SEM at apical and coronal thierds of root canal, the gaps at root dentin and sealer interface were assessed. They concluded that significant and better sealing ability was demonstrated by bioceramic sealer comparing to MTA-based sealer and resin-based sealer

(Coaguila-LIerena et al 2020) reported that BC showed the shortest initial setting time (5,2 min) followed by MTA Angelus (15,6 min), and Biodentine (27,5 min), In comparison with MTA Angelus and Biodentine, Bioceramic was the most alkaline(10,8) at the first 24 h, then, there was no difference between bioceramic and biodentine at 3,7,14 and 21 days.

Bioceramic exhibited high alkaline PH over time with the maximum value occurred on the 7 day (Abu Zeid et al 2015). (Coaguila-LIerena et al 2020) demonstrated that when comparaing the radiopacity of MTA Angelus, Bioceramic and Biodentine, MTA Angelus showed the highest radiopacity (4,8 mm Al) followed by Bioceramic (4,2 mm Al) showing significant differences between them, It was found that Biodentine was the only cement that showed solubility (4,1. In contrast, MTA Angelus and Bioceramic showed an increase in mass (-1,6% and -4,2 %, respectively). BC Sealer exhibited mild toxicity at high extract concentration (Zhou et al 2015). According to (Gaurav Ya-J et al 2016), HCSCs (MTAs) had a slightly higher final hardness than the CPSC cements, while the opposite was true regarding the compressive strength(Guo Y-j et al 2016) Bioceramic exhibited ongoing increases in solubility overtime, whereas, MTA-Fillapex displayed the most significantly lowest value (Abu Zeid et al 2015)

These characteristics put the material as one of the most important choices for dentist beside the other available materials already used like MTA (Kohli, M et al 2019). These characteristics suggest the possibility of using the material as a lining material after pulpotomy on primary molars(Kohli, M et al 2019).

This study aimed to evaluate in vitro the marginal adaptation of Bioceramic material with adjacent dentine in pulpotomised primary molars in comparison with MTA.

## Method and materials

Ten-freshly extracted human molars, without any root caries or root fracture, were selected.

The selected teeth were stored in a solution of 2% formaldehyde in distilled water and kept at 4° C for no more than 3 months before the pulpotomy procedure.

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**Teeth preparation for pulpotomy**

The crowns were prepared with 30 diamond bur on high- speed handpiece, after reaching the root canals orifices, a thin layer of 2-3 mm from either MTA (White ProRoot MTA, DENTSPLY Tusla Dental, USA) or BC material (FKG ERRM TotalFill®, swiss endo) on 5 molars for each material, a sterile saline wet cotton pellet was put over the lining material for 7 days to ensure complete setting of the materials and they were kept in a moisten incubator at 37°C, 95% relative humidity until complete setting for the whole period as they require continuous exposure to moisture during setting (Zhou H-m et al 2015) , the teeth were then filled with glass ionomer cement (Fuji II LC; GC Corp, Tokyo, Japan) and restored with resin Composite(Spectrum and Prime & Bond NT, Dentsply).

**Preparing specimens**

After restoring the teeth,the roots were sectioned with a low-speed diamond saw (Isomel, Buhler Ltd, Lake Bluf, 11, USA) to the cementoenamel junction with water cooling then the crowns were resected longitudinally (bucco-lingual direction) to two halves using hard tissue microtome

**Thermocycling**

The teeth were exposed to 200 thermal cycles between 5° and 55°C in distilled water, with 30s dwell time in each bath (Karadas M et al 2020)

**Studying on the SEM**

The samples were mounted on an aluminum stub and marginal gaps were examined and recorded in micrometer using Scanning Electric Microscopy (SEM)(Tescan- Vegall xmu) under magnification ×30 and the gaps between the inner face of lining material and dentine walls were measured at two fixed selected points (figure 1) and the mean was recorded for each sample, the mean gap of each material was then calculated, The mean ±SDs were calculated. T -Test was used to determine statistical difference between various groups ( Elsheikh HM et al 2022, Torabinejad M et al 1995 ).

## Results

Variable gaps were observed between the materials and dentinal walls. MTA had the largest mean gaps (6.716) and poorest adaptation among the studied materials, whereas BC had the smallest mean gaps (1.428) (figure 2). T- Test showed that there were significant statistical differences between the materials ($p<0,01$) (table 1).

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## Discussion

Marginal adaptation known as degree of approximation of filling material to dentine surface which is important for treatment success (Elsheikh HM et al 2022)

The aim of this study was to evaluate the marginal adaptation of Bioceramic material with adjacent dentine in pulpotomised primary molars in comparison with MTA.

This was a randomized controlled in vitro study, ten human primary first and second molar, were extracted for orthodontic reasons, treated with WMTA or BC, as pulpotomy materials and then cut bucco-lingually into two halves by using the microtome, according to longitudinal axis to observe the relation between the studied materials and the pulp chamber floor and also the root canal orifices under SEM on magnification ×1000 - ×2000 - ×5000. the average gab of each material was resulted from calculating the measurement of gabs of each picture taken from two fixed points (middle of lateral surface- middle of the floor of pulp chamber). The highest average gab measurement was 6.716 for MTA, and the lowest was 1.428for BC. T test was applied to compare the averages, and there was a statistical difference between the two materials, this disagree with( Leal et al 2011) This disagreement can be explained by that all the teeth were treated by the same manner and they used Glucose infiltration which has a low molecule weight as an indicator for the permeability and it also can be explained as the hardening reaction of calcium silicate produces calcium hydroxide that interact with phosphate to form hydroxyl abatite and water and that explains the leakage in MTA's symbols whereas the other material hardens and produces calcium silicate gel and calcium hydroxide .

And in disagreement with (Bidar et al 2007) That can be explained by studying the radicular dentin of permanent teeth in their study which has a different structure in comparing with coronal dentine. The results of this study diseagreed with (Chisnoiu et al 2019) results it can be explained by the presence of homogenous layer with extensions interesting the hybrid layer in the apical third of each root that plays a physical parrir role interacts with the insertion of the material in the dentin. In the studies used bacterial infiltration as a standard of marginal sealing, the results was in disagreement with the results of (Nair U et al 2011), and in disagreement with (Hirschberg et al 2013) and in agreement with (Antunovic et al 2021) that can be explained by that they used E. Faecalis infiltration that mesures 0.6-2 um to determine the marginal sealing.

The resulsults disagreed with (Polineni S et al 2016) The differences can be referred to using the radicular portions in their study where the dentin tubular density (which is essential for BC interaction) is lower and the high diameter of dentin tubes that facilitate the entrance of resin and thus encourage the relation with dentin.

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The results agree with (Gaurav et al 2020) it can be explained by using the sealer type of BC that consist of nanoparticles

## Conclusion

This study showed that BC RRM-FS putty was comparable to white PrpRoot MTA in marginal adaptation. there has been a superior behavior of Bioceramic Root Repair Material- Fast set (BC RRM-FS) than white Pro Root MTA and it adapts better with the adjacent dentin. It is worth saying that this study differs from other studies measured the marginal adaptation with dentin by using SEM on filled primary teeth.

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**Tables and Legends**

**Table 1.** Comparison of mean marginal gap values between MTA and Bioceramic

| Variable | Material | Number | Mean | S.D. | t.test | Sig. | Decision |
|---|---|---|---|---|---|---|---|
| marginal gap | Bio | 8 | 1.428 | 0.924 | -2.928 | 0.003 | There is statistical difference |
| | MTA | 5 | 6.716 | 5.030 | | | |

**Figures and Legends**

**Figure 1.** SEM micrographs showing marginal adaptation of MTA (A) and Bioceramic (B) to dentinal walls