

Comparative evaluation of microleakage of various retrograde filling materials: An *in vitro* study

Virat Galhotra,
Anjali Sofat¹,
Inder K. Pandit²,
Ramandeep Singh
Gambhir³,
Nikhil Srivastava⁴,
Neeraj Gugrani²

Department of Pedodontics and Preventive Dentistry, ¹Department of Prosthodontics, ³Department of Public Health Dentistry, Gian Sagar Dental College and Hospital, Rajpura, Punjab, ²Department of Pedodontics and Preventive Dentistry, D.A.V. Dental College and Hospital, Yamunagar, Haryana, ⁴Department of Pedodontics and Preventive Dentistry, Subharti Dental College and Hospital, Meerut, Uttar Pradesh, India

Address for correspondence:

Dr. Virat Galhotra, Gian Sagar Dental College, Rajpura - 140 601, Punjab, India.
E-mail: docvirat@gmail.com

Abstract

Objective: The present study is envisaged to evaluate and compare the microleakage of mineral trioxide aggregate (MTA) with commonly used retrograde filling materials, like light-cured composite with dentin-bonding agents, light-cured glass ionomer cement (LC GIC) and resin-modified zinc oxide eugenol. **Materials and Methods:** Ninety freshly extracted non-carious single-rooted human anterior teeth were used in the study. They were randomly divided into four experimental groups and two control groups of 15 each. Following the biomechanical preparation, all teeth were obturated and then the apices of the obturated teeth were resected by removing 3 mm of each apex at 90° to the long axis of the tooth with a straight fissure bur in a high-speed air-rotor handpiece with water coolant. A 3-mm-deep root end cavity was prepared and the root end fillings were placed as per the manufacturer's instructions and according to the groups divided. The samples were then immersed in 1% methylene blue at room temperature for 72 h, 96 h and 1 week and the dye penetration was measured. **Results and Conclusion:** All the four materials used in the study showed some microleakage throughout the experimental period. The sealing ability in terms of microleakage can be summarized as: *MTA > Composite resin with dentin bonding agent > LC GIC > Resin modified zinc oxide eugenol*.

Key words: Comparison, microleakage, retrograde, sealing ability

INTRODUCTION

The success of endodontics demands careful attention to case selection, which should be followed by meticulous management of canal preparation, sterilization and obturation.^[1] The primary aim of obturating a root canal is to achieve a perfect hermetic seal between the pulp space and the periradicular area. When this hermetic seal cannot be obtained through an orthograde filling, a surgical procedure is conducted to place a retrograde root filling

to prevent leakage of irritants from the root canal into the periradicular tissues, and vice versa.^[2]

The materials used for this procedure, ideally, should have the best sealing ability with no microleakage and they should also possess properties like biocompatibility with periradicular tissues, should be non-resorbable, non-toxic, dimensionally stable, impervious to dissolution or breakdown by the tissue fluids and capable of being adapted as closely as possible to the dentinal walls of the root end preparation exhibiting no/or minimal microleakage so as to prevent penetration of tissue fluids into root canal or leakage of microorganisms and/or their toxins through the apical foramina into the surrounding tissues. In addition, it should be electrochemically active, easy to manipulate and radioopaque.^[3]

Various materials are flooded in the market that claim their supremacy regarding microleakage, e.g., Direct filling gold, Silver-amalgam, Glass ionomer cement, Light cure glass

Access this article online	
Quick Response Code:	Website: www.jnsbm.org
	DOI: 10.4103/0976-9668.117014

ionomer cement (LC GIC), Composite, Super-ethoxy benzoic acid Super-ethoxy benzoic acid (EBA), Zinc oxide eugenol, Cavit, Gutta-percha, etc.^[4-11] None so far has been declared ideal and only recommendations have been made on what appeared to be the best tolerated and clinically successful material.

Mineral trioxide aggregate (MTA) is one of the recent innovations in dentistry that has multiple uses/applications, including as a retrograde filling material. Torabinejad *et al.* studied the sealing ability of a MTA when used as a root end filling material, and they concluded that leakage with MTA was significantly less compared with other root end filling materials.^[12]

The present study is envisaged to evaluate and compare the microleakage of MTA and other commonly used retrograde filling materials, e.g., LC GIC, composite and resin-modified zinc oxide eugenol, using the dye penetration method.

MATERIALS AND METHODS

Ninety freshly extracted non-carious single-rooted maxillary and mandibular human anterior teeth were collected and stored in saline. Clinical crowns were sectioned at the cemento-enamel junction using a high-speed air-rotor handpiece. The working length was determined by subtracting 0.5 mm from the length at which a no. 15 K file appeared at the apical foramen. The root canal was biomechanically prepared by using the step-back technique and obturated with gutta percha using the lateral condensation technique.

Roots were then stored at 37°C in an incubator at 100% humidity for 1 week. The apices of the obturated teeth were resected by removing 3 mm of each apex at 90° to the long axis of the tooth with a straight fissure diamond bur in a high-speed air-rotor handpiece with water coolant. A 3-mm-deep root end cavity was prepared. The prepared teeth were randomly divided into four experimental groups of 15 teeth each and two control groups of 15 teeth each. Each group was further divided into three subgroups of five teeth. The root end fillings, i.e., light-cured composite with-dentin bonding agents, LC GIC, resin-modified zinc oxide eugenol and MTA, were placed as per the

manufacturer's instructions and according to the groups divided.

Samples of each group (except negative control) were coated with two coats of nail polish to the whole surface of the total length of each root except the tip of the root where the retrograde filling was applied. Roots with no retrograde preparation and with two coats of nail polish all over the tip were selected as negative control.

The samples were then immersed in 1% methylene blue at room temperature for 72 h, 96 h and 1 week [Table 1]. The teeth were then sectioned buccolingually and were fractured with the help of osteotome and mallet.

The sections with the retrograde filling were then examined under a travelling microscope (×10 magnification manufactured by quality apparatus) to evaluate for dye penetration. The extension of dye penetration was measured in millimeter.

Statistical analysis

The data collected accordingly were tabulated accordingly and statistically analyzed. The data were analyzed statistically using an analysis of variance (ANOVA) test and Student *t*-test. ANOVA was used to test for equality of several means of microleakage in the various groups. The *P* value was taken as significant at *P* < 0.05.

RESULTS

Mean microleakage of various retrograde filling materials is shown in Table 2. The mean scores of MTA at 72 h, 96 h and 1 week were 0.78 mm, 0.90 mm and 1.0 mm, respectively. One-way ANOVA and Student's *t* test showed that MTA exhibited the least microleakage throughout the 1 week time interval as compared with the other test materials [Tables 3, 4 and 5]. Graphic representation showing least microleakage is shown in the form of bar graphs [Figures 1 and 2].

DISCUSSION

Microleakage has been defined as the passage of ions,

Table 1: Division of samples

Group no	Group I			Group II			Group III			Group IV			Group V			Group VI		
Materials	MTA			LC GIC			LC composite			Resin modified zinc oxide eugenol			Positive control			Negative control		
Subgroups	IA	IB	IC	IIA	IIB	IIC	IIIA	IIIB	IIIC	IVA	IVB	IVC	VA	VB	VC	VIA	VIB	VIC
Microleakage assessed at	72 h	96 h	1 week	72 h	96 h	1 week	72 h	96 h	1 week	72 h	96 h	1 week	72 h	96 h	1 week	72 h	96 h	1 week

MTA: Mineral trioxide aggregate, LC GIC: Light-cured glass ionomer cement

Table 2: Mean micro leakage (in mm) at various time intervals

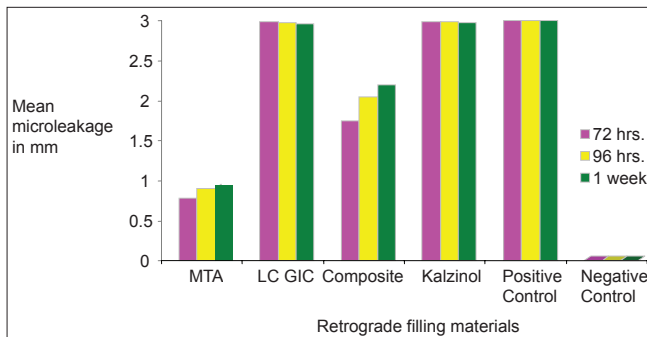
Group	Mean micro leakage (in mm)		
	72 h	96 h	1 week
I (MTA)	0.78	0.90	1.00
II (LC GIC)	2.98	2.97	2.97
III (Composite)	1.74	2.04	2.20
IV (Resin modified zinc oxide eugenol)	2.98	2.99	2.96
V (Positive control)	3.00	3.00	3.00
VI (negative control)	0.00	0.00	0.00

MTA: Mineral trioxide aggregate, LC GIC: Light-cured glass ionomer cement

Table 3: Comparison of means of microleakage with different retrograde materials at 72 h

Group	t value	P value
I:II	11.577	<0.05
I:III	1.902	>0.05
I:IV	11.533	<0.05
II:III	2.647	<0.05
II:IV	0.156	>0.05
III:IV	2.638	<0.05
I:V	(-) 11.7022	<0.05
II:V	(-) 0.9994	>0.05
III:V	(-) 2.6829	=0.05
IV:V	(-) 1.0005	>0.05
I:VI	4.1116	<0.05
II:VI	186.380	<0.05
III:VI	3.7151	<0.05
IV:VI	149.0712	<0.05

P<0.05 (highly significant), P: 0.05 (significant), P>0.05 (non-significant)

**Figure 1: Lowest mean microleakage in the mineral trioxide aggregate group in comparison to other groups at different time intervals**

molecules, fluids or bacteria between the cavity wall and the applied restorative material. It has been reported to cause failure of endodontic treatment.^[13]

Mineral trioxide aggregate

The mean microleakage of MTA increased with increase in time period, but this increase in microleakage was found to be non-significant. This was in accordance with the study done by Bates *et al.*,^[14] who determined the longitudinal sealing ability of the MTA as a root end

Table 4: Comparison of means of microleakage with different retrograde materials at 96 h

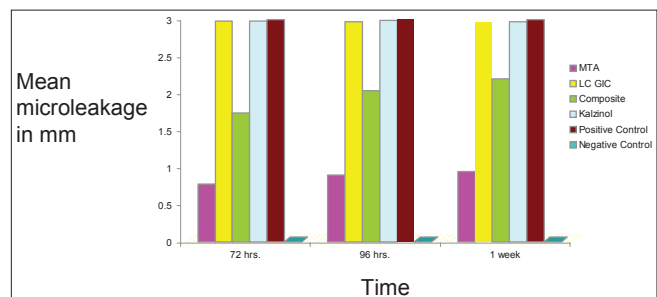
Group	t value	P value
I:II	12.519	<0.05
I:III	2.661	0.05
I:IV	12.806	<0.05
II:III	2.359	<0.05
II:IV	0.557	>0.05
III:IV	2.411	<0.05
I:V	(-) 12.9146	<0.05
II:V	(-) 0.9997	>0.05
III:V	(-) 2.4420	>0.05
IV:V	(-) 1.0012	>0.05
I:VI	5.5348	<0.05
II:VI	98.9735	<0.05
III:VI	5.1576	0.05
IV:VI	249.3049	<0.05

P<0.05 (highly significant), P: 0.05 (significant), P>0.05 (non-significant)

Table 5: Comparison of means of microleakage with different retrograde materials after 1 week interval

Group	t value	P value
I: II	58.701	<0.05
I: III	4.131	<0.05
I: IV	43.654	<0.05
II: III	2.660	<0.05
II: IV	0.146	>0.05
III: IV	2.625	<0.05
I: V	(-) 74.2137	<0.05
II: V	(-) 1.5007	>0.05
III: V	(-) 2.7704	=0.05
IV: V	(-) 1.0000	>0.05
I: VI	37.2183	<0.05
II: VI	148.5710	<0.05
III: VI	7.6186	<0.05
IV: VI	82.3317	<0.05

P<0.05 (highly significant), P: 0.05 (significant), P>0.05 (non-significant)

**Figure 2: A significant variation between the materials and a non-significant variation at different time intervals**

filling material and found almost similar microleakage results with MTA throughout 2 weeks. The potent sealing ability of MTA was probably due to its hydrophilic nature and slight expansion, which might have occurred on being cured in a moist environment. This was further supported by Torabinejad *et al.*,^[12] who concluded that hydration of the powder might have resulted in formation

of the colloidal gel that solidified to a hard structure in less than 4 h. Least microleakage was shown by MTA in the present study, which is also in accordance to some other study conducted in Brazil.^[15]

Light-cured composite resin with a dentin bonding agent

The mean microleakage values for composite increased with time period, but this increase in microleakage was found to be non-significant. This potent sealing ability of composite with dentin bonding agent could be because the contraction gaps that formed between the composite resin and the dentin walls during polymerization might have been sealed by a resin impregnation technique.^[16,17]

Light-cured glass ionomer cement

The mean microleakage values of LC GIC slightly decreased at 96 h and further slightly increased at 1 week interval. The results were found to be non-significant. The high value of dye leakage with LC GIC could be explained by the fact that cement might have well adapted to one cavity wall but the gaps might have been developed on the other cavity wall, resulting in microleakage. Chong *et al.*^[6] confirmed the above fact and suggested that polymerization contraction probably contributed to this phenomenon.

Resin-modified zinc oxide eugenol

The results of the study indicated an increase in the mean microleakage values at all the time intervals, and this increase was found to be non-significant. This could be due to the development of larger gaps as a result of marginal deterioration and moisture contamination during the procedure, leading to increased dye leakage. It is also possible that resin-modified zinc oxide eugenol, which is reinforced with polystyrene, might have suffered marginal breakdown resulting in its poorer sealing ability.^[18] Positive control possessed maximum microleakage among the experimental materials. A positive control was required so as to ensure that our experiment was showing true results. Roots with no retrograde filling in the retrograde cavities were selected as positive control.^[19] The mean microleakage of positive control remained constant at all the time intervals.

Negative control roots with no retrograde preparation and with two coats of nail polish all over the tip were selected as negative control to ensure that microleakage around the experimental materials was not just because of errors in retrograde filling. Aqrabawi^[19] emphasized the importance of taking a negative control during the dye leakage test.

Intergroup comparisons

Mineral trioxide aggregate versus composite resin with dentin bonding agent

At 72 h, Student *t* test showed that the MTA (Group I) was

highly significant when compared with the other groups, except Group II (Composite resin with dentin bonding agent), although it demonstrated less microleakage than composite, which is also in accordance with some other study.^[20]

The comparative sealing ability of composite resin at 72 h could be explained on the basis that the contraction gaps between composite resin and dentinal walls might have been formed during polymerization, which might have been sealed by the resin impregnation technique, leading to less microleakage values. MTA also showed expansion on setting in moisture, leading to comparable microleakage values. At 96 h and 1 week, one-way ANOVA analysis and Student *t* test showed a statistically significant difference in the microleakage values of MTA and composite resin with dentin bonding agent, and this could be due to increase in polymerization shrinkage of the composite resin with time.

Mineral trioxide aggregate versus light cured glass ionomer cement

The Student *t*-test showed a highly significant relation between MTA and LC GIC throughout 1 week. The high value of dye leakage with LC GIC could be explained by the fact that cement was well adapted to one cavity wall but the gaps were observed on the other cavity wall. Chong *et al.*^[6] suggested that polymerization contraction probably contributed to this phenomenon. On the other hand, MTA might have exhibited expansion while setting, leading to least microleakage.

Mineral trioxide aggregate versus resin modified zinc oxide eugenol

Resin-modified zinc oxide eugenol also showed significantly more microleakage than MTA when compared using the Student *t*-test. This could be because of disintegration of resin-modified zinc oxide eugenol with time. Resin-modified zinc oxide eugenol might have suffered marginal breakdown, contributing to its poorer sealing ability.^[18] In contrast to our finding, Bates *et al.*^[14] in their study found that microleakage of MTA was almost similar to Super-EBA, which is also a zinc oxide eugenol-reinforced cement. This could be because of the difference in components used for reinforcement and variation in methodology.

Light cured glass ionomer cement versus composite resin with dentin bonding agent

The microleakage results of composite when compared with LC GIC using Student's *t*-test showed a highly significant difference in microleakage throughout the 1 week time interval. LC GIC might have resulted in gap formation toward one cavity wall, resulting in a greater amount of microleakage.^[6,16,21]

Composite resin with dentin bonding agent versus resin modified zinc oxide eugenol

Resin-modified zinc oxide eugenol exhibited more microleakage than composite, and this difference was statistically significant ($P < 0.05$). This could be explained on the basis that resin-modified zinc oxide eugenol might have suffered marginal breakdown and resultant poor sealing.^[18] Some other study also demonstrated that composite with dentin bonding agent showed the least amount of leakage as compared with a zinc oxide eugenol-based cement.^[22]

Light cured glass ionomer cement versus resin modified zinc oxide eugenol

No statistical difference was found between LC GIC and resin-modified zinc oxide eugenol using the Student *t*-test, although LC GIC exhibited less microleakage. A similar finding was reported by Chong *et al.*^[18] This could be because of marginal breakdown of resin-modified zinc oxide eugenol and high polymerization shrinkage of LC GIC. However, Alhadainy and Himel^[23] reported less dye penetration for LC GIC followed by Cavit – a zinc oxide eugenol-based cement. According to them, the superiority of glass ionomer was because of its ability to adhere to dentin. In addition, LC GIC had good flow property that helped it seal the apical end of the furcal perforation.

Materials versus positive control

Highly significant results were found when the microleakage values for MTA and composite resin (except LC GIC and resin-modified zinc oxide eugenol) were compared using one-way ANOVA analysis and Student's *t*-test. The positive control group received no retrograde root filling in the retrograde root cavities. But, when LC GIC and resin-modified zinc oxide eugenol were compared with the positive control, although the mean values for microleakage with LC GIC and resin-modified zinc oxide eugenol were less, the difference found was non-significant. This could again be due to marginal breakdown of resin-modified zinc oxide eugenol and high polymerization shrinkage of LC GIC.

Materials versus negative control

Similarly, when MTA was compared with the negative control group using Student's *t*-test, a highly significant relation was found. The negative control group did not allow any microleakage as the tip was also coated with two coats of nail polish. This was done to confirm that the experiment performed under standard conditions was showing true results.

CONCLUSION

- All the four materials used in the study showed some microleakage throughout the experimental period
- Of the four materials used, MTA displayed minimum

microleakage while microleakage with resin-modified zinc oxide eugenol was found to be maximum

- LC GIC and resin-modified zinc oxide eugenol displayed almost similar values for dye leakage
- Except LC GIC, all the materials showed a constant non-significant increase in microleakage on being aged from 0 h to 1 week
- LC GIC showed an initial increase in microleakage till 72 h, which decreased at the end of 96 h, and again increased at 1 week, although these variations were statistically non-significant
- Thus, the sealing ability in terms of microleakage can be summarized as:

$MTA > Composite\ resin\ with\ dentin\ bonding\ agent > Light\ cured\ glass\ ionomer\ cement > Resin\ modified\ zinc\ oxide\ eugenol.$

REFERENCES

1. Schilder H. Filling root canals in three dimensions. 1967. J Endod 2006;32:281-90.
2. Friedman S. Retrograde approaches in endodontic therapy. Endod Dent Traumatol 1991;7:97-107.
3. Gartner AH, Dorn SO. Advances in endodontic surgery. Dent Clin North Am 1992;36:357-78.
4. Dorn SO, Gartner AH. Retrograde filling materials: A retrospective success-failure study of amalgam, EBA, and IRM. J Endod 1990;16:391-3.
5. Barkhordar RA, Pelzner RB, Stark MM. Use of glass ionomers as retrofilling materials. Oral Surg Oral Med Oral Pathol 1989;67:734-9.
6. Chong BS, Pittford TR, Watson TF. Evaluation of a light cured glass ionomer cement with a conventional glass ionomer cement and amalgam. Int Endod J 1991;24:223-32.
7. Rud J, Rud V, Munksgaard EC. Retrograde root filling with dentin-bonded modified resin composite. J Endod 1996;22:477-80.
8. Bondra DL, Hartwell GR, MacPherson MG, Portell FR. Leakage *in vitro* with IRM, high copper amalgam, and EBA cement as retrofilling materials. J Endod 1989;15:157-60.
9. Pitt Ford TR, Andreasen JO, Dorn SO, Kariyawasam SP. Effect of various zinc oxide materials as root-end fillings on healing after replantation. Int Endod J 1995;28:273-8.
10. Pitt Ford TR, Andreasen JO, Dorn SO, Kariyawasam SP. Effect of IRM root end fillings on healing after replantation. J Endod 1994;20:381-5.
11. Dalal MB, Gohil KS. Comparison of silver amalgam, glass ionomer cement and gutta percha as retrofilling materials, an *in vivo* and an *in vitro* study. J Indian Dent Assoc 1983;55:153-8.
12. Torabinejad M, Watson TF, Pitt Ford TR. Sealing ability of a mineral trioxide aggregate when used as a root end filling material. J Endod 1993;19:591-5.
13. Yavuz I, Aydin H, Ulku R, Kaya S, Tumen C. A new method: Measurement of microleakage volume using human, dog and bovine permanent teeth. Electron J Biotechnol 2006;9:8-17.
14. Bates CF, Carnes DL, del Rio CE. Longitudinal sealing ability of mineral trioxide aggregate as a root-end filling material. J Endod 1996;22:575-8.
15. Valera MC, Camargo CH, Carvalho AS, Gama ER. *In vitro* evaluation of apical microleakage using different root-end filling materials. J Appl Oral Sci 2006;14:49-52.
16. Danin J, Linder L, Sund ML, Strömberg T, Torstenson B, Zetterqvist L. Quantitative radioactive analysis of microleakage of four different retrograde fillings. Int Endod J 1992;25:183-8.

17. Torstenson B, Brännström M. Composite resin contraction gaps measured with a fluorescent resin technique. *Dent Mater* 1988;4:238-42.
18. Chong BS, Pitt Ford TR, Watson TF, Wilson RF. Sealing ability of potential retrograde root filling materials. *Endod Dent Traumatol* 1995;11:264-9.
19. Nicholson J. Mineral trioxide aggregate-a new experimental material for retrograde filling. *British Dent J* 2000;188:259.
20. Adamo HL, Buruiana R, Schertzer L, Boylan RJ. A comparison of MTA, Super-EBA, composite and amalgam as root-end filling materials using a bacterial microleakage model. *Int Endod J* 1999;32:197-203.
21. Leonard JE, Gutmann JL, Guo IY. Apical and coronal seal of roots obturated with a dentine bonding agent and resin. *Int Endod J* 1996;29:76-83.
22. Pameijer CH, Wendt SL Jr. Microleakage of "surface-sealing" materials. *Am J Dent* 1995;8:43-6.
23. Alhadainy HA, Himmel VT. Evaluation of the sealing ability of amalgam, Cavit, and glass ionomer cement in the repair of furcation perforations. *Oral Surg Oral Med Oral Pathol* 1993;75:362-6.

How to cite this article: Galhotra V, Sofat A, Pandit IK, Gambhir RS, Srivastava N, Gugnani N. Comparative evaluation of microleakage of various retrograde filling materials: An *in vitro* study. *J Nat Sc Biol Med* 2013;4:403-8.

Source of Support: Nil. **Conflict of Interest:** None declared.

Dispatch and return notification by E-mail

The journal now sends email notification to its members on dispatch of a print issue. The notification is sent to those members who have provided their email address to the association/journal office. The email alerts you about an outdated address and return of issue due to incomplete/incorrect address.

If you wish to receive such email notification, please send your email along with the membership number and full mailing address to the editorial office by email.