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An In Vitro Dye Penetration Study: Evaluating Apical Sealing Ability of Mineral Trioxide Aggregate Compared to Intermediate Restorative Material

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ABSTRACT

Background: The root-end filling establishes an `apical seal' to prevent the passage of micro organisms and their products into the periapical tissues. The quality of apical seal obtained by various root-end filling materials has been assessed by several methods like dye penetration, radioisotopes, bacterial leakage, electrochemical method, fluid filtration technique, and marginal adaptation.[1] This *in vitro* study compared the apical sealing ability of two common root end filling materials namely mineral trioxide aggregate (MTA) and intermediate restorative material (IRM) using dye penetration method.

Method and Methods: Single rooted maxillary anterior human teeth were used in this study. Apical 3 mm of the roots were cut at 90 degree to the long axis of tooth and a three-mm-deep cavity was prepared using an ultrasonic instrument Forty four such maxillary anterior teeth was used for the study. The samples were divided into two experimental groups (*n*=20) according to the root-end filling material including MTA and IRM and two negative and positive control groups (*n*=2). All these teeth were suspended in 1% methylene blue dye at room temperature for 72 hours, the roots were sectioned and dye penetration measured by using stereomicroscope. The sealing abilities of these materials were determined by their ability to inhibit dye penetration.

Result: The study comes with outcome that Intermediate restorative material showed maximum mean leakage when used as a root-end filling material as compared to Mineral trioxide Aggregate.

Conclusion: The Mineral trioxide aggregate is more effective as compared to IRM which showed poor sealing abilities.

Keywords: Mineral trioxide aggregate, Intermediate restorative material.

INTRODUCTION

Endodontic failures though rare but may occur due to incomplete cleaning of root canal system and consequently penetration of bacteria and other pathogens into the periradicular tissues. The complexity of root canal systems, inadequate instrumentation and presence of physical barriers may necessitate surgical endodontic therapy in some cases. When non-surgical attempts prove unsuccessful or are contraindicated, surgical endodontic therapy is needed to save the tooth. The exposed root canal may be treated from the apical retrograde direction by means of a simple filling -

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the root-end filling or by retrograde obturation of the entire root canal. It has been reported that the apical seal is the most important factor in achieving success in surgical endodontics.[3, 4]

It becomes therefore the prime necessity to use materials that will create fluid tight seal between the root canal system and the periapical tissues[5].Root-end filling materials should therefore ideally have appropriate sealing ability in addition to antimicrobial activity which inhibit microbial growth and biocompatibility [6]. This procedure offers a great challenge to the materials scientists as the specifications of an ideal root-end filling material are quite exacting, and although a plethora of materials are available and have been used, no material has been found that conforms to all of the properties of an ideal root-end filling material.

Metals such as gold-foil, silver posts, titanium screws, tin posts , amalgam (with and without bonding agent) and gallium alloy are some of the solid, commonly used retro-filling materials. Cements and sealers such as ZnOE Cement IRM, Super EBA, cavit, zincpolycarboxylate, zinc phosphate and glass Ionomer cements, mineral trioxide aggregate, calcium phosphate cement and bone cement have also been employed for retro-fillings[7,8]. As early as in 1962, Nicholls showed preference for zinc oxide-eugenol cements over amalgam.[9] Reinforced zinc oxide-eugenol cements were developed in an attempt to increase the strength, reduce the setting time and resorbability of zinc oxide-eugenol cement and have emerged as the nonmetallic root-end filling materials of choice. Intermediate Restorative Material and Super-EBA have shown favorable results with respect to their sealing ability, tissue tolerance and clinical success.[10] Mineral Trioxide Aggregate (MTA), introduced in 1993 was suggested as a potential root-end filling material by its developers- Dr. M. Torabinejad and his associates at the Loma Linda University in California.[11] Its clinical usage worldwide followed after it was subjected to a battery of *in vitro* and *in vivo* investigations, to test its physical and chemical properties, sealing ability, marginal adaptation, cytotoxicity, antibacterial effects and histological evaluation in animal studies, in which it has emerged as the most suitable root-end filling material.

Henceforth this study was thought of to evaluate and compare the sealing ability of Mineral Trioxide Aggregate with that of Intermediate Restorative Material when used as root-end filling materials using *in vitro* dye penetration.

MATERIALS AND METHODS

Tooth selection with sample preparation- Fourty-four extracted, intact, non-carious, single- and relatively straight-rooted teeth with fully formed apices, consisting of human permanent maxillary central and lateral incisors and canines were selected. Teeth with multiple canals, calcifications, root fractures or cracks were excluded from the study. The roots were then debrided by scaling The anatomical crowns of all selected teeth were removed at the cemento enamel junction by airoter. # 10 K-file was then used to establish the patency of the canal. The pulp tissue was extirpated and all root canals were prepared using a step-back technique. The canals were obturated using AH-26 sealer cement and standardized gutta-percha cones using lateral condensation technique. The canal walls were coated with sealer cement using the lentulo filler at slow speed. The teeth were radiographed to evaluate the obturation.

Root-End Preparation: Apical root resections were performed on all roots removing 3mm of apical root-end at 90˚ to the long-axis of the tooth and root-end cavities were prepared.

Root-End Filling: Apical root resection was done at all roots by removing 3 mm of each apex at 90 degree to the long axis of the tooth by using the fissure bur in high speed hand piece with water coolant. A 3 mm deep root end cavity was prepared by round diamond bur in highspeed hand piece. Two coats of nail polish were applied on the whole surface of the root leaving only the access openings uncovered except teeth in the negative control group, which were completely covered with nail varnish.

The teeth where divided in to 3 groups and root-end fillings were done using

1. Retro filled with Intermediate Restorative Material (IRM), (Dentsply, U.S.A.)(20 roots)

2. Retro filled with MTA (Pro Root MTA, Dentsply, Tulsa Dental, U.S.A.). (20 roots)

3. Not Retro filled (4 roots),two positive and two negative control group.

Then the roots were dried and coated with 2 coats of nail varnish and one coat of sticky wax.

Dye Immersion-

Dye immersion done by placing each root into a separate 20ml glass vial and immersed in 5ml of dye solution measured using a glass pipette. After 7 days, the roots were removed from the dye and rinsed with tap water for 20 minutes. They were allowed to air dry for 24 hours before removing the nail polish and sticky wax The teeth were sectioned in labiopalatal direction by cutting labial and palatal longitudinal grooves in the root with a carborundum disc. The amount of leakage was measured from the most apical part of the root-end preparation to the most coronal extent of dye penetration along the root-end cavity walls using a stereomicroscope.

Observations were tabulated and subjected to statistical analysis, using the **unpaired Student's `t' test.**

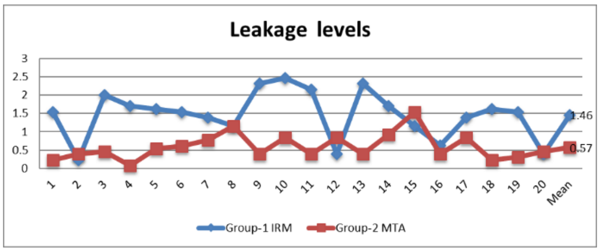
RESULT

The leakage of the experimental materials are compared in chart-1 where vertical axis is representing Dye penetration in mm while horizontal axis showing both the samples with mean values. The calculated value of `t' =5.56 is more than the table value of t = 2.58 hence there is highly significant difference in leakage values between group A and group B.

None of the negative control samples showed dye leakage through the external coatings of nail varnish and sticky wax. Positive control samples showed complete dye penetration proving the efficacy of air evacuation through subjecting the samples to vacuum.

DISCUSSION

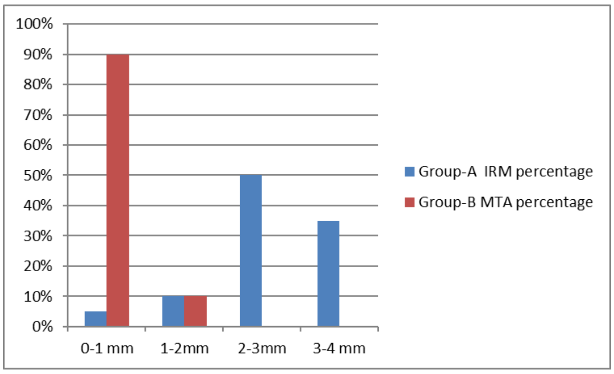
The goal of all the endodontic treatments is to achieve a three-dimensional fluid tight seal. The failures seen in root canal treatments are usually



Graph 1: Comparative frequency distribution of specimens in each leakage Groups of A and B.

Table 1: Showing Comparative Frequency distribution (Group-A) IRM & (Group-B) MTA.

Dye penetration (Depth in mm)	No. of specimens Group-A	No. of specimens Group-B
0-1	4	18
1-2	11	02
2-3	5	00
Total	20	20



Graph 2: Showing comparative percentage of dye penetration in mms of both Groups A and B.

Table 2: Comparison of mean dye penetration, Standard Deviation (SD) and range of dye penetration (in mm) between both Groups.

Sr. No.	Groups	Mean (mm)	SD	Range (mm)
1	Group-A: IRM	1.46	0.64	0.231-2.464
2	Group-B: Mineral Trioxide Aggregate	0.57	0.35	0.077-1.540

Table 3: Comparison of mean dye penetration in Group A and Group B.

Group A Mean ± SD	Group B Mean ± SD	S.E.	"t" value	p value	Result
1.46 ± 0.64	0.57 ± 0.36	0.16	5.56	$p<0.01$	Highly Significant

caused when microorganisms and/or their products gain access into the canals due to an improper seal leading to microleakage into the canals. Thus, we need to take utmost care in creating best of the seals in all the three directions apically, coronally, and laterally. To prevent loss of the crucial coronal seal, we need to place a good restoration after the endodontic treatment. This post endodontic restoration should have the ability to prevent recontamination of the root canal system from food debris, oral fluids and microorganisms in the oral cavity[13].

Since the root-end filling material after its insertion at the root-end, remains in a vital environment, it should ideally be stable, well tolerated by periapical tissues, ideally bond to the tooth structure, resistant to dissolution, promote cementogenesis, bacteriocidal or bacteriostatic, noncorrosive in nature, should not stain, readily available and easy to handle along with radioopaque properties.[14] To detect and end this a plethora of materials were evaluated and the process still continued.

Nicholls E. (1962)[15] reported the use of fast setting zinc oxide-eugenol compound for retrograde filling. According to him, the compound required considerably less skill in handling and control than did amalgam and the postoperative results were found to be as satisfactory as amalgam. IRM is a ZOE (Zinc oxide eugenol) cement reinforced with polymethyl methacrylate. Oynick J. and Oynick T. (1978)[16] compared Stailine (Reinforced zinc oxide-eugenol cement) and silver amalgam as root-end filling materials. The results showed that Stailine was more biocompatible and gave better apical seal than silver amalgam.

Bondra Daniel L. et al (1989)[17] compared the sealing ability of high-copper amalgam with copalite varnish, IRM and EBA cement using the dye leakage technique. Statistical analysis showed that IRM and EBA cement had significantly less leakage than amalgam with copalite. However, the difference between IRM and EBA cement was not significant.

However, the potential disadvantages of zinc oxide-eugenol based cements include:[18]

(a) Moisture sensitivity,
(b) Irritation of vital tissues,
(c) Solubility and
(d) Difficult clinical handling of the material.

Fischer Edward J. et a1 (1998)[19] checked for bacterial leakage of MTA as compared with zinc-free amalgam, IRM and Super EBA when used as root-end filling materials. They determined the time needed for Serratia marcescens to penetrate 3 mm thickness of each of these materials. Statistical analysis showed that MTA was the most effective root-end filling material against penetration of S. marcescens. Greer B.D., West L.A. and Liewehr F.R. (2001)[20] studied the ability of two compomers - Dyract and Geristore, IRM and Super EBA as root-end filling materials using fluid filtration device. The results indicated that the new compomers were equal or superior to IRM and equivalent to Super-EBA in their ability to reduce apical leakage when used as retrofiling materials.

Fogel H.M. and Peikoff M.D. (2001)[21] evaluated the microleakage of amalgam, IRM, a dentin-bonded resin, Super-EBA, and MTA by fluid filtration system. They found that there was no significant difference between amalgam and IRM. However IRM was also not significantly different from the other groups. Chong B.S., Pitt Ford and Hudson MB (2003)[22] carried out a prospective clinical study of MTA and IRM as root-end filling materials with the result of a high success rate that was not significantly better than that of IRM. This reinforcement provides the restoration with improved compressive strength, abrasion, resistance and hardness.[23] .The manufacturers recommend the use of IRM as a temporary restoration for cavities for up to 1 year using a powder to liquid ratio of 6:1.Following these recommendations usually results in a less than ideal seal but provides more optimum physical properties. The use of less powder provides a better seal at the expense of minimally compromising the physical properties.[24] .In addition, a softer mix exhibits greater antibacterial activity due to hydrolysis and the subsequent increase in the release of eugenol, an antibacterial agent which may prevent bacterial colonization if leakage takes place. But the leakage of IRM is increased when subjected to thermal stress, which was attributed to its dimensional instability[25]

Above pitfalls have been overcome to a certain extent by the use of MTA. Saunders philip william (2008) studied of periradicular surgery using microsurgical techniques and root-end filling with mineral trioxide aggregate (MTA) was performed. They found that overall success rate was 88.8%, including all teeth with no clinical symptoms. In this study, the use of MTA as a root-end filling, following microsurgical techniques, showed a high success rate.[26] . It claims to seal off all the pathways of communication between the root canal system and the external surface of the tooth.[27].

Similarly in our study also significant difference in the pattern of microleakage is observed between both the groups studied.

Group A was root-end filled with Intermediate Restorative Material (IRM). This group showed mean leakage value of 1.46 mm. Group B was root-end filled with Mineral Trioxide Aggregate. This group showed the least leakage as compared to IRM and the average leakage value was 0.57 mm. This sealing ability of MTA is probably due to its hydrophilic nature and slight expansion when it sets in moist environment.[28] similar finding was also corroborates with Torabinejad et a1.[30]

CONCLUSION

Hence, the present *in vitro* study corroborates the finding of significantly superior sealing efficacy of Mineral Trioxide Aggregate as compared to that of Intermediate Restorative Material when placed as root-end materials.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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