Comparative Evaluation of Sealing Ability of Root End Filling Materials: An In-Vitro Study

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ABSTRACT

Introduction: One of the functions of a root-end filling material during periradicular surgery is to provide a fluid tight apical seal at the root apex, thereby sealing the periradicular tissues from egress of bacteria and bacterial by-products from infected root canals. For an ideal cavity there should be an ideal root end filling materials which should be loaded with ideal properties. A plethora of materials have been suggested for use as root end filling such as poly carboxylate cement, zinc phosphate cement, zinc oxide eugenol cement, IRM cement, Cavit, Glass ionomers, composite resins, gold foil and leaf, silver points, hydron, diaket root canal sealer, etc. **Aim:** The purpose of this in-vitro study was to compare and evaluate the best sealing ability of four different root end filling materials i.e. GIC, IRM, MTA Angelus and Biodentine using scanning electron microscope and stereomicroscope. **Materials and Method:** 80 extracted caries free, single-canal teeth were collected and were root canal treated using protaper system. Apical root resections followed by retrograde cavity preparation were done. The teeth were divided into 4 different groups and these groups were tested with 4 root end filling materials GIC, IRM, MTA Angelus and Biodentine. The data was analyzed by ANOVA and Post Hoc test. **Results:** Amongst all the groups, Group IV (Biodentine) showed with least width of gap values, whereas Group II (IRM) showed maximum values of gap amongst the tested samples. Group I (GIC) was better than Group II (IRM). Group III (MTA) was found to be better than Group I (GIC) and Group II (IRM). **Conclusion:** it was concluded that Biodentine exhibits best sealing ability followed by mineral trioxide aggregate, followed by glass ionomer cement, whereas intermediate restorative material exhibited least sealing ability.

KEYWORDS: Root end fillers, Glass Ionomer Cement, Interim Restorative material, Mineral Trioxide Aggregate.

INTRODUCTION

Carious teeth are aimed at restorations, mutilated teeth are conserved by crown fabrication and teeth with pulpal involvement are treated by endodontic treatment.[1] Effective endodontic obturation must provide a dimensionally stable, inert fluid tight apical seal that will eliminate any portal of communication between the canal space and the surrounding periapical tissues through the apical foramen. Conventional endodontic treatment is reported to succeed in 79%-96% of cases. If it fails, revision of the orthograde root filling should be considered. Endodontic approach is indicated when non surgical endodontic approach has failed to heal the lesion.

One of the functions of a root-end filling material during periradicular surgery is to provide a fluid tight apical seal at the root apex, thereby sealing the periradicular tissues from egress of bacteria and bacterial by-products from infected root canals. For an ideal cavity there should be an ideal root end filling materials which should be loaded with ideal properties. A plethora of materials have been suggested for use as root end filling such as poly carboxylate cement, zinc phosphate cement, zinc oxide eugenol cement, IRM cement, Cavit, Glass ionomers, composite resins, gold foil and leaf, silver points, hydron, diaket root canal sealer, titanium screws and teflons, lasers, calcium phosphate, castor oil polymer, super EBA, etc. The purpose of this in-vitro study was to compare and evaluate the best sealing ability of four different root end filling materials i.e. GIC, IRM, MTA Angelus and Biodentine using scanning electron microscope and stereomicroscope.[2,3]

MATERIALS & METHODS

This in-vitro study was conducted to compare and evaluate the best sealing ability of four different root end filling materials i.e. GIC, IRM, MTA Angelus and Biodentine using scanning electron microscope and stereomicroscope. Previously a pilot study was carried out in the same department to overview the proper study design and to take care of the possible constraints during the main study.

Preparation of the Samples: Eighty extracted, caries free human teeth with intact apices and no previous endodontic treatment were collected and stored in normal saline. The teeth were radiographed to determine the

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existence of a single relatively straight canal and teeth were excluded if radiographs demonstrated multiple canals or pulpal obliteration. The periodontal remnants were removed with 5.25% NaOCl for 10 minutes. The crowns were sectioned at the cementoenamel junction using a diamond disk under constant water irrigation to a standardize length of 15mm. Collection, storage, sterilization and handling of extracted teeth followed the Occupational Safety and Health Administration (OSHA) recommendations and guidelines.

Root Canal Preparation: After determination of the working length, Gates Glidden drills were used for coronal flaring and the canals were shaped using the Protaper rotary system till F4. The canals were flushed with 2 ml of 5.25% NaOCl solution during the instrumentation after each change of file. Smear layer was removed using 5 ml of 17% EDTA for 1 min followed by 5 ml of 5.25% NaOCl. The canals were obturated using lateral compaction technique and AH plus sealer. Following obturation, the gutta percha was removed with a warm instrument and vertically condensed with hand pluggers. To obtain coronal seal access cavities were restored with composite resin.

Apical Root Resection & Retrograde Cavity Preparation: The apical 3mm of each root was resected with diamond disk at angle of 0°. An apical cavity of 3mm depth and 1 mm diameter was made in each root with ultrasonic retro tip (S12-70D, P15RD, Satelac) in a Venus ultrasonic device set at Endo mode and at lowest power setting of 2 MHZ and depth was checked using a William's graduated probe. Afterwards the tooth specimens were randomly divided equally into 4 groups of 20 each, depending upon the restorative material to be used for retrograde restoration. Restorative materials were manipulated according to manufacturer's recommendations.

Samples were grouped as follows:

Group 1: Roots retro filled with Glass Ionomer Cement, GC Fuji II placed with a plastic instrument and tamped down with hand pluggers.

Group 2: Roots retro filled with Intermediate Restorative material, IRM placed with a plastic instrument, tamped down with hand pluggers and finished with diamond finishing bur at high speed after setting.

Group 3: Roots retro filled with Mineral Trioxide Aggregate, MTA Angelus mixed (in a 3:1 powder to water ratio in sterile water) and incrementally placed using an amalgam carrier. The material was then compacted with hand pluggers and burnished with a ball burnisher to remove excess material and improve adaptation. These samples were allowed to set in moist gauze for 2 hours.

Group 4: Roots retro filled with Biodentine**,** placed with plastic instrument and gently puddled in the cavity with it.

Method of Evaluation: The samples were stored individually in screw capped vials in an incubator at 37° C for 48 hours. A water saturated cotton pellet was placed in each vial to assure 100% humidity.

All samples (n=80) were then randomly assigned into two halves (n=40) depending upon the method employed for evaluating marginal adaptation/ micro leakage of material. Forty samples were evaluated for marginal adaptation using SEM and remaining forty samples were evaluated for micro leakage assessment using stereomicroscope.

Statistical Analysis: The data obtained was statistically analyzed with ANOVA for pair wise comparison between different retro filling material groups. Post Hoc test was applied for multiple comparisons between different retro filling materials. The results were regarded highly significant if $p < 0.001$ and non-significant if $p > 0.05$.

RESULTS

Scanning Electron Microscope Evaluation: The results revealed gaps (in µm) were present in all groups between root dentin and retro filling material (Table 1) Amongst all the groups, Group IV (Biodentine) showed with least width of gap values, whereas Group II (IRM) showed maximum values of gap amongst the tested samples. Group I (GIC) was better than Group II (IRM). Group III (MTA) was found to be better than Group I (GIC) and Group II (IRM) but less efficient than Group IV (Biodentine) Group IV (Biodentine) was best amongst all (Table 3),(Figure 1,3).

	GROUP I (GIC)	GROUP II (IRM)	GROUP III (MTA)	GROUP IV (Biodentine)
1	2.82µm	4.48µm	1.22µm	0.96µm
2	2.81µm	4.72µm	1.10µm	1.02µm
3	2.56µm	4.42µm	1.10µm	0.98µm
4	2.54µm	4.54µm	1.20µm	1.02µm
5	2.98µm	4.75µm	1.10µm	1.00µm
6	2.77µm	4.78µm	1.22µm	1.06µm
7	2.82µm	4.65µm	1.14µm	0.99µm
8	2.84µm	4.43µm	1.10µm	1.02µm
9	2.52µm	4.43µm	1.10µm	1.00µm
10	2.72µm	4.38µm	1.20µm	1.02µm

Table 1: sem analysis depicting gap (in µm) between root end filling materials and surrounding dentin

	GROUP 1 (GIC)	**GROUP II (IRM)**	**GROUP III (MTA)**	**GROUP IV (Biodentine)**
1	2.0mm	2.8mm	1.00mm	0.9mm
2	2.1mm	3.0mm	1.00mm	0.7mm
3	2.3mm	2.6mm	1.00mm	0.9mm
4	1.9mm	2.5mm	1.10mm	0.9mm
5	1.8mm	2.7mm	1.20mm	0.9mm
6	2.0mm	2.7mm	1.00mm	0.9mm
7	1.9mm	3.0mm	1.10mm	1.0mm
8	2.2mm	2.7mm	1.10mm	1.0mm
9	1.9mm	3.0mm	1.00mm	0.9mm
10	1.9mm	2.5mm	1.10mm	0.8mm

TABLE 2: stereomicroscope analysis depicting linear microleakage (in mm) from apical root end

Stereomicroscope Evaluation: The results reveal that all the root end filling materials showed microleakage (Table 2). Amongst all the groups compared, Group IV

Multiple Comparisons , Dependent Variable: SEM ANALYSIS BONFERRONI						
(I) GROUP I	**(J) GROUP I**	**Mean Difference (I-J)**	**Std. Error**	**Sig.**	**95% Confidence Interval**	
					Lower Bound	**Upper Bound**
1	**2**	-1.820(*)	0.054	<0.001**	-1.982	-1.677
	3	1.590(*)	0.054	<0.001**	1.420	1.726
	4	1.731(*)	0.054	<0.001**	1.568	1.873
2	**1**	1.820(*)	0.054	<0.001**	1.677	1.982
	3	3.410(*)	0.054	<0.001**	3.250	3.556
	4	3.551(*)	0.054	<0.001**	3.398	3.703
3	**1**	-1.590(*)	0.054	<0.001**	-1.726	-1.420
	2	-3.410(*)	0.054	<0.001**	-3.556	-3.250
	4	0.141	0.054	0.058	-0.005	0.300
4	**1**	-1.731(*)	0.054	<0.001**	-1.873	-1.568
	2	-3.551(*)	0.054	<0.001**	-3.703	-3.398
	3	-0.141	0.054	0.058	-0.300	0.005
* The mean difference is significant at the 0.05 level.						

Table 3:- Mean difference of SEM analysis and multiple comparisons of various groups by using Post Hoc Test

Multiple Comparisons, Dependent Variable: MICROLEAKAGE, Bonferroni						
(I) GROUP I	**(J) GROUP I**	**Mean Difference (I-J)**	**Std. Error**	**Sig.**	**95% Confidence Interval**	
					Lower Bound	**Upper Bound**
1	**2**	-0.750(*)	0.062	<0.001**	-0.964	-0.615
	3	0.940(*)	0.062	<0.001**	0.765	1.114
	4	1.110(*)	0.062	<0.001**	0.935	1.284
2	**1**	0.750(*)	0.062	<0.001**	0.615	0.964
	3	1.690(*)	0.062	<0.001**	1.555	1.904
	4	1.860(*)	0.062	<0.001**	1.725	2.074
3	**1**	-0.940(*)	0.062	<0.001**	-1.114	-0.765
	2	-1.690(*)	0.062	<0.001**	-1.904	-1.555
	4	0.170	0.062	0.060	-0.004	0.344
4	**1**	-1.110(*)	0.062	<0.001**	-1.284	-0.935
	2	-1.860(*)	0.062	<0.001**	-2.074	-1.725
	3	-0.170	0.062	0.060	-0.344	0.004
* The mean difference is significant at the 0.05 level.						

TABLE 4: Mean difference on Stereomicroscopic analysis and multiple comparisons of various groups by using Post Hoc Test.

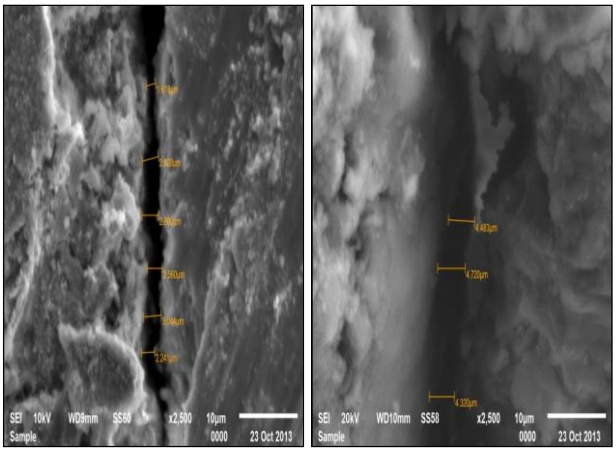
(Biodentine) showed least dye penetration values, whereas Group II (IRM) showed maximum dye penetration values amongst tested samples.Group I (GIC) was found to be significantly better than Group II (IRM).Group III (MTA) was found to be better than Group I (GIC) and Group II (IRM) but less efficient than Group IV (Biodentine)Group IV (Biodentine) was best amongst all(TABLE4) (FIGURE 2,4).

DISCUSSION

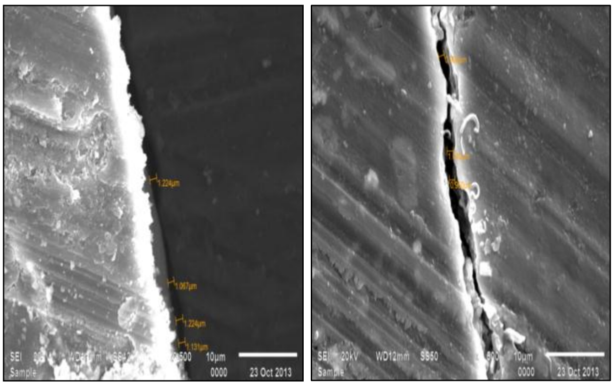
The purpose of placing a retrograde seal after apicoectomy is to establish an effective barrier between the root canal and the periapical tissues when a conventional orthograde seal is not possible. An ideal root end filling material would adhere and adapt to the walls of root end preparation, prevent leakage of microorganisms and their toxins into the periradicular tissues, be biocompatible, be insoluble in tissue fluids and dimensionally stable and remain unaffected by the presence of moisture.[4-6]

Solubility is a very important factor in assessing the suitability of potential substances to be used as restorative materials in dentistry. Lack of solubility has also been stated as an ideal characteristic for root end filling materials. It seems logical that lesser leakage would prevent migration of bacteria and toxins into the periradicular tissue.[7-9]

The probable reasons for better marginal adaptation and less micro leakage seen in GIC in comparison with IRM can be attributed to the chemical binding of GIC to the tooth structure. The probable reasons for better marginal adaptation and less micro leakage of MTA in comparison with GIC is because MTA has superior marginal sealing ability resulting from its hydrophilic properties and formation of interfacial layer between material and dentin. It was found that further hydration of MTA powder by moisture can result in increase in compressive strength and decreased leakage. The probable reasons for better marginal adaptation and less micro leakage seen in Biodentine in comparison to GIC may be attributed to formation of tag like structures composed of Calcium or Phosphate rich crystalline deposits which increases over time hence minimizing the gap between tooth and retro filled material.[9,10]

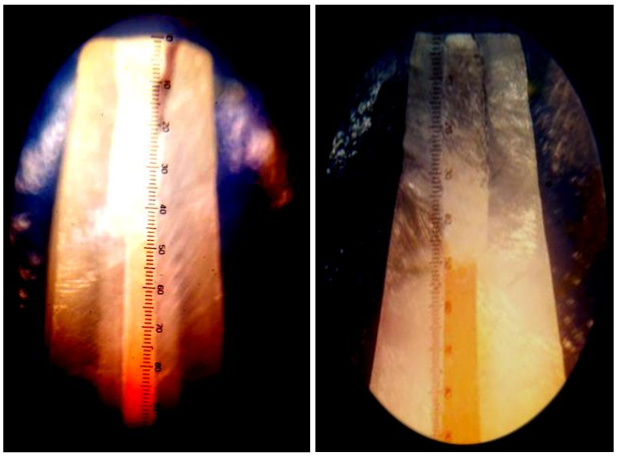


GROUP I (GIC) GROUP II (IRM)

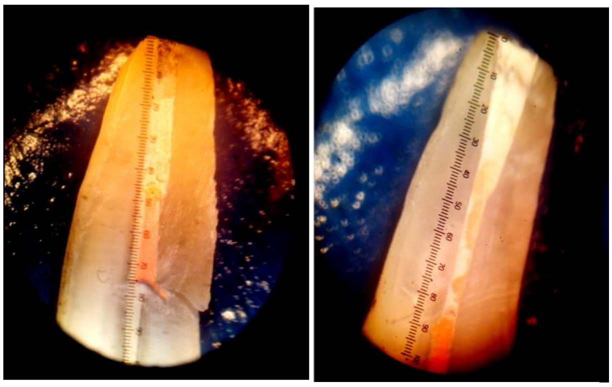


GROUP III (MTA) GROUP IV (Biodentine)

Fig 1: photographs of the apical third of group i, ii, iii & iv as observed under sem at the magnification of 2500 x



GROUP I (GIC) GROUP II (IRM)



GROUP III (MTA) GROUP IV (Biodentine)

Fig 2: photographs of the apical thirds of group i, ii, iii & iv as observed under stereomicroscope at 10 x

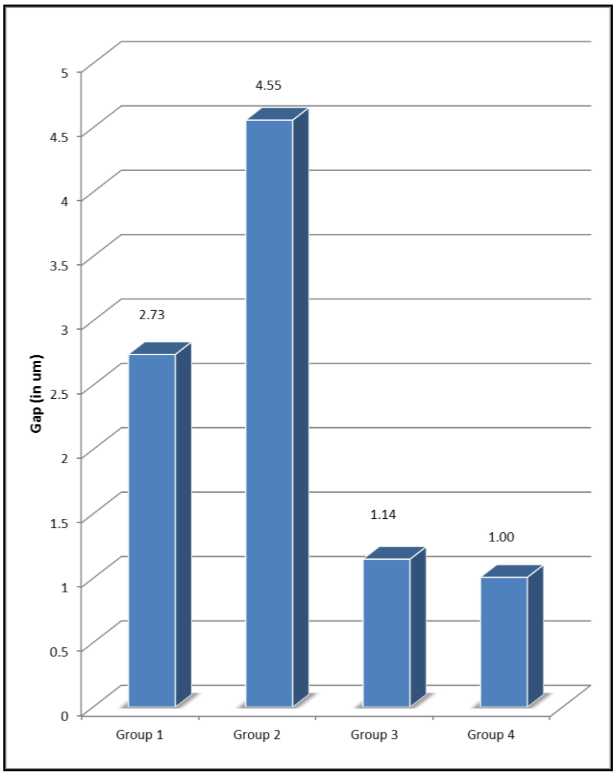


Figure 3- bar diagram showing mean values (in µm) of sem analysis depicting gap between root end filling materials and surrounding dentin

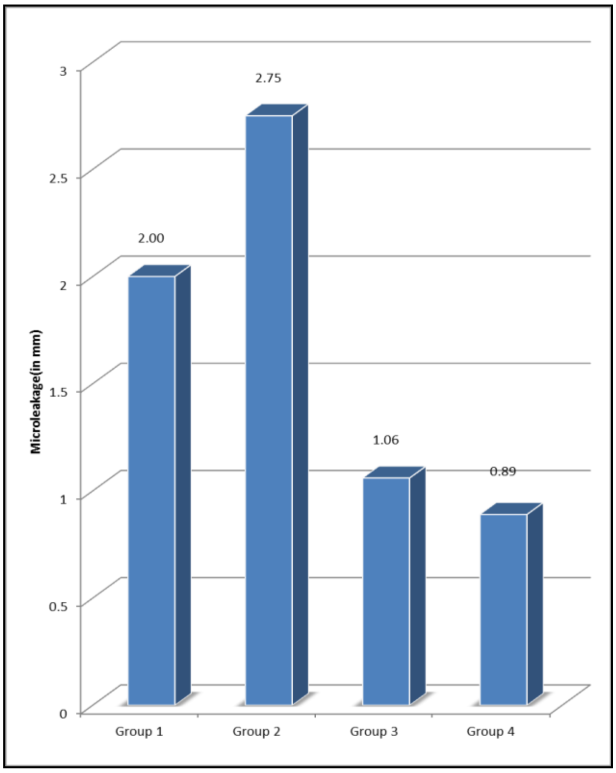


Figure 4- bar diagram showing mean values (in mm) of stereomicroscope analysis depicting linear microleakage from apical root end

MTA releases calcium ions and promotes an alkaline pH. These calcium ions diffuse through the defects in the dentin and its concentration increases with time. There is production of hydroxyapatite when calcium ions released by MTA comes into contact with tissue fluid or moisture, hence provide better sealing ability.[11,12]

CONCLUSION

This in vitro study was done to evaluate the effectiveness of newer root end filling materials versus the older ones in relation to their sealing ability. Eighty maxillary central incisors were selected, decoronated to a standardized root length of 15mm and prepared using Protaper rotary files up to size F4. The teeth were then randomly divided into 4 groups of 20 teeth each and filled with retro filling materials, Group I: Glass Ionomer Cement, Group II: Intermediate Restorative Material, Group III: Mineral Trioxide Aggregate, and Group IV: Biodentine. The teeth were sectioned and forty samples were observed under scanning electron microscope (SEM) and remaining forty samples were observed under stereomicroscope. No material tested in this study was capable of providing a complete leak proof seal. Based on the results obtained from the present study, it was concluded that Biodentine exhibits best sealing ability followed by mineral trioxide aggregate, followed by glass ionomer cement, whereas intermediate restorative material exhibited least sealing ability. Newer root end filling materials proved better than older ones but statistically the difference between MTA and Biodentine is non-significant.

To conclude, the effectiveness of the 4 root end filling materials is in the following decreasing order:

Biodentine ≥ MTA > GIC > IRM

Therefore the search for newer materials is aimed to reduce costs and to increase the feasibility of both professional clinician and patient.

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