

## Apical and Coronal Microleakage using Mineral Trioxide Aggregate (Comparative Study)

**Dr. Jamal Aziz Mahdi** B.D.S. M.Sc.

The purpose of this study was to evaluate the potential of using mineral trioxide aggregate (MTA) as a root canal filling material by comparing its apical sealing ability with that of laterally condensed gutta-percha with sealer in extracted one canal teeth. In addition, this study was evaluating the MTA and ZnPo<sub>4</sub> cement as barriers to coronal microleakage.

Forty single canal extracted teeth, were prepared in a standard manner using GT file, randomly divided into two groups of 20 teeth, and obturated with laterally condensed gutta-percha or MTA.

In each group, 10 teeth received a 4-mm barrier of MTA or ZnPo<sub>4</sub> cement. The sealing ability of each part was assessed by immersion in 1% methylene blue dye for 72 h. The leakage was recorded in apical and coronal part. Data were analyzed by One-Way ANOVA test, T-test, and LSD test.

Canal filled with laterally condensed gutta-percha showed significantly less apical dye penetration than canals obturated with MTA. However, coronal barrier filled with MTA showed significantly less dye penetration than ZnPo<sub>4</sub> cement barrier.

**Key words:** MTA, Apical microleakage, Coronal barrier.

### Introduction

One of the objectives of a successful endodontic treatment is the total obturation of the root canal system. To achieve this, the root canal filling must seal the canal space both apically and coronally to prevent the ingress of microorganisms or tissue fluids into the canal space. Apical leakage is considered a common reason for the clinical failure of endodontic therapy (1). Likewise, coronal leakage is also reported to be an important reason for failure (2,3). Many studies have indicated that leakage, whether apical or coronal, adversely affects the success of root canal therapy. Therefore, leakage studies on sealers remain important and necessary to determine the most suitable materials and to gain more understanding of the factors influencing the sealing properties.

Many filling materials have been used in root canal therapy in an attempt

to achieve success. The material most commonly recommended for obturation is gutta-percha combined with a sealer. Gutta-percha is considered an impermeable core material; therefore, leakage through an obturated root canal is expected to take place at the interfaces between sealer and dentin or sealer and gutta-percha, or through voids within the sealer. Hence, the sealing quality of a root canal filling depends much on the sealing ability of the sealer (4).

A review of a large number of published leakage studies points to general agreement that leakage occurs between the root filling and the root canal walls (5,6). Therefore, any thing that may influence the adaptation of the root filling to the canal wall is of great significance in determining the degree and the extent of leakage, and ultimately the prognosis of the endodontic therapy. Cold lateral condensation is widely used to obturate root canals and has been

considered for years to be the standard by which other obturation methods are judged, but some authors (7) have reported that it produces voids that may remain empty or be filled by sealer that may resorb in time and decrease the effectiveness of the root canal obturation (8).

Leakage studies have shown that the loss of the coronal seal provides a route for bacterial recontamination of endodontically treated teeth (9). A lack of the coronal seal may lead to endodontic failure (10). Coronal microleakage might be the major cause of non surgical endodontic failure (3). Delay in placement of a permanent restoration, fracture of the coronal restoration and/or tooth, in adequate thickness of the temporary restoration, and preparation of the post space with inadequate remaining apical filling are potential means of coronal recontamination of obturated root canals (3). In addition, recurrent caries and restorations within adequate margins may result in coronal leakage (11). The technical quality of the coronal restoration was conducted to be significantly more important than the technical quality of the endodontic treatment for periapical health, based on the radiographic evaluation of more than 1000 endodontically treated and restored teeth (10).

A variety of restorative materials have been used in an attempt to produce a coronal barrier with varying results and lack of agreement between the studies (12). One of these materials, Mineral Trioxide Aggregate (MTA) has been evaluated for a wide variety of application (13). These include pulp capping, apical barrier, perforation repair, and root end filling material. In addition, the use of MTA as an orthograde root-filling material has been suggested (14). One reason that MTA has gained attention is its superior ability to resist leakage (15).

Such behavior may be explained by superior marginal adaptation of MTA (16). The purpose of this study was to evaluate the potential of using MTA as a root canal filling material and coronal barrier by comparing its sealing ability.

## Materials and Methods

Forty, extracted single canal, human teeth were used in this study. The teeth were stored in 0.2% thymol solution immediately after extraction. All teeth were carefully debrided of any soft tissue with periodontal curette and decoronated of 3mm above the cemento-enamel junction using high speed fissure burs and water spray. An access opening was prepared using a high speed hand piece and a #2 round bur with a constant water spray. A #10 file was used to establish working length and maintain patency. Working length was determined by measuring the length at which a #10 file was first visible at the apical foramen and subtracting 1.0mm. The canals were instrumented with 0.08 to 20 GT rotary files to working length (Dentsply Tulsa Dental). During instrumentation, each canal was irrigated with a total of 5ml of 5.25% sodium hypochlorite. Canals were dried with paper points. The forty teeth were randomly placed into one of two groups, each group of 20 teeth.

In group I, a master gutta-percha cone was fitted to within 0.5mm of the working length and removed. The canal walls were coated with Dorifil sealer (Dorident, Austria) using lentulo spiral. The tip of the master cone was coated with sealer and resealed. Obturation was completed using a standard lateral condensation technique, excess gutta-percha was removed from the coronal portion of the root canal with a warm instrument, and the material was vertically compacted.

In group II, 1g of Pro Root MTA (Dentsply, Tulsa, OK) powder was mixed with 0.35g of the supplied root canal repair material water per the manufacturer's instructions. This mixture was applied to the canal walls using lentulo spiral until the material reached the canal orifice, because pilot work demonstrated that this technique produced the most consistently radio dense canal fills. Master gutta-percha was then placed into the canal to within 2mm of the working length to facilitate retreatment. Any apically extruded MTA was removed flush with the apical foramen. Excess gutta-percha and MTA cement was removed from the coronal portion of the root canal. In all the forty teeth, the coronal aspect of the gutta-percha and the pulp chamber was adjusted to terminate 4 mm apical to the level of decoronation as measured by a periodontal probe, the coronal 4 mm of the pulp was cleaned of gutta-percha and sealer with alcohol-moistened pellet, rinsed with sterile saline, and dried with air stream.

The twenty teeth of the group I were divided into 2 experimental groups of 10 teeth. In group (Ia), 10 teeth received a 4 mm barrier of MTA, in group (Ib), 10 teeth received a 4 mm barrier of zinc phosphate cement (Dorident, Austria). All materials were mixed to manufacturers instructions. MTA was placed using a messing Gun and condensed with a #5/7 endodontic plugger. MTA was leveled with the coronal root surface using a moist cotton pellet. The same procedure was done for the group II.

All teeth were wrapped in wet gauze, placed in closed individual vials, which were placed in an incubator at 37<sup>0</sup>C for 24h to allow for a complete set of the barrier materials. The teeth were then covered with a two

layers of fingernail varnish so that only the apical foramen and the coronal surface remained exposed. All specimens were immersed in 1% methylene blue dye for 72h. After removal from the dye, the roots were rinsed in tap water and the fingernail varnish was completely removed by scraping with a number II scalpel. After removal of nail varnish, the teeth were longitudinally sectioned in a bucco-lingual direction using a low-speed diamond wheel under constant water lubrication.

Dye penetration was measured in millimeters in both sites apically and coronally, using a calibrated stereomicroscope. One examiner, who had knowledge of the treatment, analyzed the sections. The section that had the greatest depth of dye penetration was used as the final score for that specimen. The results were tabulated, and the mean value for each group was calculated. Statistical significant differences were established using ANOVA, T-test and LSD test.

## Result

The extended of dye leakage in millimeter, the means, and the standard deviations for each group are listed in table (I). All experimental groups demonstrated dye leakage. Data for apical leakage were subjected to a one-way ANOVA test. The differences in the median values among the groups were found to be statistically highly significant (table II). The T-test showed no significant difference between paired subgroups (table III) in coronal microleakage. The LSD test exhibited that ZnPo<sub>4</sub> cement group significantly more leakage than MTA group (table IV) in coronal microleakage.

**Table I : Descriptive statistics**

Groups	No.	Minimum	Maximum	Mean	Std. Dev.
<b>Gr.I</b>	20	0.5	2.2	1.3	0.1163
<b>Gr.II</b>	20	2.9	5.0	3.8	0.1103
<b>Gr.Ia</b>	10	0.3	1.8	1.02	0.1718
<b>Gr.Ib</b>	10	0.8	2.3	1.51	0.1683
<b>Gr.IIa</b>	10	0.4	1.9	0.99	0.1703
<b>Gr.IIb</b>	10	0.7	2.2	1.49	0.1441

**Table II: ANOVA Test**

Source of variation	Sum of sq.	Df	Mean Sq.	F.	Prob.	Significant
<b>Between Measures</b>	62.5000	1	62.5000	336.4023	0.000	H.S.
<b>Residual</b>	3.5300	19				
<b>Total</b>	66.0300	20				

**Table III: T-Test between paired sample groups**

Groups	t	df	Sig.	
<b>Gr.Ia Vs. Gr.IIa</b>	0.519	9	0.616	N.S.
<b>Gr.Ib Vs. Gr.IIb</b>	0.480	9	0.642	N.S.

**Table IV: LSD test**

Groups	t	df	Sig.	
<b>Gr.Ia Vs. Gr.Ib</b>	-7.869	9	0.000	H.S.
<b>Gr.IIa Vs. Gr.IIb</b>	-5.441	9	0.000	H.S.

## Discussion

Microleakage in the root canal is a complex subject because many variables may influence leakage, such as root filling techniques, the physical and chemical properties of sealers, and smear layer. When evaluation a new root canal sealer, analysis of its sealing ability under the different conditions is therefore, very important. Use of chemically active, adhesive root canal sealers may play an important role in minimizing both apical and coronal leakage. Therefore, root canal sealers must be examined for their ability to minimize both leakage (17).

Root canal filling materials are intended to prevent microorganism and toxins in the canal from passing along the root canal space and into the periradicular tissues (1). Difficulty obliterating accessory canals, fins, anastomoses, apical deltas, and other irregularities of the root canal space

and failure to adequately seal the apical foramen have been reported to account for a large percentage of root canal space occurs, the ability to obtain an adequate seal is further compromised by the irregular shape and increased size of the area to be sealed. Clinical support for the use of MTA as an obturating material, however, was presented in a case report by O Sullivan et al (19), in which MTA was used as the obturating material for the root canal system of a retained primary second molar. At the four-month follow up, the patient was a symptomatic, clinical finding were within normal limits, and there was evidence of radiographic healing.

MTA was compared with gutta-percha because gutta-percha is the root canal filling material must commonly used today. The present study demonstrated a significant difference in the apical seal produced by lateral

condensation when compared with MTA. This result was surprising given the numerous studies reporting that MTA is an effective root-end filling material (16,20).

MTA powder consists of fine hydrophilic particles that set in the presence of moisture. Hydration of the powder results in a colloidal gel that solidifies to a hard structure in less than 4 h (21). In the present study, the MTA was mixed according to the manufacturer's directions and allowed to set in 100% humidity for 24 h. After that time period, the set of the material was confirmed by probing the MTA at the apical foramen with a No. 16 endodontic explorer, which was found to be brick hard. It was, however, impossible to determine the depth of set of the cement. MTA is not usually used in bulk; therefore, it's possible that some of the mid root material deep to either the coronal or apical ends of the canal remained unset due to its lack of exposure to water for the setting hydration reaction, affecting the seal. Root-end filling studies, therefore, may not be comparable to root canal filling studies due to the disparity in preparation depths and resultant material thickness. We did, however, place a master gutta-percha point to within 2 mm of the working length in the MTA group to facilitate retreatment. This should have effectively reduced the MTA to a thickness comparable to a root end filling.

Amalgam, intermediate restorative material (IRM), TERM, glass-ionomers, resin-bonded cements, and recently, MTA have been tested for their ability to prevent microleakage when used as a barrier to augment the coronal seal (2,9,22).

All studies differ in methodological design, making comparison difficult. In this study, extracted intact teeth were used and a thickness of 4 mm of

restorative material inserted. It has been reported (23) that a minimum of 3.5-4 mm of restorative material is necessary to prevent microleakage, however, clinically a 4-5 mm thickness of temporary restorative material cannot always be achieved, in particular not in severely broken-down teeth requiring endodontic therapy.

Placing a root canal orifice plug (13) offers an advantage over sealing the pulp chamber floor (3), because it can also be placed in canals prepared for post space. If retreatment becomes indicated, the 2-4 mm plug can be easily removed. Torabinejad and Chivian (13) suggested the use of MTA for this purpose, based on the materials proven sealing ability against microbial penetration. MTA was found to be suitable for use as an orifice plug. It was easily manipulated and compacted into the canal orifices. One disadvantage of MTA is the lengthy setting time and the moisture required to enhance setting. This suggests that restoration of the tooth cannot be performed immediately after the placement of the MTA plug.

The present study demonstrated a highly significant difference in the coronal seal produced by MTA when compared with ZnPo<sub>4</sub> cement. This came in agreement with Torabinejad et al (21) who investigate the sealing ability of MTA as root-end filling material after root end amputation. MTA allowed significantly less dye penetration than the other materials. In addition, this study came in agreement with Lee et al (24) who compared the sealing ability of MTA for repair of experimentally induced root perforations in extracted teeth. The results showed that MTA allowed significantly less leakage and overfilling tendency.

To date, the relationship between dye penetration and the success of endodontic treatment is not clear.

Information provided by passive dye leakage techniques such as we employed does not include the volume of tracer that penetrates and is thus only semi quantitative. Multiple factors such as the size of the dye molecules, the immersion time, presence or absence of a smear layer, can make comparisons between studies difficult (6).

Under the conditions of our study, the apical seal produced by traditional gutta-percha techniques was superior to that produced by MTA. The coronal seal produced by MTA was superior to that produced by ZnPo<sub>4</sub> cement. As MTA has proven successful in numerous other clinical applications, further investigation should be conducted to determine whether MTA itself or the technique for its placement could be modified for use as a root canal filling material in perforated roots.

## References

- 1- Cohen S, Burns RC. Pathways of the pulp. 8<sup>th</sup> ed. St. louis: CV Mosby Co, 2002: 183.
- 2- Madison S, Swanson K, Chiles SA. An evaluation of coronal microleakage in endodontically treated teeth, Part II: Sealer types. *J Endodon* 1987;13:109-12.
- 3- Saunders WP, Saunders EM. Coronal leakage as a possible cause of failure in root canal treatment: a review. *Endod Dent Traumatol* 1994; 10:105-8.
- 4- Wu MK, DeGee AJ, Wesselink PR. Leakage of four root canal sealers at different thickness. *Int Endod J* 1994; 27: 304-8.
- 5- Hovland EJ, Dumsha YC. Leakage evaluation in vitro of the root sealer sealapex. *Int Endod J* 1986; 19:21-8.
- 6- Wu MK, Wesselink PR. Endodontic leakage studies reconsidered, Part I : Methodology, application and relevance. *Int Endod J* 1993; 26: 37-43.
- 7- Brayton SM, Davis SR, Goldman M. Gutta-percha root canal fillings. An in vitro analysis. *Oral Surg Oral Med Oral Pathol* 1973; 35: 226-31.
- 8- Peter DD. Two-year in vitro solubility evaluation of four gutta-percha sealer obturation techniques. *J Endod* 1986; 12: 139-45.
- 9- Torabinejad M, Ung B, Kettering J. In vitro bacterial penetration of coronally unsealed endodontically treated teeth. *J Endod* 1990; 16:566-9.
- 10- Ray HA, Trope H. Periapical status of endodontically treated teeth in relation to the technical quality of the root filling and the coronal restoration. *Int Endod J* 1995; 28:12-8.
- 11- Wolanek GA, Loushine RJ, Weller RN. In vitro bacterial penetration of endodontically treated teeth coronally sealed with a dentin-bonding agent. *J Endod* 2001; 27:354-7.
- 12- Wells JD, Pashely DH, Pereira PN. Intra coronal sealing ability of two dental cements. Clinical applications of MTA. *J Endod* 1999; 25: 197-206.
- 13- Torabinejad M, Chivian N. Clinical applications of MTA. *J Endod* 1999; 25: 197-206.
- 14- Wallis EA, Browning DF, Hsu GHR, Roland DD, Torabinejad M. Microleakage of resected MTA *J Endod* 2003; 28:573-4.
- 15- Torabinejad M, Rastegar AF, Kettering JD, Pittford TR. Bacterial leakage of MTA as a root-end filling material. *J Endod* 1995; 21: 109-13.
- 16- Torabinejad M, Smith PW, Kettering JD, Pittford TR. Comparative investigation of marginal adaptation of MTA and other commonly used root-end filling materials. *J Endod* 1995; 21: 295-9.
- 17- Funda KC, Necdet A, Sema B. Evaluation of the influence of smear layer on the apical and coronal sealing ability of two sealers. *J Endod* 2004; 6: 406-9.
- 18- Dow PR, Ingle JJ. Isotope determination of root canal failure. *Oral Surg* 1955; 8: 1100-4.
- 19- O'Sullivan S, Hartwell GR. Obturation of a retained primary mandibular second molar using MTA: A case report. *J Endod* 2001 27: 703-5.
- 20- Luccy CT, Weller RN, Kulild JC. An evaluation of the apical seal produced by lateral and warm lateral condensation technique. *J Endod* 1990; 16: 170-2.
- 21- Torabinejad M, Watson TF, Pittford TR. Sealing ability of a MTA when used as a root end filling material. *J Endod* 1993; 19: 591-5.
- 22- Barthel CR, Strobach A, Roulet JF. Leakage in roots coronally sealed with different temporary fillings. *J Endod* 1999; 25: 731-4.
- 23- Turner JE, Anderson RW, Pashley DH. Microleakage of temporary endodontic restoration in teeth restored with amalgam. *J Endod* 1990; 16: 1-4.
- 24- Lee SJ, Monsef M, Torabinejad M. Sealing ability of a MTA for repair of lateral root perforations. *J Endod* 1993; 19: 541-4.