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Original Research

Evaluation of Sealing Ability of Five Different Root End Filling Material: An *In Vitro* Study

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Abstract:

Background: Aim of the study was to evaluate sealing ability of five different root end filling materials by dye penetration method.

Materials and Methods: About 100 extracted maxillary central incisors were sectioned at Cementoenamel junction. Access cavities were prepared, instrumented chemo-mechanically, and obturated with laterally condensed gutta-percha and AH Plus sealer. Access cavities were sealed with composite resin. After 3 mm of root resection a 3 mm deep root-end cavity was prepared in each tooth. The teeth were retrofilled with glass ionomer cement (GIC), super-ethoxy benzonic acid (EBA), gray-mineral trioxide aggregate (MTA), white-MTA and biodentine. Three coats of nail varnish were then applied to the whole surface of total length of each root except tip of the root where retrograde filling was applied. All roots were stored in 1% solution of methylene blue for 72 h; after which roots were rinsed under tap water. The teeth were sectioned buccolingually, depth of dye penetration was evaluated under stereomicroscope.

Results: The overall results showed no statistically significant difference between two types of MTA and biodentine, but all the three materials are superior to GIC, super-EBA.

Conclusion: Both forms of MTA, biodentine provide a better seal than GIC, super-EBA.

Key Words: Biodentine, glass ionomer cement, micro-leakage, mineral trioxide aggregate, root-end filling and super-ethoxy benzonic acid

Introduction

Complete obliteration of the root canal system and development of a fluid tight seal are among the most important factors of successful endodontic treatment. Although non-surgical endodontic procedures have been shown to be successful, failures in treatment sometimes occur. Apicoectomy and retrograde root 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.[1] 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 characteristics of an ideal apical root end filling material include adherence to dentinal walls of the retrograde preparation, periradicular tissue tolerance and bioactive promotion of healing. The filling material should not corrode or be electrochemically active nor should it stain the periradicular tissues. It should be easy to manipulate and radiopaque. In addition, it should be dimensionally stable, non-absorbable, not penetrable by bacteria, and unaffected by moisture.[3]

Several root-end filling materials have been used like gutta-percha, amalgam, cavit, intermediate restorative material, super-ethoxy benzonic acid (EBA), glass ionomers, composite resins, carboxylate cements, zinc phosphate cements, zinc-oxide eugenol cements, and mineral trioxide aggregate (MTA).[3] 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.[4]

MTA was introduced by Dr. Torabinajed in 1993 as grey MTA. Because of discoloration potential of gray-MTA, white-MTA was developed in 2002. This version improved esthetics because the original gray-colored MTA was proved to darken overlying tissues. The principal components of MTA are tricalcium aluminate, tricalcium silicate, bismuth oxide, dicalcium silicate, tetracalcium aluminoferrite. White-MTA differs from gray-MTA in that it has a significant reduction in the proportion of tetracalcium aluminoferrite content. MTA has all the properties of retrograde filling material except its poor handling properties, long setting time (165 ± 5 min) and requirement of additional moisture for setting reaction.[5-7] Biodentine,[8] 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 and 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.[9,17] Previous studies proved its biocompatibility and the ability to induce odontoblast differentiation and mineralization in cultured pulp cells.[10] This study aimed to compare the sealing ability of super-EBA, glass ionomer cement (GIC), white-MTA, gray-MTA, biodentine.

Materials and Methods

100 extracted maxillary central incisors with completely formed apices and straight canals were selected for the study. They were cleaned by ultrasonic. Pre-operative radiographs were taken before access cavity. Teeth were sectioned at cementoenamel junction using diamond disc mounted on a micromotor straight handpiece. Access cavities were prepared by Endo access bur. 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. Apical portion of root canal was prepared to 50 no K-file. The rest of canal was flared using a conventional step-back technique. Sodium hypochlorite (3%) was used as the irrigant. The cleaned and shaped 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 resections were performed by removing 3 mm of each apex at 90°to long axis of teeth with cross-cut fissure bur 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.

The teeth were assigned into five groups of 20 teeth each.
Group 1: Retrofilled with GIC
Group 2: Retrofilled with super-EBA
Group 3: Retrofilled with white-MTA
Group 4: Retrofilled with gray-MTA
Group 5: Retrofilled with biodentine

Materials were mixed according to manufacturer's direction, cavities were filled using Messing's carrier. Roots were coated with 3 coats of nail varnish except at the tip and allowed to dry. Roots were stored in 1% solution of methylene blue for 72 hrs; after which roots were rinsed under tap water. The teeth were sectioned buccolingually using diamond disc. Depth of dye penetration was evaluated under stereomicroscope (Figures 1-5).

Scoring criteria (Tronstad *et al*. 1983)[1] for depth of dye penetration was as following:
Score 0: No leakage
Score 1: Marginal leakage not reaching retrograde cavity floor
Score 2: Leakage all around retrograde filling
Score 3: Leakage deeper than retrograde cavity floor

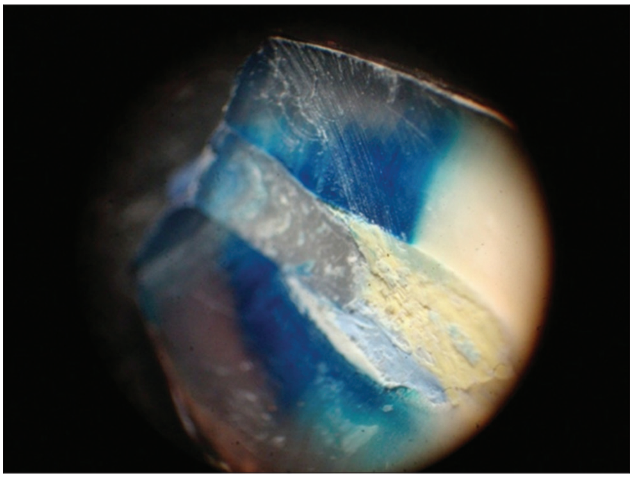

Figure 1: Stereomicroscopic view of Group 1 (glass ionomer cement).

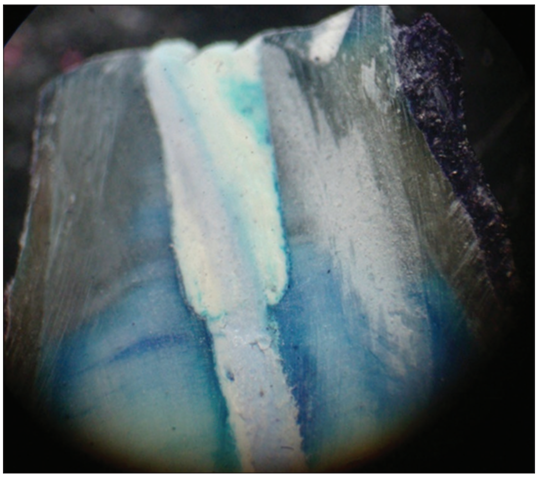

Figure 2: Stereomicroscopic view of Group 2 (super-ethoxy benzonic acid).

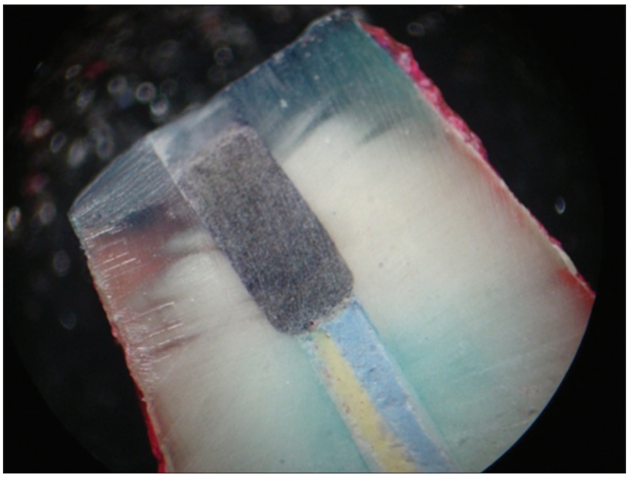

Figure 3: Stereomicroscopic view of Group 3 (gray-mineral trioxide aggregate).

Results

The statistical analysis was performed by Kruskal–Wallis ANOVA test (Table 1). Pair wise comparision was done by Mann–Whitney U-test (Table 2). Mean value for biodentine was 0.35. Mann–Whitney U-test indicates statistically significant difference when biodentine, white-MTA, gray-MTA were compared with GIC, super-EBA ($P < 0.05$). No significant difference was seen between MTA, biodentine ($P > 0.05$).

Discussion

The quality of apical sealing obtained by root end filling materials has been assessed in different ways such as degrees of dye penetration, bacterial penetration, electrochemical ways, and fluid filtration technique.[13] Dye penetration technique is the most frequent used method to evaluate sealing ability of dental materials. Methylene blue dye is widely used for convenience and its small molecular weight provides it with a high degree of penetrability. Despite their popularity, dye leakage studies have several disadvantages; molecular size of most dye particles is smaller than bacteria, most studies measure penetration in one plane rather than total leakage,

Table 1: Comparison of five groups with respect to micro-leakage by Kruskal–Wallis ANOVA test.

Group	Mean	SD	Median	Sum of ranks	*H* value	*P* value
Biodentin	0.35	0.58	0.00	583.60	46.181	0.000*
GIC	1.90	0.91	2.00	1420.20		
Super EBA	2.10	0.91	2.00	1505.60		
Gray MTA	0.60	0.68	0.50	741.00		
White MTA	0.70	0.733	1.00	799.60		

SD: Standard deviation, GIC: Glass ionomer cement, EBA: Ethoxy benzonic acid, MTA: Mineral trioxide aggregate, *: ???

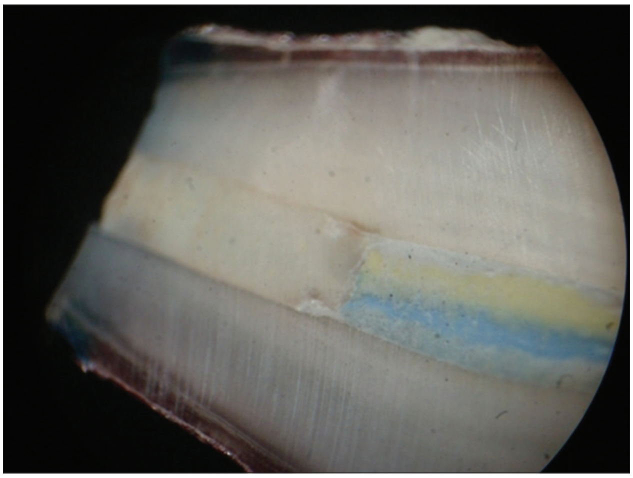

Figure 4: Stereomicroscopic view of Group 4 (white mineral trioxide aggregate).

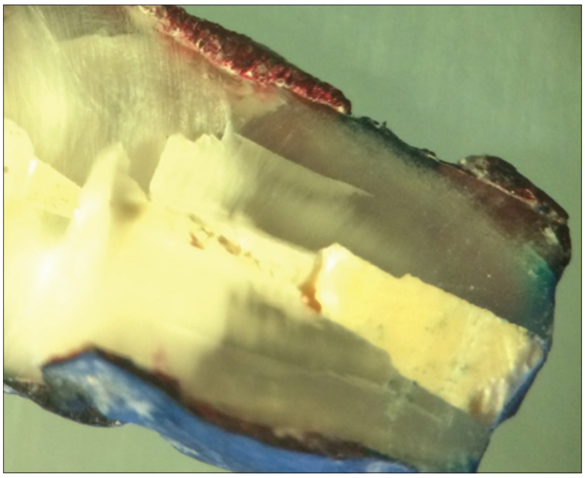

Figure 5: Stereomicroscopic view of Group 5 (biodentine).

Table 2: Pairwise comparison of five groups with respect to micro-leakage by Mann–Whitney *U*-test.

Group	Mean	SD	Median	Sum of ranks	*U* value	*Z* value	*P* value
Biodentin	0.35	0.58	0.00	247.50	37.5	−4.594	0.000*
GIC	1.90	0.91	2.00	572.50			
Biodentin	0.35	0.58	0.00	240.50	30.5	−4.779	0.000
Super-EBA	2.10	0.91	2.00	579.50			
Biodentin	0.35	0.58	0.00	369.00	159.0	−1.281	0.200
Gray-MTA	0.60	0.68	0.50	451.00			
Biodentin	0.35	0.58	0.00	356.50	146.5	−1.644	0.100
White-MTA	0.85	1.04	1.00	463.50			
GIC	1.90	0.91	2.00	174.0	174.00	−0.742	0.458
Super-EBA	2.10	0.91	2.00	384.00			
GIC	1.90	0.91	2.00	552.00	58.00	−4.000	0.000*
Gray-MTA	0.60	0.68	0.50	268.00			
GIC	1.90	0.91	2.00	542.00	68.00	−3.716	0.000*
White-MTA	0.85	1.04	1.00	278.00			
Super-EBA	2.10	0.91	2.00	564.00	46.00	−4.312	0.000*
Gray-MTA	0.60	0.68	0.50	256.00			
Super-EBA	2.10	0.91	2.00	556.00	54.00	−4.086	0.000*
White-MTA	0.85	1.04	1.00	264.00			
Gray-MTA	0.60	0.68	0.50	396.00	186.00	−0.416	0.677
Whit-MTA	0.85	1.04	1.00	424.00			

*P<0.01, **P<0.05. SD: Standard deviation, GIC: Glass ionomer cement, EBA: Ethoxy benzonic acid, MTA: Mineral trioxide aggregate

and they are static and do not reflect the dynamic interaction with periradicular tissues.[11,12] In this study, resection of root was performed at the depth of 3 mm to eliminate any lateral canals or apical ramifications. Resection at the depth of 3 mm reduces the apical ramifications by 98% and lateral canals by 93%.[12,29]

GIC with their dentin adhesive property, antibacterial activity, and mild cytotoxic effect has attracted the attention of many clinicians. To achieve chemical bonding of GIC to hard tissue of teeth it is essential to avoid moisture. This sensitivity to moisture is a fact that can't be neglected by clinicians who would like to use GIC as retrograde filling. A commonly used alternative is reinfoced zinc oxide eugenol based cement containing EBA that is super-EBA. Advantages are: Its adhesiveness to dentinal walls; It has been associated with formation of collagen fibers growing into and over its surface. Disadvantages are; moisture sensitivity; partial solubility in oral fluids, and technique sensitivity.[14] In the present study, sealing ability of super-EBA is found to be equal as that of GIC ($P = 0.458$). This finding is in contrast with study conducted by Wu *et al.*[18] he found that super-EBA leaked more than GIC. Clinically, super-EBA can be frustrating to handle, mixing is difficult. Super-EBA when freshly mixed and in an unset state is cytotoxic, but loses the cytotoxic effect as it ages.[30]

The results of the present dye leakage study showed that gray-MTA, white-MTA and biodentine provide better seal as root end filling material than super-EBA and GIC. These results are similar to previous leakage studies.[19-21] The reason may be the formation of the hydroxyapatite like crystals at the interface between material and canal wall due to which the material shows superior adhesion preventing the penetration of the dye and thus showed less microleakage.[25] However, the main disadvantages of MTA in a surgical setting are its difficult handling and long setting time,[5-7] possibly resulting in material wash out and disturbance of the apical seal. It is well recognized that with MTA as a root-end filling, one is not able to verify a set material before wound closure. Because root-end filling materials do not typically experience loading, the relatively long setting time should not be of concern. Moreover MTA is hydrophilic so it undergoes setting expansion when it is cured in moist environment, and thus the presence of moisture in the surgical field does not affect its setting or the properties.[26-28]

There was no statistically significant difference between gray-MTA and white-MTA when sealing ability was compared ($P = 0.677$). Fernando Accorsi *et al.* compared sealing ability of gray-MTA, and CPM sealer (which is a type of white-MTA) showed more leakage with CPM sealer.[21] Hamad *et al.* observed white-MTA behaved similarly with gray-MTA.[11] Al Hezaimi *et al.* showed more saliva leakage with white-MTA compared to gray-MTA. However, difference was not statistically significant.[22] The smaller particle size of white-MTA results in greater specific surface area, which causes an increase in the wetting volume, water-binding capacity and hydration rate. At the same water–powder ratio, white-MTA will be thicker with an increase in the cohesiveness; better workability is expected as compared to gray-MTA.[15,25]

The present study showed that biodentine produce less amount of microleakage compared to white-MTA, gray-MTA, but results are not statistically significant. This is in contrast to a study conducted by Pragna *et al.*[15] Previous studies proved the better sealing ability of biodentine.[16,31] The interfacial layer formed between biodentine and dentine may be compared to the hard tissue layer formed by ProRoot MTA.[9,23] Biodentine contains tricalcium silicate and zirconium particles of finer particle size. The rate of reaction of tricalcium silicate is higher for biodentine than MTA due to its optimized particle size distribution, the presence of calcium carbonate ($CaCO_3$) and the use of calcium chloride ($CaCl_2$).[8] The adhesion of Biodentine cement to dentin may result from the physical process of crystal growth within the dentinal tubules leading to micromechanical bonding.[23,24]

Conclusion

Within the limitations of the present study it can be concluded that biodentine and MTA showed less microleakage as compared to super-EBA and GIC. There is no significant difference between both forms of MTA and biodentine.

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