Apical Sealing Ability of Four Different Root End Filling Materials - An In-Vitro Study

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Abstract

Aims and Objective: The aim of this in-vitro study is to compare and evaluate the best sealing ability of four different root end filling materials i.e Reinforced ZOE (IRM), Glass Ionomer cement (GIC), Mineral trioxide aggregate (MTA) and Biodentine.

Material and Method: Eighty extracted human mandibular premolar were instrumented and obturated with gutta percha using lateral compaction technique. Following this, the teeth were stored in saline. After one week the teeth were apically resected & standardized root end cavities were prepared. The teeth were then randomly divided into 4 groups of 20 specimens each & were filled with Group – I: IRM, Group – II: GIC, Group – III: MTA and Group – IV: Biodentine . The samples were coated with varnish & after drying, they were immersed in 2% methylene blue dye for 72hrs. The teeth were then sectioned longitudinally. The depth of dye penetration was examined and microleakage associated with different root end filling materials was evaluated.

Results: Microlekage value was found to be significantly less in Biodentine compared to IRM, GIC and MTA.

Conclusion: On comparative evaluation of results of this in vitro study, it was concluded that IRM, GIC, MTA & Biodentine exhibited microleakage with Biodentine showing the least microleakage of all.

Keywords: IRM, MTA**,** Biodentine**,** Retrograde filling**,** Root end filling materials.

INTRODUCTION

The objective of modern dentistry is conservation of human dentition. Carious teeth are aimed at restorations, mutilated teeth are conserved by crown preparation and teeth with pulpal involvement are treated by endodontic treatment. There is success and failure in every field and the most common cause of failure involving endodontic therapy can be attributed to lack of apical seal leading to leakage at apex.

Effective endodontic obturation thus , must provide a dimensionally stable , inert fluid tight apical seal that will eliminate any portal of communication between the canal space and surrounding periapical tissue through the apical foramen.

When nonsurgical root canal treatment fails to treat periradicular lesions of endodontic origin or retreatment is not feasible, endodontic surgery may be indicated[1]. objective of periradicular surgery is to access the affected area, remove the diseased tissue ,evaluate the root circumference and root canal system and place a biocompatible seal in the form of root end filling that can stimulate regeneration of the periodontium [2].

The main objective of root end filling material is to provide an apical seal that prevents the movement of bacteria and diffusion of bacterial products from the root canal system into the periapical tissues. **Gartner and Dorn** proposed the ideal properties of a root end filling material. The material should be easy to manipulate, radiopaque , dimensionally stable, nonabsorbable, insensitive to moisture, adhesive to dentine, nontoxic and biocompatible [3,4,5].

Numerous material have been suggested for use as root end fillings including Gutta-percha, silver amalgam, intermediate restorative material(IRM) , super EBA, Diaket, glass ionomers, composite resins, Zinc oxide eugenol cements, MTA, & latest one Bio dentine. The quality of apical sealing obtained by different root end filling materials can be assessed in different ways such as dye penetration, bacterial penetration, electromechanical ways, fluid filtration technique etc[1,3,6].

Amalgam has been the most extensively used retro-filling material for past seven decades, but one of the first reports of placing it as a root-end filling subsequent to resection is attributed to Farrar (1894). Later Rhein (1897), Faulhaber & Neumann (1912), Hippels (1914) and Garvin (1919) extolled the use of root-end amalgam fillings.

IRM is zinc oxide eugenol cement modified by addition of 20% polymethyl methacrylate by weight to the powder. the effect of IRM as a root-end filling placed in teeth prior to replantation was observed by Pitt Ford et al in 1994 and the tissue response was found to be less severe than that to amalgam. Eugenol in IRM may have an affinity for poly methyl methacrylate which reduces its release into the tissues, thereby reducing the cytotoxicity.[7]

MTA contains tricalcium silicate, tricalcium aluminate, tricalcium oxide, silicate oxide and other mineral oxides forming a hydrophilic powder, which sets in presence of water. The resultant colloidal gel solidifies to a hard structure within 4 hours. Initially the pH is 10.2 which rises to 12.5 three hours after mixing. MTA provides superior seal when compared with Amalgam, IRM and Super EBA. [8]

More recently, a fast-setting calcium silicate-based restorative material especially designed for restorative dentistry has been brought onto the market (**Biodentine**, Septodont, St Maure des Foss´es, France). The main component of the powder is a tricalcium silicate, with the addition to the powder of dicalcium silicate, calcium carbonate, and a radioopaquer ZrO2. The liquid is a solution of CaCl2 with a water reducing agent.[13] This material exhibits the same excellent biological properties as MTA and can be placed in direct contact with dental pulp . It has been claimed to be a bioactive dentin substitute for the repair of root perforations, apexification and retrograde root filling by the manufacturers[9,10]

The purpose of this study is to evaluate the best sealing ability of four different root end filling material i.e GIC**,** IRM**,** MTA**,** Biodentine .

METHODOLOGY

Study samples

This was a comparative experimental study, which involved 80 extracted teeth (Permanent mandibular premolar teeth) consisting of four groups, each with 20 samples.

Specimen Preparation

Eighty extracted, caries free human teeth with intact apices and no previous endodontic treatment, were collected and were stored in isotonic saline containing 0.2% sodium azide (to inhibit microbial growth) at room temperature throughout the study. The external surfaces of teeth were cleaned with scalers to remove any gross debris and calculus deposits. The teeth were decoronated from the level of cementoenamel junction using a diamond disc (DFS, Germany) before root canal preparation. . Preoperative radiographs were taken and access cavities were prepared using an Endo Access Bur. The pulp tissue was extirpated with a barbed broach. A size 10 K- File (Dentsply Maillefer, USA) was used to confirm canal patency. The working length was determined with the help of radiographs.

Canal Preparation& Root Resectioning

Canals were cleaned and shaped. 3% sodium hypochlorite and 17% EDTA (META BIOMED, MD Chelcream) were used as irrigants. All the canals were enlarged upto No. 40 K- file (master apical file) at the apical foramen. The specimens were stored in normal saline until obturation. Canals were dried using absorbent paper points and master cone selection was confirmed with radiographs. Canals were obturated with gutta percha by lateral compaction technique. Radiographs were taken to confirm the quality of obturation and the access cavities were sealed with composite resin restorative material after 24 hours.

The teeth were then stored in saline for 1 week. They were resected apically at 90° angle to the long axis of the root using diamond disc (DFS, Germany) removing 3 mm of the apex. The cut surface was made without bevelling, to enhance measurement accuracy of the apical cavity depth. The 3 mm deep retrograde cavity was prepared using No. 2 round diamond bur (Mani, Japan) the cavities were irrigated with saline and dried. The teeth were randomly divided into 4 groups of 20 specimens each:

Fig 1: Sectioning the teeth from the level of cementoenamel junction

Fig 2: Specimen after sectioning the teeth from the level of cementoenamel junction

Fig 3: Resected specimen after coating with nail varnish

Grouping

The teeth were randomly divided into 4 groups of 20 specimens each according to four different cements used. Each sample were restored with different materials and the materials was manipulated according to manufacturer's recommendations. Samples were grouped as follows:

Group 1 - IRM

Group 2 - GIC

Group 3 - MTA,

Group 4 – Biodentine

Storage and Application of Nail Polish Over Root Surfaces

The samples were stored individually in screw capped vials in an incubator at 37° C for 48 hours. A water saturated cotton pellet were placed in each vial to assure 100% humidity. After removing the samples from the incubator, roots were covered with two layers of nail varnish . The second layer was applied after drying the first layer. The nail varnish was applied along all the surfaces except 1-2 mm around the retrograde fillings. The specimens were suspended in 2% methylene blue for 72 hours. Following this, the roots were rinsed for 15 minutes under tap water. The teeth were split longitudinally with a diamond disc using a water coolant. The depth of dye penetration in each tooth was assessed under 20X magnification with a stereomicroscope (Olympus SZ40) (Refer to Colour Plate 9) and microleakage associated with different root end filling materials was evaluated .

The 3 mm deep retrograde cavity was prepared using No. 2 round diamond bur (Mani, Japan). The teeth were randomly divided into 4 groups of 20 specimens each. Teeth in each group were retrofilled according to the restorative technique described in the previous chapter. Then nail varnish was applied and teeth were immersed in 2% methylene blue for 72 hours. The samples were then sectioned longitudinally and observed under a stereomicroscope (Olympus SZ40) with 20X magnification.

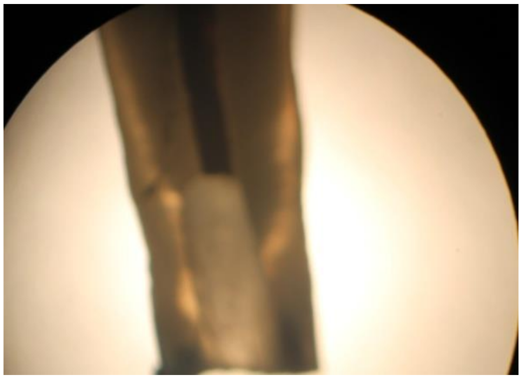


Fig 4: Microlekage with biodentine

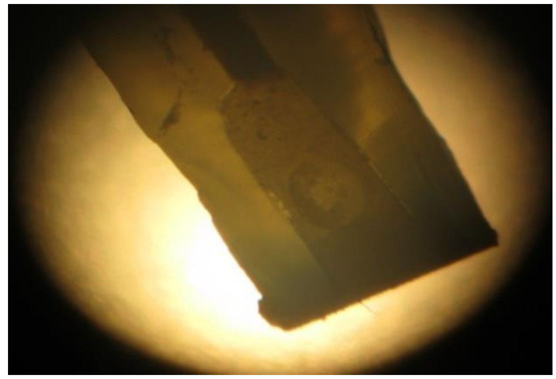


Fig 5: Microlekage with MTA

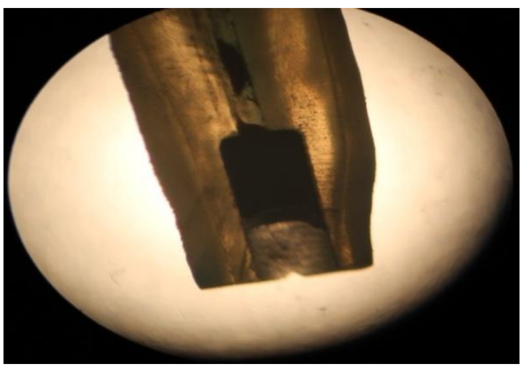


Fig 6: Microlekage with glass ionomer cement

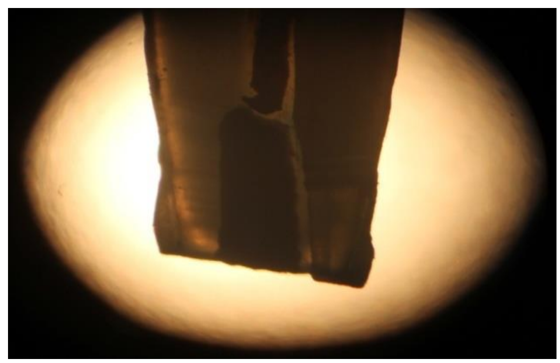


Fig 7: Microlekage with IRM

RESULTS

To determine statistically significant differences in leakage among four tested groups, data were analyzed using one-way Analysis of Variance test and statistical analysis were made using SPSS 19 software.

One Way Analysis of Variance (Refer to Table 1.)

It was done to detect any significant difference in microleakage in all groups. The microlekage value estimated for different groups were:

Table 1: Microlekage (in mm)

	N	Mean	Std. Deviation	Minimum	Maximum	P-Value	Significance
IRM	20	1.8100	.23611	1.31	2.31	.000	HS
GIC	20	1.5820	.22073	1.23	2.01		
MTA	20	.8950	.22265	.46	1.22		
BIODENTINE	20	.4975	.24723	.18	1.06		
Total	**80**	**1.1961**	**.57565**	**.18**	**2.31**		

Table 1 shows microleakage values for different groups. Comparison of microleakage showed an average leakage value of 0.4975 mm with a standard deviation of 0.24723 for Biodentine, 0.8950mm with a standard deviation of 0.2226 for MTA and 1.582mm with a standard deviation of 0.2207 for GIC and . and 1.810mm with a standard deviation of 0.2361 for IRM.

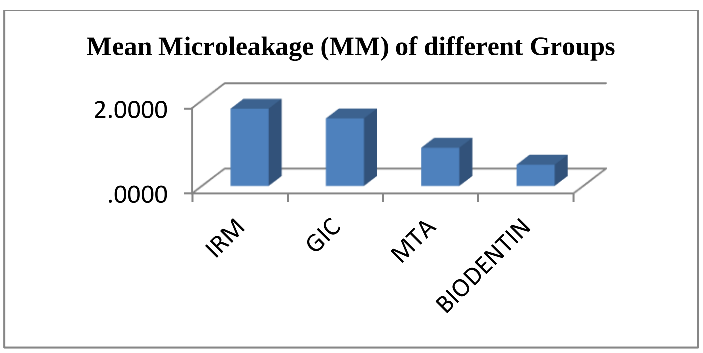
If the result is found to be significant ($p < 0.05$), then to identify the differences between the groups post-hoc test is carried out.

II) Post Hoc Tests

Table no. 2 **Multiple Comparisons**

(I) GROUP	(J) GROUP	Mean Difference (I-J)	P-Value	Significance
IRM	GIC	.22800	.003	HS
	MTA	.91500*	.000	HS
	BIODENTINE	1.31250*	.000	HS
GIC	IRM	-.22800	.003	HS
	MTA	.68700*	.000	HS
	BIODENTINE	1.08450*	.000	HS
MTA	IRM	-.93500*	.000	HS
	GIC	-.70300*	.000	HS
	BIODENTINE	.39400*	.000	HS
BIODENTINE	IRM	-1.32900*	.000	HS
	GIC	-1.09700*	.000	HS
	MTA	-.39400*	.000	HS
*. The mean difference is significant at the 0.05 level.				

Microlekage was found to be significantly less in biodentine compared to IRM , GIC., and MTA
Microlekage was found to be significantly less in MTA compared to IRM and GIC .
Significantl difference was found when microlekage in IRM was compared with GIC.



Graph 1: Mean microleakage scores for the four experimental groups

DISCUSSION

Apical surgery is performed in presence of persistent periradicular pathosis when orthograde endodontic treatment is unfeasible. Because some endodontic failure are due to inadequate cleaning of root canals and egress of antigen into periradicular tissues, a number of investigators have recommended placement of root end filling in teeth that require root end resection.[11]

To compare microlekage of different root end filling materials study can be carried out by conducting both in vitro and in vivo. But due to limitation with in vivo studies like larger number of specimen, time consumption in vitro study was performed.

Various methods have been employed to access the extent of microlekage of root end filling material like dye penetration, radioisotope penetration, bacterial penetration and electrochemical means and fluid filteration techniques.[8] The most frequently used technique is linear measurement of dye penetration. Although this technique presents the disadvantage of semi-quantitative analysis , often involving one plane of view, it is the easiest method to select new material.[12].

Studies reveal that IRM seals better than non zinc amalgam but it also has potential disadvantages including moisture sensitivity, irritation to vital tissues, solubility, and difficult in handling. IRM gave good results, but in clinical studies [13] the use of MTA as a root-end filling material resulted in a high success rate, better than that of IRM.

Glass ionomer cement is a material with universal properties. It is a dentin substitute, its ability to exhibit chemical bond to tooth structure provides an excellent marginal seal. Studies have shown that glass ionomer cement possesses antibacterial activity due to slow releases of fluorides[11,14]. Hence this was choosen in this study.

Adamo et al compared MTA, Super-EBA, composite and amalgam and found statistically no significant difference in the rate of microleakage but studies of Fischer et al [15] proved MTA to be superior as compared to super EBA and IRM .The marginal adaptation of MTA was better with or without finishing when compared to IRM and Super EBA

With the introduction of MTA several in vitro studies have indicated excellent sealing properties, and animal experiments have supported the biological biocompatibility of MTA.[8,16] Torabinejad et al suggested that MTA promotes healthy apical tissue formation more often than other materials, as confirmed by a lower incidence of inflammation.[8,17]

Despite its good physical, biological properties and it being hydrophilic in nature, MTA has some disadvantages such as long setting time and high cost. The search for alternative materials is aimed to reduce costs and to increase the feasibility to both professional and patient.[18,19]

Biodentine is similar to MTA in basic composition . The manufacturers claim that it's modified powder composition i.e the addition of setting accelerators and softeners, a new predosed capsule formulation for use in a mixing device largely improve the physical properties of the material making it more user-friendly.

Biodentine proves superior to MTA as it does not require a two step obturation & as the setting is faster there is a lower risk of bacterial contamination . [20]

As there is limited literature for Biodentine as a retrograde filling material the aim of this study was to compare its sealing ability with GIC , IRM & MTA

The results of this study showed that all materials exhibited microleakage but there was significantly less leakage in Biodentine (0.4975 mm) when compared to MTA (0.8950 mm) ,GIC (1.5820mm) and IRM (1.8100). These results obtained were similar with previously done studies on Glass Inomer Cement & MTA.[21]

In this study MTA shows less microlekage than IRM and GIC [22],which is in congruence with previous studies.[15,18,19,24]

SUMMARY AND CONCLUSION: Following conclusion are drawn from present study:

1. On comparative evaluation of results of this in vitro study, it was concluded that there is significantly less microlekage in Biodentine compared to MTA, IRM and GIC.
2. The above discussion on the basis of study concludes that Biodentine is the btter material as root end filling material in preventing microlekage.
3. This study was a humble effort to evaluate the sealing ability of the newly introduced material Biodentine. However, it is still open for further research not only for the sealing ability but also the related physical properties as well as critical manipulative steps.

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