RESEARCH PAPER

In Vitro Comparison Of Sealing Ability Of Mta And Activa Bioactive Restorative As Root End Filling Materials: A Confocal Laser Scanning Microscopy (Clsm) Study

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Abstract

Background: The success of endodontic surgery largely depends on achieving an effective apical seal to prevent microleakage and reinfection. Mineral trioxide aggregate (mta) is widely regarded as the gold standard for root-end filling; however, newer bioactive materials such as activa™ bioactive restorative have been introduced with claims of improved handling and bioactivity.

Aim: To compare the sealing ability of activa bioactive restorative and mta angelus when used as root-end filling materials using confocal laser scanning microscopy (clsm).

Materials and Methods: Fifty-four extracted human single-rooted teeth were selected and randomly divided into two groups: activa bioactive restorative (n=27) and mta angelus (n=27). Following standardized root canal preparation, obturation, apical resection, and root-end cavity preparation, the respective materials were placed. Specimens were coated with nail varnish (except apical region) and immersed in 1% rhodamine b dye for one week. Teeth were then sectioned and evaluated under clsm to assess dye penetration. Statistical analysis was performed using student's t-test with significance set at $p<0.05$.

Results: A total of 43 samples were analyzed. The activa group demonstrated significantly higher mean dye penetration (28,215 ± 1,547 µm²) compared to the mta group (22,710 ± 1,314 µm²). The difference was statistically significant ($t=12.4$, $p<0.001$).

Conclusion: Within the limitations of this in vitro study, mta angelus exhibited superior sealing ability compared to activa bioactive restorative. Mta remains a reliable root-end filling material, especially in surgical environments where moisture control is challenging. Further clinical studies are required to validate the performance of activa bioactive restorative.

Keywords: Mta Angelus, Activa Bioactive Restorative, Root-End Filling, Sealing Ability, Microleakage, Confocal Laser Scanning Microscopy (Clsm), Dye Penetration, Endodontic Surgery, Bioactive Materials.

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INTRODUCTION:

The objective of endodontic treatment is to disinfect the root canals and to achieve a hermetic seal thereby preventing further ingress of microbes. Despite the advancements, orthograde root canal treatment can fail. Surgical Endodontics poses as the next line of treatment option. Endodontic surgery has made tremendous leaps in the past decades; with the advancements in microsurgery and Bioactive materials. (1)

Many materials have been proposed as root end filling materials, such as silver amalgam, calcium hydroxide, gutta-percha, calcium enriched mixture etc. These materials were excellent as cavity filling materials. But their role as root end filling materials was not satisfactory; due to poor retention, nano leakage and cytotoxicity.

Activa Bioactive Restorative is a dual cured restorative material introduced by Pulpdent (USA). The material combines the physical property and

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aesthetics of a composite cement, and chemical property of a Glass ionomer cement. The cement is composed of patented bioactive ionic resin, rubberized resin and a bioactive ionomer glass. The material has a matrix of bioactive ionic resin with high release and recharge rate of calcium (Ca^{2+}), phosphate (PO_4^{3-}) and fluoride (F^-) ions.

Because of the superior properties, they are indicated for restorations. Their dual cure property makes them an ideal choice of material in scenarios where achieving isolation is a challenge.(2)

Mineral trioxide Aggregate (MTA) is a bioactive cement; calcium and silicate elements as the major constituents. The cement was introduced by Torabinejad in the 1990s. It is the modification of Portland cement. It has wide range of application including for vital pulp therapy (VPT) pulpotomy, root repair and as root end filling material.(3)

MTA and Activa Bioactive Restorative were chosen for this study because, MTA is a time tested material for root end fillings; it has a superior sealing ability and shows excellent bioactive properties. But MTA also has a longer setting time and retention in a blood filled environment is a drawback. Whereas Activa Bioactive Restorative with its dual cure setting mechanism can be excellent material for poorly isolated areas. Chemical property mimicking GIC can provide a better sealing to the resected roots.

The purpose of this study is to compare the sealing ability of Activa Bioactive restorative with MTA ANGELUS, as root end filling material.

METHODOLOGY

Sample Size and Grouping

A total of **fifty-four samples** were included in the study. The samples were randomly divided into two groups of **twenty-seven specimens each**:

- **Group A:** ACTIVA™ Bioactive Restorative™ (Pulpdent®, Watertown, MA, USA)
- **Group B:** MTA Angelus (Angelus, Londrina, Brazil / Clinician's Choice, New Milford, CT, USA)

The sealing ability of ACTIVA Bioactive Restorative was evaluated and compared with that of the commonly used root-end filling material, MTA Angelus.

Sample Preparation

Preparation of Specimens

Extracted human single-rooted teeth with **completely formed apices and straight canals** were selected for the study. Teeth with visible root caries, fractures, cracks, internal or external resorption, or calcifications were excluded. The selected teeth were stored in **normal saline** until use. Radiographs were taken in **buccolingual and mesiodistal views** to confirm the selection criteria.

The specimens were randomly allocated into two groups of twenty-seven teeth each corresponding to the experimental groups.

The crowns of all teeth were sectioned at the **cementoenamel junction** using a diamond cutting disc (Shofu, India) mounted on a micromotor. Canal orifices were located, and pulp tissue was extirpated. Canal patency was confirmed using a **#10 K-file** (Mani, Tochigi, Japan). A **#15 K-file** was used to determine the working length for each specimen.

Root canals were prepared using a standardized technique up to a **master apical file size #45 K-file**. Irrigation was performed between instruments using **3% sodium hypochlorite** (Prevest DenPro Hyposol 3%). Following cleaning and shaping, the canals were obturated using **cold lateral compaction of gutta-percha** with **AD Seal Plus** (Meta Biomed) as the sealer. Radiographs were taken to confirm the quality of obturation.

The access cavities were sealed with **light-cured composite resin (Beautifil II, Shofu Inc.)**. Apical root resection was performed by removing **3 mm of the root apex** at **90° to the long axis** of the tooth using a straight fissure bur (SF-41, Mani, Tochigi, Japan) in a high-speed handpiece under water coolant.

A **3-mm deep root-end cavity** was prepared using the same straight fissure bur under water coolant. The cavity floors were burnished with a heated plugger to smear the gutta-percha. The root-end cavities were filled with **ACTIVA Bioactive Restorative** and **MTA Angelus** in their respective groups according to the manufacturers' instructions. Radiographs were taken to confirm the placement of the root-end filling materials.

The external root surfaces were coated with **three layers of nail varnish**, except for the apical region, and allowed to dry. The specimens were then immersed in **1% Rhodamine B dye solution** for **one week**. After dye immersion, the

specimens were rinsed under running tap water for **30 minutes** to remove surface dye.
The roots were sectioned **buccolingually into two halves** using a **hard-tissue microtome**. The sections were examined under **Confocal Laser Scanning Microscopy (CLSM)** to evaluate the **adaptation of the root-end filling material to the cavity walls** and to assess the **extent of dye penetration**.

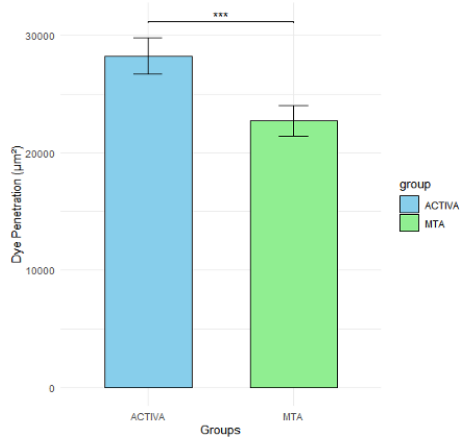
STATISTICAL ANALYSIS:

Data was coded in MS Excel and all statistical analysis were carried out using R (v 4.5.1) software. The summary of Dye Penetration were presented using maximum, minimum, mean and standard deviation. Further, it was observed that Dye Penetration follows Normality through the Shapiro-Wilk test and homogeneity of variance between the groups using Levene's test. Thus the significant difference between two groups was assessed through Student t . A p value <0.05 was considered statistically significant.

RESULTS:

A total of **43 specimens** were included in the final analysis. The **MTA group comprised 27 samples**, while the **ACTIVA Bioactive Restorative group comprised 16 samples**, as samples with loss of material during preparation were excluded from analysis.
The mean dye penetration value for the **ACTIVA Bioactive Restorative group** was **28,215 ± 1,547 µm²**, with values ranging from **25,890 to 30,870 µm²**. In contrast, the **MTA group** showed a lower mean dye penetration value of **22,710 ± 1,314 µm²**, with values ranging from **20,510 to 25,130 µm²**.
Intergroup comparison using Student's t-test revealed a **statistically significant difference** between the two groups (**t = 12.4, p < 0.001**), with the MTA group exhibiting significantly lower dye penetration than the ACTIVA Bioactive Restorative group.

	Group	n	Mean	SD	Minimum	Maximum	Test statistic	p value
etration ²)	ACTIVA	16	28215	1547	25890	30870	12.4	<0.001***
	MTA	27	22710	1314	20510	25130		



Comparison of dye penetration values (µm²) between ACTIVA Bioactive Restorative and MTA Angelus.

DISCUSSION:

The present study evaluated the sealing ability of MTA and Activa Bioactive as root end filling materials. The study demonstrated that, MTA showed superior sealing when compared to Active Bioactive Restorative, as evidenced by lower dye penetration values.

Sealing ability of cements can be evaluated using, leakage methods, confocal microscopy, scanning electron microscopy. Among these methods dyes are most commonly used; especially methylene blue due to its low molecular weight, better penetration and diffusion into the dentinal tubules. In the present study Rhodamine B dye was used because unlike methylene blue, because rhodamine b dye does not suffer chemical degradation and discoloration. It has also been noted by Kontakiotis EG et al that methylene blue exhibits incompatibility when it comes in contact with alkali substances.(4)

Activa Bioactive Restorative showed greater dye penetration compared to MTA. This could be due to its resin modified composition, polymerisation shrinkage, inadequate marginal adaptation in the retrograde cavities.

During the sample preparation, 10 samples of Activa Bioactive Restorative group showed loss of material from the root- end cavity and were excluded from final analysis. None of the MTA Angelus group showed loss of material. Similar observations were reported by Ana Raquel Benetti et al., who also reported frequent loss of Activa Bioactive Restorations during evaluation,

particularly when no surface pretreatment or adhesive was used. The authors attributed this to the **lack of true self-adhesive properties** of the material and its **inadequate marginal adaptation**.(5)

ACTIVA Bioactive Restorative was placed without surface pretreatment or adhesive in the present study, intentionally simulating the practical constraints of the surgical endodontic environment. Several authors have highlighted that it is not possible to ensure a moisture-free surgical field during retrograde filling placement, and that bond failure of adhesive materials has been directly linked to incomplete haemostasis in retrograde cavities.(REF) Resin-based systems, while adjusted from restorative dentistry, still require adequate humidity control during application — a condition that is difficult to guarantee in periapical surgery.(6)

According to the 2017 manufacturer guidelines , ACTIVA Bioactive Restorative was recommended for use with surface pretreatment using phosphoric acid. However, subsequent revisions in the 2019 guidelines advised the use of an adhesive system(type not specified) prior to placement, acknowledging limitations in bonding performance.(7–9)

In the context of , root end surgery where **haemostasis, limited working time, and moisture control are critical**, the use of additional adhesive steps may be clinically challenging. Consequently, the material's chemical curing and claimed self- adhesive properties alone may be insufficient to ensure stable retention and effective sealing in retrograde cavities.

The shape and configuration of root end cavity may have further influenced the sealing performance of Activa Bioactive Restorative. Root end preparations have high C factor due to greater number of bonded to unbonded surfaces. High C- factor environments subject resin containing materials into increased polymerization stresses, which exceeds the bond strength at dentin- material interface, leading to marginal gap formation and increased dye penetration.(10)

MTA has the ability to set in the presence of moisture; giving an added advantage in surgical endodontic environment. The current study showed lower dye penetration which is due to its hydrophilic nature, dimensional stability and formation of calcium phosphate layer in the dentin- material interface. The absence of resin in the mix eliminates polymerisation shrinkage and setting expansion enable MTA to maintain an intimate contact with dentinal walls which may further contribute to reduced microleakage.(11)

CLSM analysis was chosen for the current study. The specimens were physically sectioned using a microtome to expose root end filling- dentin interface prior to microscopic evaluation. CLSM allows visualisation of fluorescent dye penetration.
CLSM does not require dehydration or sputter coating, thereby minimising artifacts such as shrinkage and crack formation at dentin- material interface giving a significant advantage over SEM.

Thus, the use of CLSM with fluorescent dye penetration enhances the validity of the sealing ability assessment and supports the reliability of the observed differences between the materials; however, the findings should be interpreted within the inherent limitations of an in vitro study.

CONCLUSION

The present study aimed to compare the sealing ability of **ACTIVA Bioactive Restorative** and **MTA Angelus** when used as root-end filling materials. Within the limitations of this in vitro study, **MTA demonstrated better sealing performance than ACTIVA Bioactive Restorative**, as evidenced by lower dye penetration values.
These findings suggest that MTA continues to exhibit favorable characteristics for use as a root-end filling material, particularly in the surgical endodontic environment where moisture control is challenging. Although this study provides insight into the behavior of ACTIVA Bioactive Restorative and MTA in retrograde cavities, the results should be interpreted cautiously due to the in vitro nature of the investigation. Further **in vivo and long-term clinical studies** are required to evaluate the suitability of ACTIVA Bioactive Restorative as a root-end filling material and to validate its performance under clinical conditions.

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