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Comparative Evaluation of Sealing Ability of Root End Filling Materials MTA, Biodentine and Pozzolan Cement Using SEM: An In-Vitro Study

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ABSTRACT

Background: Comparative Evaluation of Sealing Ability Of Root End Filling Materials MTA, Biodentine And Pozzolan Cement Using Sem: An In-Vitro Study.

Material and method: 45 central incisors will be collected for study which will be randomly divided into 3 equal groups of 15 each. Conventional root canal treatment will be carried out, and then retrograde filling will be done using MTA, Biodentin and Pozzolan cement. The samples will be viewed under scanning electron microscopy (1000X magni-fication) for evaluating the adaptation of the material to the canal walls. The largest gap present between the material and canal wall was measured in four quadrants, and the mean gap was calculated for each sample.

Results: Mean value of MTA and Biodentin Shows no significant difference. Mean value of Pozzolan was highly significant in comparison to MTA and Biodentin at both 1mm and 2mm.

Conclusion: Pozzolan can be considered as an alternative to MTA and Biodentine as root-end filling material.

Keywords: Apical surgery, Marginal adaptation, MTA, Biodentin, Pozzolan, root end filling materials.

INTRODUCTION

The main objective of the endodontic procedure is to obtain a hermetic seal between the periodontium and root canal system so that no bacteria or bacterial by-products can penetrate or leave from the root canal [1]. Root canal treatment is generally a successful procedure if the problem is accurately diagnosed and thorough cleaning and shaping and proper obturation are done[2]. But failures in treatment sometimes occur[3] due to persistence of bacteria (intra-canal and extra-canal) inadequate filling of the canal (canals that are poorly cleaned and obturated) overextensions of root filling

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materials untreated canals (both major and accessory) and iatrogenic procedural errors.[4] Apicoectomy and root-end filling are common surgical procedures performed in an attempt to seal the root canal. Adequacy of the apical seal is the single most important factor for successful apicoectomy [3]. Root end filling is the procedure by which an inert non-toxic material is packed into the root canal through an apical cavity[2].

The ideal endodontic root-end filling material should have specific physical, chemical, and biological properties such as radiopacity, chemical and dimensional stability, antibacterial action, and biocompatibility. Traditionally, amalgam had been well known and used as a material of choice for root-end filling in the endodontic surgeries. However, because of its evident disadvantages such as micro-leakage and cytotoxicity, intermediate restorative material, super ethoxy benzoic acid cement, and mineral trioxide aggregate have been suggested as alternative root-end filling materials to amalgam.[5] Some potentially, available materials like bioactive glass, biodentine, bioaggregate, bioceramics, CER (Cemento Endodontico Rapido/ Fast endodontic cement), endosequence root repair material and Endocem (MTA-derived pozzolan cement) have been introduced with the aim of overcoming some of the disadvantages of the MTA [3].

MTA (Fig no.1)

It was introduced by Dr. Torabinajed in 1993. The principal components of MTA are tricalcium aluminate, tricalcium silicate, bismuth oxide, dicalcium silicate, tetracalcium aluminoferrite [3]. The advantages of MTA are believed to be its sealing ability, biocompatibility, bioactivity and capacity to promote mineralized tissue formation.[6] MTA has all the properties of retrograde filling material except its poor handling properties like long setting time (165 ± 5 min) and requirement of additional moisture for setting reaction. [3].

BIODENTINE (FIG NO. 2)

It is a calcium silicate based material was introduced as dentin substitute by Septodont in 2010. Biodentine is available in capsule containing dicalcium silicate, tricalcium silicate, calcium carbonate, iron oxide, and zirconium oxide filler. Liquid consists of calcium chloride which acts as accelerator and a polymer which act as a water reducing agent. It can be used for pulp capping, pulpotomy, apexification, root perforation, internal, and external resorption and also as a root end filling material in periapical surgery. Advantage of biodentin over MTA include reduced setting time, better handling and mechanical properties [3].

POZZOLAN (FIG NO. 3)

A newly developed material based on pozzolan cement (Endocem, Maruchi, Seoul, Korea) has been manufactured in South Korea endorsing its short setting time (5 minutes). Even though the major component of a pozzolan cement is the amorphous or glassy silica, the chemical composition of Endocem is very similar to that of MTA: 20% bismuth oxide (Bi_2O_3) is added for radiopacity and it is composed of 46.7% CaO, 5.43% Al_2O_3, 12.80% SiO_2, 3.03% MgO, 2.32% Fe_2O_3, 2.36% SO_3, 0.21% TiO_2, 14.5% H_2O/CO_2, and 11.0% Bi_2O_3 in wt%. When mixed with sterile water, there is a gradual decrease in the amount of free calcium hydroxide and an increase in formation of calcium silicate hydrate (CaO SiO_2 nH_2O), which lower the hydration heat, neutralize the pH and increase the compressive strength[5].

Fig 1: MTA.

Very few studies have compared sealing ability of these three materials as retrograde filling materials using SEM. Therefore, aim of this study is to compare and evaluate the apical sealing ability of MTA, Biodentine and Pozzolan cement using SEM.

Fig 2: Biodentin

Fig 3: Pozzolan.

MATERIALS AND METHOD

The prospective experimental study was conducted in the department of Conservative Dentistry and Endodontics at Chhattisgarh Dental College & Research Institute, Rajnandgaon. This study included 45 extracted maxillary single rooted central incisors having completely formed apices and straight canals, non-carious, non-cracked and no root resorption were selected. Teeth with caries, fractured or cracked teeth and teeth having curved canal or more than one canal or one root were excluded.

The sample size was 45 which was further randomly divided into 3 equal groups of 15 each (n = 15).

Group I: MTA as root-end filling material.

Group II: Biodentine as root-end filling material.

Group III: Pozzolan cement as root-end filling material.

Procedure

Pre-operative radiographs were taken before access cavity. Teeth were sectioned at cementoenamel junction using diamond disc mounted on a micromotor straight handpiece (Fig no. 4). Access cavities were prepared using Endo access bur and working length was determined for each tooth by subtracting 0.5 mm from the length at which 15 no. K-file appeared at the apical foramen. Biomechanical preparation was done till 50 no K-file (fig no. 5) and canals were irrigated using sodium hypochlorite (3%). The rest of canal was flared using a conventional step-back technique. Then canals were dried with paper points, obturated with laterally condensed gutta-percha and AH Plus sealer. Radiographs were taken to confirm the quality of obturation. Access cavity of each tooth was sealed with composite resin. Apical root resection was performed by removing 3 mm of each apex at 90°to long axis of teeth with cross-cut fissure bur.

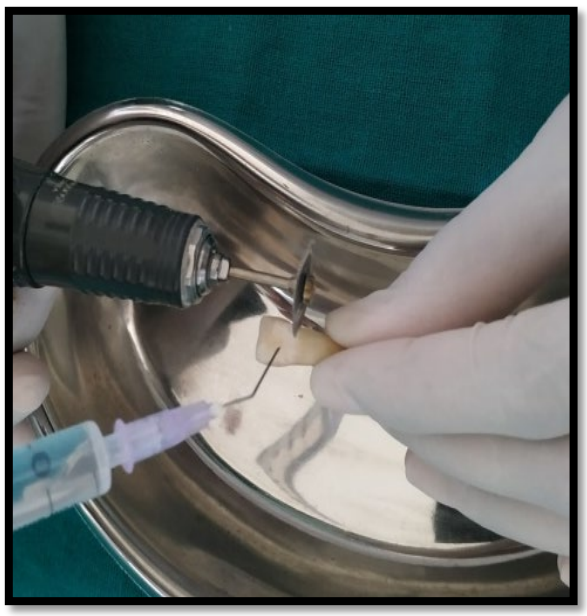

Fig 4: Sectioning at cementoenal junction using straight handpiece and disk.

Fig 5: Biomechanical preparation till 50 no. k file.

Fig 6: Showing marking at 1mm and 2 mm apically which would be sectioned.

in a high speed handpiece with water coolant. A 3 mm deep root-end cavity was prepared with a straight fissure bur in a high speed handpiece with water coolant.[7]

Then teeth were assigned into three groups of 15 teeth each. Materials were mixed according to manufacturer's instruction, cavities were filled.[3] Correct placement and thickness of all the MTA apical plugs was checked radiographically. All the samples were stored in relative humidity (95%) at 37 degree C for 5 days.[7]

The samples were then mounted in a resin block to create a platform for sectioning with a diamond disc mounted on low speed hand straight handpiece under water[8] and sectioned apically at 1mm and 2mm levels from the apex (fig no. 6). The samples were gold sputtered and viewed under scanning electron microscopy (1000X magnification) for evaluating the adaptation of the material to the canal walls. The largest gap present between the material and canal wall was measured in four quadrants and the mean gap was calculated for each sample.[7]

STATISTICAL ANALYSIS

Statistical analysis was done using ANOVA and Tukey post hoc test to compare 2 groups for their significant difference in mean.

RESULTS

Mean and standard deviation were calculated for each group at 1mm and 2mm.

Table 1: Shows mean and standard deviation calculated at 1mm for MTA, Biodentin and Pozzolan.

1 mm	MTA	BIODENTIN	POZZOLAN
Mean	2.56	2.48	1.3
SD	0.61	0.45	0.52

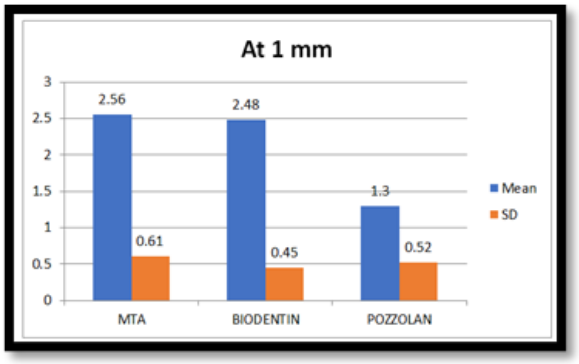

Fig 7: Graph of mean and standard deviation at 1mm.

ANOVA shows the difference in mean is highly significant at 1mm (table no. 1 and fig no.7) then tukey post hoc test was applied. Mean value of MTA and Biodentin Shows no significant difference. Mean value of Pozzolan was highly significant in comaparison to MTA and Biodentin.

$Mean_{MTA}$ vs $Mean_{POZZOLAN}$ **P <0.01 Highly Significant (HS)**

$Mean_{BIODENTIN}$ vs $Mean_{POZZOLAN}$ **P <0.01 HS.**

Table 2: Shows mean and standard deviation calculated at 2mm for MTA, Biodentin and Pozzolan.

2 mm	MTA	BIODENTIN	POZZOLAN
Mean	1.77	1.76	0.58
SD	0.27	0.52	0.3

ANOVA shows the difference in mean was highly significant at 2 mm (table no. 2 and fig no. 8). Then tukey post hoc test was applied. Mean value of MTA and Biodentin Shows npo significant difference. Mean value of Pozzolan was highly significant in comparison of MTA and Biodentin.

$Mean_{MTA}$ vs $Mean_{BIODENTIN}$ vs $Mean_{POZZOLAN}$ **P <0.01 HS.** $Mean_{MTA}$ vs $Mean_{BIODENTIN}$ P>0.05 Not significant

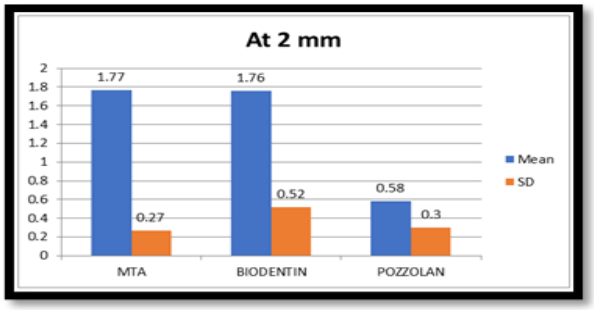

Fig 8: Graph showing mean and standard deviation.

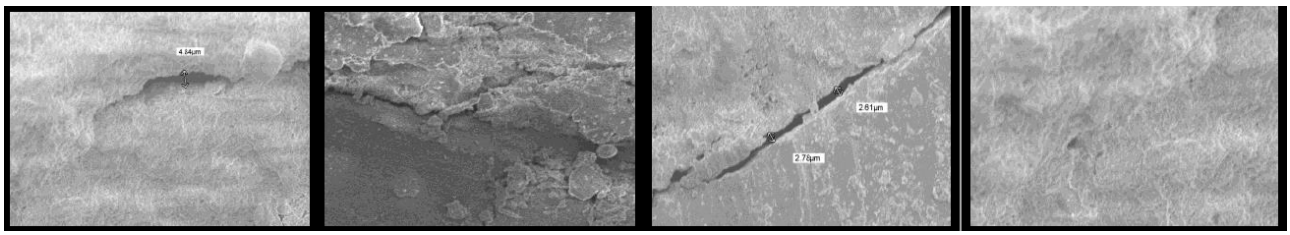

Fig 9: SEM of MTA showing marginal seal at 1mm level.

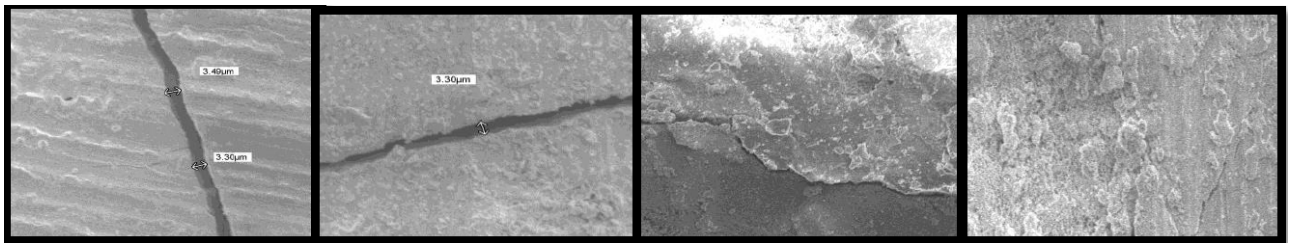

Fig 10: SEM of Biodentin showing marginal seal at 1mm level.

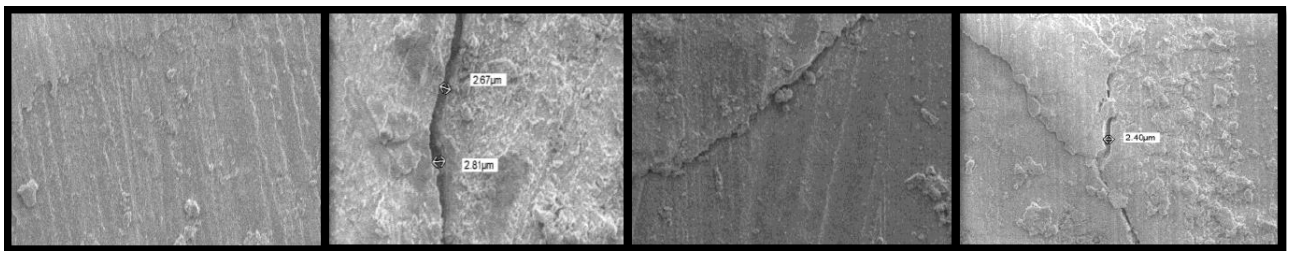

Fig 11: SEM of Pozzolan showing marginal seal at 1mm level.

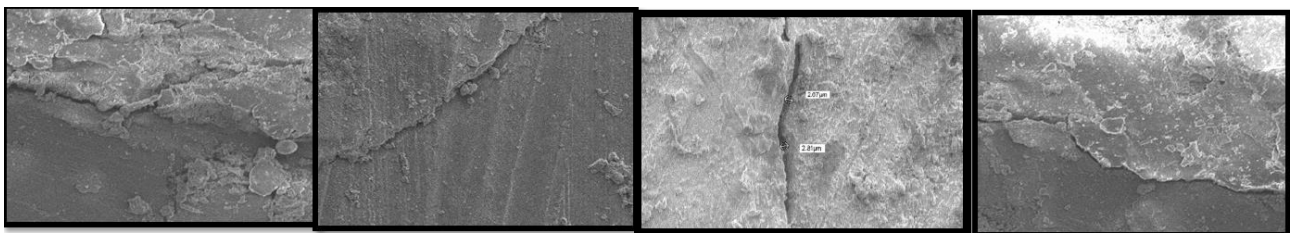

Fig 12: SEM of MTA showing marginal seal at 2mm level.

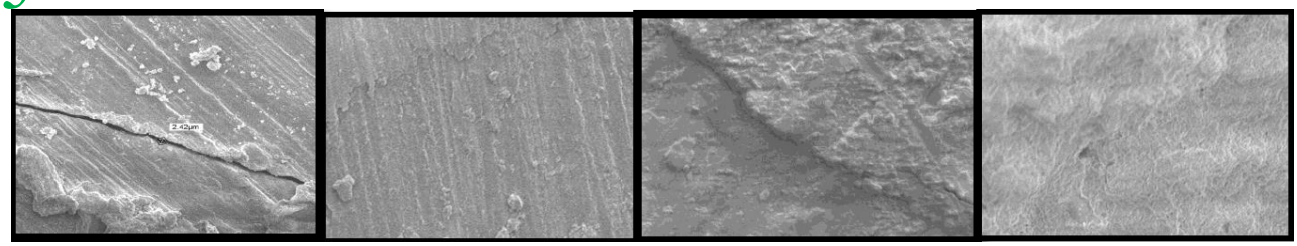

Fig 13: SEM of Biodentin showing marginal seal at 2mm level.

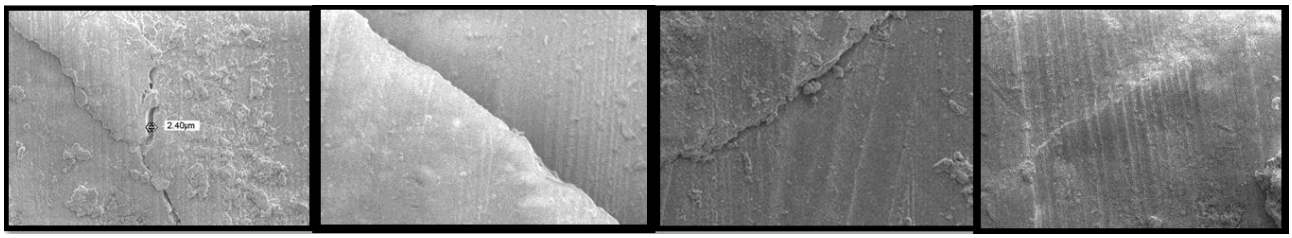

Fig 14: SEM of Pozzolan showing marginal seal at 2mm level.

DISCUSSION

Apical surgery belongs to the field of endodontic surgery that also includes incision and drainage, closure of perforations, and root or tooth resections. The objective of apical surgery is to surgically maintain a tooth that has an endodontic lesion which cannot be resolved by conventional endodontic (re-)treatment. This goal should be achieved by root-end resection, root-end cavity preparation, and a bacteria-tight closure of the root-canal system at the cut root end with a retrograde filling.[9] In root-end resection at least 3mm of the root-end must be eliminated to reduce 98% of the apical ramifications and 93% of the lateral canals, which might be responsible for endodontic failure. Perpendicular resection minimizes the number of exposed dentinal tubules. Hence 3mm of root-end was resected perpendicular to the long axis of the tooth in this study.[7] Incremental placement of the retrograde filling material was done to minimize the voids and enhance the quality of the filling. Numerous materials are used as retrograde filling material namely MTA, GIC, IRM, super EBA and composite resins.[7] Biodentine is a relatively new tricalcium silicate based material, which forms hydrated calcium silicate gel and calcium hydroxide on hydration. Marginal adaptation is one of the desirable properties for a retrograde filling material.[7] Regarding root-end filling materials, the vast majority of the reviewed studies consider thess Mineral Trioxide Aggregate (MTA) as an ideal root-end filling material as it permits the formation of a physical and biological double seal covering the severed apex is the desired outcome of periapical surgery.[10]

In dentistry, the microleakage evaluation could be performed by various methods and devices such as fluid filtration, dye extraction, dye penetration, bacterial and protein leakage models. New alternative methods are introduced recently such as artificial caries, radioactive isotopes, scanning electron microscopy, neutron activation analysis, and electrical conductivity.[11] SEM aids in assessing the marginal adaptation at the filling material - tooth interface under higher magnification.[7] Transverse sections allow the visualization of the restoration-dentin interface throughout the circumference. Hence, the samples were sectioned transversely and examined the interface directly under SEM in this study.[7] Marginal adaptation was evaluated only at 1mm and 2mm levels; 3mm level section was avoided, as it would encroach upon the junction between the retrograde filling material and the gutta-percha.[7]

Biodentine has similar properties to those of ProRoot MTA, calcium hydroxide is produced during the setting of Biodentine cement. It is well known that Biodentine is recommended as an endodontic repair material due to its good sealing ability, short setting time, high compressive strengths, biocompatibility and biomineralization properties.[12] This study shows no significant difference between marginal sealing alibilty of MTA and Biodentine. This result is in accordance with

study done by Bolhari et al which stated that both the materials had a similar composition with calcium silicate as their main constituent.[13] Mousavi S A et al evaluate the sealing ability of ProRoot mineral trioxide aggregate (MTA), Biodentine, and Ortho MTA as the root canal obturation materials using the fluid infiltration method. They found that microleakage values were similar to MTA ProRoot, Biodentine, and Ortho MTA using the fluid infiltration technique.[14] On controray to these result, Samuel A etal in their study found Biodentine™ showed lesser microleakage compared to MTA[15] and Nabeel M et al found sealing ability of ProRoot MTA is superior to Biodentine. [12]

In this study, Pozzolan cement showed better sealing ability as compared to that of MTA and Biodentine. This may be attributed to its biocompatible and bioactive material with resistance to compression due to the presence of natural additives (pozzolana and calcium carbonate) in its composition. This result is in accordance to Silva et al.[16] This property i.e sealing ability of pozzolan cement need to be investigated, as very less literature is available on pozzolan.

CONCLUSION

This study shows that marginal sealing ability of Pozzolan is comparatively better than that of MTA and Biodentine due to its fast setting time and due to presence of natural additive. Within the limitation of the study, it can be concluded that Pozzolan can be considered as an alternative to MTA and Biodentine as root end filling material.

CONFLICTS OF INTEREST

The authors declare they have no potential conflict of interests regarding this article.

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