Section: Research Paper
ISSN 2063-5346

COMPARATIVE EVALUATION OF APICAL SEALING ABILITY OF MTA PLUS AND MTA ANGELUS: AN INVITRO STUDY

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Abstract

Background: Mineral trioxide aggregate(MTA) has been widely used as a root end filling material. Different studies have been carried out on the evaluation of apical sealing ability of MTA. But the results were conflicting. Also sample size used in the studies were not enough to conclude the efficacy of the materials like MTA plus and MTA angelus. The Study was designed to Compare and Evaluate the Efficacy of two commercially available MTA: MTA PLUS (Avalon Biomed Inc. by Prevest Denpro Ltd, Jammu, India) and MTA-ANGELUS (ANGELUS Dental Solutions, Brazil) in terms of apical sealing ability.

Aim: To compare and evaluate the apical sealing ability of two formulations of Mineral trioxide aggregate (MTA): MTA Angelus and MTA Plus.

Materials & Methods: To determine apical sealing ability, 300 Freshly extracted single rooted and single canal sound human teeth, were compiled by simple random sampling method. Teeth were decoronated, apical 3rd was enlarged and root canals were prepared to receive MTA as 5mm apical filling. The root segments were randomly assigned into 2 experimental groups, Group A (MTA plus) and Group B (MTA angelus) of 100 samples each and 100 root segments each were used as control (Unfilled). Apical sealing ability was determined using Dye extraction method by UV spectroscopy.

Results: The mean absorbance values were 243.87, 258.73 and 4822.35 for Group A, Group B and Group C respectively. The highest sealing ability was seen with MTA plus (Group A) and least with unfilled group (Group C)

Conclusion: The composition and structure of MTA plus(Group A) makes it better sealing agent than MTA angelus (Group B).

Section: Research Paper
ISSN 2063-5346

Key words: MTA plus, MTA angelus, apical sealing ability.

INTRODUCTION:

Endodontic treatment of the pulpless tooth with an immature root apex poses a special challenge for the clinician. The main difficulty encountered was the lack of an apical stop against which an interim dressing of calcium hydroxide (Ca $(OH)_2$), or the final obturation was to be carried out. In these situations, the unpredictability of the result, the difficulty in creating a leak-proof temporary restoration for the duration of treatment, and the difficulty in protecting the thin root from fracture may lead to complications when using traditional (Ca $(OH)_2$ -based) apexification techniques. Furthermore, given the increased mobility of today's society, lengthy treatment protocols were fraught with problems, and may not be followed through to completion.[1] This may lead to ultimate failure of the case.

Initially, calcium hydroxide mixed with a number of different substances such as, camphorated mono chlorophenol, distilled water, saline, anesthetic solutions, chlorhexidine, cresatin etc, was used to create an apical barrier. However, calcium hydroxide had many limitations such as, variable treatment time ranging from 5 months to 20 months, apical closure in relationship to treatment time is unpredictable, an increased risk of tooth fracture, and poor patient compliance with follow-up due to the extended treatment time, all of which had a poor effect on treatment outcomes.[2]

Mineral Trioxide Aggregate (MTA) was eventually introduced for use in endodontics. Current literature supports its efficacy in a multitude of procedures including apexification.[3]

Materials previously considered for apical barriers included dentin chips, freeze-dried cortical bone/dentin, calcium phosphate and calcium hydroxide which were efficient in creating a barrier for obturation in one appointment but did not provide a well-sealed environment. Goodell studied the effect the of calcium phosphate cement (MTA based cements) and proved that it can be used as an apical barrier than calcium hydroxide. Thus Mineral Trioxide Aggregate was advocated for use as an apical barrier because of its sealing capabilities, ability to set in the presence of moisture, its biocompatibility and ability to induce hard tissue formation.[4,5]

Many current root end filling materials may not provide a perfect apical seal; a microscopic space was likely to exist at the root end cavity/filling interface along which microorganisms and their products can penetrate.

Therefore, the purpose of this study was to evaluate and compare root end sealing ability of two commercially available formulations of MTA: MTA plus (Avalon Biomed Inc. by Prevest Denpro Ltd, Jammu, India) and MTA-Angelus (ANGELUS Dental Solutions, Brazil) by in vitro method.

MATERIALS & METHODS

The study was conducted in the Dept of Pediatric Dentistry, Rural Dental College, Dept of Microbiology, Rural Medical College, Loni and Indian Institute of Technology (IIT) Powai, Mumbai after obtaining the clearance from Institutional Ethical Committee, PIMS (Deemed to be University), Loni (PMT/PIMS/IEC/2017/440) and after the confirmation of registration in PhD course in Rural Dental College, PIMS (DU) (PIMS/Ph.D/R/2018/260).

To determine the apical sealing ability, 300 freshly extracted single rooted and single canal sound human teeth, were compiled from Dept of Oral & Maxillo-Facial Surgery.

Sample Size was calculated by doing power analysis. Assumptions of sample size calculation were effect size 0.25, α error 5%, Power 80%. G Power 3.1.9.7 calculator was used for sample size calculation.

The sampling was done by **simple random sampling method.** Immediately after collection, the teeth were stored in sodium hypochlorite (5%) for initial 2 hours.

The teeth were cleaned of calculus, soft tissue tags, attached bone or other debris by ultrasonic scaling and were autoclaved. The teeth were stored in 0.1% thymol (VDH industries Ltd., India) for initial 1 month followed by Normal saline (Nirlife, Nirma Ltd., India) until further use.

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Sound extracted teeth (without caries), Extracted Teeth with complete root formation, Single canal and single rooted teeth extracted **due to orthodontic reasons** (with prior consent for extraction from patient) were included in the study.

Fractured teeth & Cracks in the roots were excluded from the study.

METHODOLOGY & GROUPING

Decoronation of teeth to 10mm root length with MM handpiece and diamond disc was carried out in step 1. This was followed by Simulation of the root segments to clinical situation of open apices with GG burs 5-1 in crown down manner. #1 GG bur was used to pass through the apical foramen. This was designated as step 2. The segments were then prepared with Flexofiles until an ISO size 90 file (Mani Inc, Japan) could be visualized 1mm past the apex. Sodium hypochlorite 5% was used as an irrigant throughout the procedure.

All the root canals were prepared with step down technique using Protaper Gold (Sequence S1, S2, F1, taper 0.06). The specimens received the final rinse 1ml 17%EDTA solution in order to remove the smear layer followed by normal saline.[6]

The 300 root segments for fracture resistance included in this study were randomly assigned into 2 experimental groups of 100 samples each and 100 root segments each were used as control:

Group A: MTA-PLUS was placed as 5mm apical barrier in 100 root segments.

Group B: MTA-ANGELUS was placed as 5mm apical barrier in 100 root segments.

Group C: no material was placed as apical barrier in 100 root segments and the obturation was carried out by Lateral Condensation method. All materials were manipulated as per manufacturer's instructions.

The MTA used in both the groups was mixed on a paper-pad with distilled water in 3:1 powder water ratio. When the mixture exhibited putty like consistency after about 30 seconds of mixing, it was immediately placed as apical barriers. MTA was carried to the site with the bone graft carrier. A plugger followed by a wet cotton pellet was used to condense the material gently at the simulated open apex. An apical plug of at-least 5mm was formed. Radiographs were taken to verify the placement of the apical barriers.

In both the groups A & B, after condensing MTA at the apical third, the coronal portion was sealed with a cotton pellet and Intermediate Restorative Material (IRM). After 2 hours, the IRM and cotton pellet was removed and the canals were dried and obturated with gutta-percha (Dentsply Maillefer, Dentsply France SAS) using lateral condensation method and zinc oxide eugenol sealer (Deepak Enterprise, Dental Products of India, India). Brothman P[7] has shown equivalent efficacy of vertical condensation and lateral condensation in obturation of permanent teeth, hence lateral condensation was used in our study. Coronal portion of all samples were then sealed with Type IX Glass Ionomer (Fuji IX, GC Corporation, Japan). In Group C, 100 of the prepared root segments used as control, no material was placed as apical barrier. All the samples were obturated with gutta percha and zinc oxide eugenol sealer using lateral condensation method. Coronal portion of all samples will be then sealed with Glass Ionomer (Fuji IX).

Radiographs were taken of samples in all 3 groups to verify the obturation.

All the samples were subjected to thermocycling process in water between 5^{o} C -55^{o} C for 100 cycles. The storage time in each bath was for 20 seconds. The transfer time between the baths was 5 seconds. All root segments were stored at 37ºC in normal saline.

Transporting the samples

The extracted teeth were cleaned of calculus, soft tissue tags, attached bone or other debris by ultrasonic scaling and were autoclaved. Initially, the samples were stored in 0.1% thymol for 1 month followed by Normal saline at 37ºC until further use. Infection control guidelines for dental care by CDC-2003 were followed.

During transportation, the teeth were transported in the three well-constructed plastic containers with sealable lids, each containing 0.1% thymol solution. The containers were labelled with names of the groups and also with biohazard label.

Protective eye ware, gloves, masks, headcaps and aprons were used by the investigator and the assistant. Waste samples were collected in red bags and were disposed to biomedical waste management team.

Measurement of sealing ability of MTA plus and MTA angelus by dye extraction method (using UV spectrophotometer)

The root segments from all groups (Figure 1, 2, 3) were double coated with nail varnish except for the apical 1mm and apical ends of all root segments were suspended vertically in Indian Ink dye (Faber Inc, Lewisburg, TN) for 48 hours at room temperature. The teeth were then placed in vacuum chambers containing Indian Ink and a vacuum of 7.98 Pa for 15 min was applied. Then the specimens were stored in a hermetic sealed vial containing 65% nitric acid for three days. The vials were then centrifuged at 14,000 rpm for 5 min to separate gutta-percha debris from the extracted dye. Dye concentration in the supernatant solution was analyzed using an UV spectrophotometer (Agilent Technologies, Carry 100 UV vis model; Shimadzu printer, Shimadzu Corp., Kyoto, Japan; IIT, Powai Mumbai) (figure 4) at 550 nm using concentrated nitric acid as a blank.[8]

The methodology described here was carried out in Lab number 413B, First floor of IIT, Powai, Mumbai. The applications of UV spectrophotometer were qualitative & quantitative analysis, RNA/DNA quantification, metal concentration, and validation.

The Principle of UV-Visible Spectroscopy was based on the absorption of ultraviolet light or visible light by chemical compounds, which results in the production of distinct spectra. Spectroscopy was based on the interaction between light and matter. When the matter absorbs the light, it undergoes excitation and de-excitation, resulting in the production of a spectrum.

When matter absorbs ultraviolet radiation, the electrons present in it undergo excitation. This causes them to jump from a ground state (an energy state with a relatively small amount of energy associated with it) to an excited state (an energy state with a relatively large amount of energy associated with it). It was important to note that the difference in the energies of the ground state and the excited state of the electron was always equal to the amount of ultraviolet radiation or visible radiation absorbed by it.[8]

RESULTS

As shown in table 1, the mean absorbance values were 243.87, 258.73 and 4822.35 for Group A, Group B and Group C respectively. By applying ONE WAY ANOVA TEST and Post hoc Tukey Kramer Multiple Comparison Test there was a significant difference between mean values of Apical sealing ability of Test materials (Group A & B) with Group C. (p=0.0001).(table 2)

By applying Z test there was a significant difference between mean values of Apical sealing of Test material when Group A: MTA Plus and Group B: MTA Angelus and Group C: Unfilled group were compared using dye extraction method with a spectrophotometer (mm) (p=0.0001). (table 3)

DISCUSSION:

MTA (Mineral Trioxide Aggregate) was introduced by Mahmoud Torabinejad in the 1990s. Over the last two decades it has been one of the most researched biomaterials. The trioxide aggregate in MTA consists of calcium, aluminium and selenium. MTA has several desirable properties such as biocompatibility, bioactivity, hydrophilicity, radiopacity, sealing ability and low solubility. One of the most important advantages of MTA in dentistry was its ability to set in a moist environment.[9]

MTA was first introduced in 1993 and received FDA approval in 1998. In 1999 Pro Root MTA (Dentsply Tulsa Dental Specialties, Johnson City, TN) was the first commercially available MTA product to be launched in the United States. MTA Angelus (Angelus, Londrina, Brazil / Clinician's Choice, New Milford, CT) was launched in Brazil in 2001 and received FDA approval in 2011, after which it was made available in the United States. MTA Plus (Prevest Denpro Limited, Jammu, India, for Avalon Biomed Inc) had a finer powder, lower-cost product introduced in the year 2011.[10]

The sealing of the root canal apically by the sealer was essential in the prevention of communication of root canal contents with periapical tissue. Characteristics such as flow, consistency, setting characteristics, solubility, and adhesion to root canals were vital in obtaining a hermetic seal of the root canal.[11]

In our study, we measured sealing ability by using the dye extraction method and a UV spectrophotometer on simulated root apices. The maximum apical seal was obtained at minimum dye penetration values. As seen in the result tables, Group A (MTA Plus) showed the lowest mean dye penetration values at 243.87±6.65 and by that logic, MTA plus displayed the highest degree of sealing ability as compared to both Group B (MTA Angelus) and Group C (Control- Unfilled) with the mean values being at 258.73±8.68 and 4822.35±96.15 respectively. The results were found to be significant ($p<0.01$). The highest value and therefore lowest sealing ability was seen for the control group (Group C).

Lolayekar et al in 2009[12] conducted an investigation on the use of MTA as a 5mm apical barrier by comparing the sealing ability of ProRoot MTA to that of MTA-Angelus. The results showed no statistically significant difference in the sealing ability of ProRoot MTA and MTA-Angelus when used as apical barriers.

Katge et al in 2016[13] compared the sealing ability of mineral trioxide aggregate (MTA) Plus™ and Biodentine™ for the repair of furcal perforation in primary molars using spectrophotometry. The mean value dye penetration of MTA Plus™ was 24 ± 3.1 and Biodentine™ was 31 ± 2.6. The mean value of dye penetration of MTA Plus™ was lesser than Biodentine™ but it was statistically insignificant. The results of our study in terms of sealing ability were similar to the study carried out by Katge et al in 2016.[13]

CONCLUSION

From our study we can conclude that in terms of Apical Sealing ability- MTA plus (Group A) was superior to MTA angelus (Group B) and Control (Group C). Furthur studies can be conducted to compare the different formulations of MTA.

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Annexures

Figure 1: Root segments coated with nail varnish for MTA plus (except apical 1mm)

Figure 2: Root segments coated with nail varnish for (except apical 1mm) MTA angelus

Figure 3: Root segments coated with nail varnish for (except apical 1mm) Unfilled

Table No.1: Comparison of mean and SD values of Apical sealing of Test materials (Group A & B) and Control group (Group C) using dye extraction method with a spectrophotometer (mm):

	Group A (MTA Plus)	**Group B (MTA Angelus)**	**Group C (Control)**
	Mean ± SD	**Mean ± SD**	**Mean ± SD**
Apical sealing of Test materials	243.87±6.65	258.73±8.68	4822.35±96.15

The mean absorbance values were 243.87, 258.73 and 4822.35 for Group A, Group B and Group C respectively.

Table No.2: Table showing the results of apical sealing ability after applying One way ANOVA (Tukey's Multiple comparison test) for the three group

Source of variation	**d.f.**	**Sum of squares**	**Mean square**	**Result**
Treatments (between columns)	2	14210000	710400	Value of F =227612, p=0.0001, Significant
Residual (within columns)	303	945721	3121.2	
Total	**305**	**15155721**		

By applying ONE WAY ANOVA TEST and Post hoc Tukey Kramer Multiple Comparison Test there was a significant difference between mean values of Apical sealing ability of Test materials (Group A & B) with Group C. (p=0.0001).

Table No. 3: Showing the intergroup comparison of apical sealing ability using dye extraction method with a UV spectrophotometer (mm) by applying Z test.

Apical sealing ability using dye extraction method using UV spectrophotometer	**Group A vs Group B Mean ±SD Mean ±SD MTA plus vs MTA angelus**	**Group A vs Group C Mean ±SD Mean ±SD MTA plus vs Unfilled**	**Group B vs Group C Mean ±SD Mean ±SD MTA angelus vs unfilled**
Mean ±SD	243.87±6.65 258.73±8.68	243.87±6.65 4822.35±96.15	258.73±8.68 4822.35±96.15
Z value	13.735	479.79	477.44
P value	0.001(hs)	0.001(hs)	0.001(hs)

*hs= highly significant

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By applying Z test there was a significant difference between mean values of Apical sealing of Test material when Group A: MTA Plus and Group B: MTA Angelus and Group C: Unfilled group were compared using dye extraction method with a spectrophotometer (mm) ($p=0.0001$).