

# Evaluation of Apical Sealing Ability of Three Different Mineral Trioxide Aggregates Placed in Orthograde Manner and Followed by Apicoectomy

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## ABSTRACT

**Introduction:** To enhance the success rate of periapical surgeries, it is of utmost importance to have fluid tight seal in apical third of root canal. This study compared the apical sealing ability of three different mineral trioxide aggregates placed in orthograde manner using UV-VIS spectrophotometer.

**Materials and Methods:** 80 human extracted single rooted teeth were selected and decoronated to create standardized root length of 16mm. All teeth were prepared up to Protaper F4 (Dentsply, Maillefer, Switzerland) at working length 15.5 mm. These teeth were equally and randomly divided into 4 groups (n=20). In Group I (control group); teeth were obturated with gutta percha (Dentsply, Maillefer, Switzerland) and AH Plus sealer (Dentsply-Detrey, Konstanz, Germany). In Group II, III, IV; approximately 7 mm apical plug of MTA Angelus (Londrina, PR, Brazil), ProRoot MTA (Maillefer, Dentsply, Switzerland), MTA Plus (Bradenton FL, Prevest Denpro, USA) respectively; was placed in orthograde manner and remaining canal was obturated with gutta percha and AH Plus sealer. In all samples; apical 3mm was cut and they were placed in 2% methylene blue dye for 72 hours. Microleakage was tested using dye extraction method and UV- VIS Spectrophotometer. Data were analysed using One way ANOVA & Tukey's Post-hoc t test.

**Results:** Control group leaked most. MTA-Plus (Bradenton FL, Prevest Denpro, USA ) showed least microleakage whereas there was no significant difference in sealing ability of MTA-Angelus (Londrina, PR, Brazil) and ProRoot MTA (Dentsply, Maillefer, Switzerland).

**Conclusion:** MTA Plus reduces apical microleakage as compared Angelus MTA and Pro-Root MTA.

**Keywords:** Apical sealing, microleakage, MTA-Angelus, MTA-Plus, periapical cyst, ProRoot MTA.

## INTRODUCTION

Conventional root canal treatment (RCT) of the teeth has shown high success rate (70-95 %).<sup>1</sup> However, the endodontic treatment of teeth with large periapical lesion has questionable prognosis.<sup>2</sup> The best treatment option in such cases is surgical enucleation of cyst, resection of apical 1/3<sup>rd</sup> of root and placement of appropriate root end filling material with appropriate technique.<sup>3</sup>

The ideal characteristics of an apical root-end filling material includes: easy of manipulation, good radio-opacity and dimensional stability, should be non-absorbable; non-penetrable by bacteria and unaffected by moisture, should provide intimate adaptation and adherence to the canal walls, non-toxic; nonirritating to periradicular tissue, promote bioactive healing of periradicular tissues, should be noncorrosive or electrochemically inactive, should not stain periradicular tis-

sue.<sup>4</sup> Many materials such as amalgam, gold foil, gutta-percha, zinc oxide eugenol cements (super EBA, IRM, Rickert), calcium hydroxide cements (Sealapex, Sealer 26), glass ionomer, titanium screws, composite resin have been used for root end filling purpose.<sup>5</sup>

Mineral trioxide aggregate developed by Torabinejad in 1993 (at Loma Linda University, CA, USA.) is considered as a gold standard for root end filling material because it fulfils most of the ideal requirements mainly extreme biocompatibility and thus promotes regeneration of original tissues when placed in contact with dental pulp or periradicular tissues.<sup>6,7</sup> Literature suggests; teeth with large periradicular lesion can be treated by orthograde placement of MTA plug.<sup>2</sup> Further Many studies have compared the apical sealing ability of various root end filling material placed in retrograde manner<sup>8,9</sup> but there is lack of literature comparing the apical sealing ability of three different mineral trioxide aggregates placed in orthograde manner. This study aims to analyse the apical sealing ability of three MTA pastes when placed in orthograde manner; followed by apical resection.

## MATERIAL AND METHODS

Eighty freshly extracted, human permanent, single rooted teeth with complete apex were used in this study. Each tooth was radiographed to evaluate anatomy and apical morphology. Teeth with aberrant anatomy, improperly formed roots, cracks and fracture lines and more than one canal were excluded. Teeth were decoronated with diamond disk under water stream to create standardized root length of 16mm. Canal patency was evaluated with #10 K File (Mani, inc, Tochigi, Japan) and canal orifice enlargement was done with # 3 and 2 Gates Glidden drill (Mani, inc, Tochigi, Japan). All teeth were prepared to working length 15.5 mm using rotary Protaper (Dentsply, Maillefer, Switzerland); in crown down manner up to size F4 using RC-Help (Prime Dental Products PVT. LTD., Thane, India) as a lubricant. All teeth were irrigated with 20 ml of 5.25% Sodium hypochlorite

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solution after every change of instrument using 30 gauge side vented needle. Root canals were dried with absorbent paper points (Protaper F4, Dentsply, Maillefer, China).

Depending on the type of MTA (as a 7 mm apical barrier) placed; all prepared teeth were randomly and equally divided into 4 groups containing 20 each (n=20) as follows:

**Group I:** Control group (No MTA placed)

**Group II:** MTA Angelus (Londrina, PR, Brazil)

**Group III:** ProRoot MTA (Maillefer, Dentsply, Switzerland)

**Group IV:** MTA Plus (Bradenton FL, Prevest Denpro, USA)

Teeth in the control group were obturated to its full working length with # 40, 6% Gutta Percha (Dentsply, Maillefer, Switzerland) and AH Plus sealer (Dentsply-Detrey, Konstanz, Germany). In rest of test groups, respective MTA were manipulated according to manufacturer's instructions and with the 20 gauge spinal anaesthesia needle; it was carried into the prepared canal incrementally. MTA was condensed with moist paper points and # 40 finger plugger (Medicept, Middlesex, United Kingdom). Approximately 7 mm of apical plug of MTA was placed in each root. A cotton plug moistened with saline was placed inside the canal and MTA was allowed to set for 24 hours in an incubator at 37° C and 100 % humidity. The remaining canal was backfilled with the # 40, 6% gutta percha (Dentsply, Maillefer, Switzerland) which was cut 7 mm from its tip and AH plus sealer (Dentsply-Detrey, Konstanz, Germany). The canal orifice of all teeth was sealed with MD-Temp (Meta Biomed, Korea).

The apical 3 mm of the root apex of each tooth was resected at approximately 90° to its long axis using a diamond disk. The coronal and lateral aspects of these teeth were then coated with two coats of nail varnish except for its apical 4 mm from resected end and allowed to dry. This uncoated part (apical 4 mm) of each tooth was immersed into the 2% methylene blue dye solution (Fisher's Scientific, India). Specimens were then stored in an incubator at 37° C and 100 % humidity for 3 days. Nail varnish was removed with BP blade and teeth were washed in running tap water for 30 seconds. Leaked dye was extracted by keeping the specimen into 5 ml of 35% nitric acid (Fisher's Scientific, India) for 3 days in an incubator at 37° C and 100 % humidity. The resultant solutions were filtered and centrifuged (Remi R-8C, Vasai, India) at 14,000 rpm for 5 minutes. The supernatant solution were subjected to UV-VIS spectrophotometer (Perkin Elmer, USA) using an filter of 670nm where percentage light transmission was measured using 35% nitric acid as a blank.

According to the Beer-Lambert's Law<sup>10</sup>

$$A = \log_{10}(I_0/I) = \epsilon \cdot c \cdot L$$

Where,

A is the measured absorbance,

I<sub>0</sub> is the intensity of the incident light at a given wavelength,

I is the intensity of the transmitted light,

L the path length through the sample, and

c the concentration of the absorbing species.

For each species and wavelength,  $\epsilon$  is a constant known as the molar absorptivity or extinction coefficient. This law states that, the magnitude of absorbance is directly proportional to the concentration of dye in the solution and inversely pro-

portional to % transmission. Thus, values of % transmittance indicate the absorption of light waves in the solution. If the value of % transmittance is less then it indicates that the concentration of methylene blue in the solution is more and thus more microleakage.

## STATISTICAL ANALYSIS

Statistical analysis was performed by using one-way analysis of variance (ANOVA). A Tukey's post hoc test was used for pair-wise comparison between the means when analysis of variance test was significant. The significance level was set at  $p \leq 0.05$ . Statistical analysis was performed with SPSS 16.0 (SPSS Inc., Chicago, IL, USA).

## RESULTS

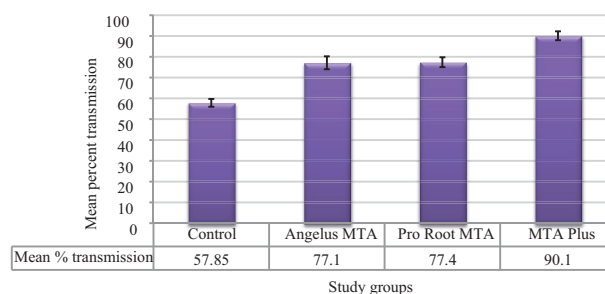
MTA Plus showed significantly high mean percentage transmission ( $90.1 \pm 4.81$ ) indicating least microleakage. ProRoot MTA ( $77.4 \pm 5.29$ ) and MTA Angelus ( $77.1 \pm 6.98$ ) had no significant difference in between ( $p=0.998$ ), and thus having similar microleakage. Control group showed significantly least mean percentage transmission ( $57.85 \pm 4.17$ ) among all the groups representing maximum dye leakage ( $p<0.0001$ ) (Figure 1).

## DISCUSSION

The goal of both surgical and endodontic therapy is to eradicate the microorganisms and hermetically seal the root canal system at the periapex that prevents the movement of bacteria and bacterial by products from the root canal system into the periapical tissues.<sup>4</sup> Therefore, the proper apical seal is the most important factor in achieving success in surgical endodontics.<sup>11</sup> In this study, we considered only MTA because it is well known for its extreme biocompatibility<sup>6,7</sup>, regenerative property<sup>6,7</sup>, sealing ability<sup>12</sup> and adaptation to the canal wall.<sup>13</sup> Single rooted teeth were selected for this study to reduce the variation in the anatomy of all roots. To cor-

Groups	N	Percentage transmission
		Mean $\pm$ SD
Group I (Control)	20	57.85 $\pm$ 4.17 <sup>a</sup>
Group II (Angelus MTA)	20	77.1 $\pm$ 6.98 <sup>b</sup>
Group III (Pro Root MTA)	20	77.4 $\pm$ 5.29 <sup>b</sup>
Group IV (MTA Plus)	20	90.1 $\pm$ 4.81 <sup>c</sup>

**Table-1:** Percentage transmission of light across various groups (different superscripted letters indicate statistically significant difference in mean percentage transmission across groups).



**Figure-1:** A bar diagram showing the mean percentage transmission and standard deviation values across the groups

relate the clinical situation and maintain the uniform apical diameter; teeth specimens in all groups were enlarged to # F4; at working length 15.5mm.

All the MTA used in this study were white MTA as many authors did not notice any significant difference in microleakage between grey and white MTA.<sup>5,14,15</sup> It also has the advantage that it does not stain periapical tissue and radicular dentin. MTA was condensed by hand instruments (# 40 finger plugger) because hand condensation method has proven to provide a better seal than ultrasonic condensation.<sup>16</sup> AH Plus sealer was used because it is a resin based sealer and have deeper and more consistent penetration into dentinal tubules than other sealers both *in vitro* and *in vivo*.<sup>17</sup> 3mm root end resection was done perpendicular to long axis of the tooth so as to remove all ramification and expose lower number of dentinal tubules to the dye.<sup>18,19</sup> Approximately 4 mm apical plug of MTA was kept behind because Coneglian et al<sup>15</sup> have found it to be most efficient root canal sealing ability and resistance to displacement.

Andelin et al and Lamb et al found no significant difference in microleakage between teeth in which MTA was placed in orthograde manner and resected to those in which MTA was placed in retrograde manner.<sup>7,20</sup> Further resected MTA was not found to prevent the regeneration of cementum and periradicular tissue.<sup>7</sup>

There is no published data explaining clinical significance of microleakage in apical surgery but it seems logical that less leakage will allow less bacteria and bacterial toxins to reach periapical tissue.<sup>21</sup> 2% Methylene blue dye was used to check the microleakage because it is inexpensive, easy to manipulate, has high degree of staining and molecular weight lower than that of bacterial toxins.<sup>22</sup> Torabinejad et al. stated that a material that has potential to prevent the penetration of small molecules (dye) should be able to prevent larger substances like bacteria and their by-products.<sup>23</sup> We did not measure the linear dye leakage which has a little clinical significance and several drawbacks.<sup>24,25</sup> We used the dye-extraction method which takes into account, the dye actually leaked through root canal dentin-mineral trioxide interface.<sup>25</sup> Camps and Pashley stated that the dye-extraction method produced same results as the fluid-filtration method and also saved much laboratory time.<sup>24</sup>

These findings are in conformity with Hashem et al<sup>25</sup> and Lolayekar et al<sup>26</sup>; who compared them for sealing ability in case of perforations repair and open apex barrier formation respectively. All the MTA used in this study have similar ingredients or composition.<sup>27</sup> Observed differences within MTA groups may be due to particle size, consistency of final mix, setting reaction and setting expansion.<sup>27</sup>

Finer the particle size; excellent will be the speed of hydration<sup>28</sup>, adaptation and adhesion with dentinal wall.<sup>9</sup> Percentage of fine particles (6 to 10  $\mu$ m) has been reported to be 73% for White ProRoot MTA and 53% for White MTA Angelus.<sup>27</sup> MTA plus has a specific surface area 1.5 times times to that of ProRoot MTA confirming MTA plus is finer than that of ProRoot MTA.<sup>27</sup>

In this study, MTA Angelus and ProRoot MTA powder was mixed with provided distilled water which results into wet sandy mix. MTA plus powder was mixed with the provided

salt free polymer gel which is claimed to improve the wash-out resistance.<sup>27,28</sup> Washout resistance refers to the tendency of freshly prepared cement paste to disintegrate upon early contact with blood or other fluids.<sup>29</sup> Mixture of MTA Plus powder and gel results into mix with putty or Dycal like consistency<sup>28</sup> which allows easy handling and condensation against canal walls whereas there might be incorporation of porosity while condensing sandy mix of MTA Angelus and ProRoot MTA.

Hydrated mineral trioxide aggregate (MTA) has the property to leach calcium hydroxide in solution<sup>27</sup> This calcium hydroxides reacts with phosphates available in tissue fluids to form amorphous calcium phosphate phase which later transforms into B-type carbonated apatite crystallites.<sup>27</sup> This hydroxyapatite crystal may have a role in prevention of microleakage.<sup>9</sup> Camillery et al<sup>27</sup>, stated that hydrated MTA Plus exhibits a strong peak of calcium hydroxide than Pro-Root; signifying a greater rate of reaction with enhanced formation of reaction by-products and thus resulting in lesser microleakage.

MTA plug slightly expand after setting; which fills the porosity and improves adaptation of MTA to canal walls.<sup>30</sup> With dycal like consistency due to polymer gel MTA plus may show greater expansion and thus improved sealing ability than Pro Root MTA and MTA Angelus but as MTA plus is relatively new material this may require further studies.

However this is an *in vitro* study not totally simulating an *in vivo* periapical conditions. Observed microleakage may be slightly exaggerated as methylene dye has lower molecular weight than bacterial toxins passing easily through small microgaps or dentinal tubules through which even bacterial toxins may not. However, the microleakage in clinical situation can be considered in proportion to the observed microleakage in the present study.

## CONCLUSION

Within the limitations of the present study, we can conclude that improved properties of MTA Plus; has significantly reduced the apical microleakage as compared Angelus MTA and Pro-Root MTA when they were placed in orthograde manner.

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