

COMPARATIVE STUDY OF DENTIN BOND STRENGTH, SEALING ABILITY AND ADAPTATION OF TWO DIFFERENT ROOT CANAL SEALERS (AN IN VITRO STUDY)

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ABSTRACT

Aim of the study: to evaluate dentin bond strength, sealing ability, adaptation and penetration into dentinal tubules of epoxy resin based sealer (MM-Seal) and MTA based sealer (MTA Fillapex).

Methodology: Forty extracted human central permanent incisors were selected and decoronated. The canals were instrumented using crown down technique by Revo-S rotary system and obturated using single cone technique. The teeth were divided into two groups (n=20) according to sealer that used in obturation (MM-Seal or MTA Fillapex). For all samples, the coronal three millimeters were used for bond strength test. The remaining apical portions of each group were further divided to be used for dye penetration and SEM evaluation. The obtained data was analyzed using the One Way ANOVA and failure modes were classified as adhesive, cohesive or mixed.

Results: Push-out bond strength test showed that, MM-Seal showed significantly higher values than that of MTA Fillapex while MTA Fillapex showed significantly higher values than MM seal regarding dye penetration test. There were no statistically significant differences between the two filling materials regarding the adaptation and the penetration into dentinal tubules.

Conclusion: MM-Seal root canal sealer performed better than MTA Fillapex in respect of bond strength to dentin of the canal wall, adaptation and penetration into dentinal tubules and lower dye penetration than MTA Fillapex root canal sealer.

INTRODUCTION

One of the main objectives of root canal treatment is complete seal of prepared canal system with root canal sealer in conjunction with a core material.

Dimensional changes affect the integrity of the bond between the sealer and the root dentin or core material. The irregularities of the root canals and presence of accessory canals make the flow characteristic of special interest. Sealers should

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flow into irregularities and lateral canals of the root canals without causing periapical extrusion.

Different obturating materials and methods have failed to show a long-lasting perfect seal with the canal wall. Eventually, microscopic gap is formed at the material and tooth interface, which allows leakage of oral fluids and percolation followed by bacterial penetration and growth.

MTA Fillapex and MM-seal are classified as resin based sealers, presenting different compositions. MM seal, epoxy resin based sealer, has good radiopacity, biocompatibility, flow, and sealing. MTA Fillapex, a salicylate resin based sealer containing MTA, is biocompatible, and presents adequate working time, easy handling and acceptable radiopacity. MTA Fillapex also presents little antibacterial activity before setting.

Similarities related to resin based sealers and some differences on the physical properties of the original MTA formulation were expected for MTA Fillapex in spite of its favorable biological features and ability to release calcium ions.

Therefore, the aim of this study was to evaluate bond strength, sealing ability, adaptation and penetration into dentinal tubules of MM seal and MTA Fillapex root canal sealers.

MATERIALS AND METHODS

Specimens selection, preparation, grouping and obturation

Forty extracted human central permanent incisors with straight roots fully developed and free of caries, restoration or resorption. All teeth were examined with magnifying lens (7X) to rule out unacceptable teeth with root fracture or crack then stored in 1% chloramine T. The teeth were decoronated using double coated diamond disc with water coolant. The working length was determined and the canals were instrumented using Revo-S rotary instruments with crown down technique. Glyde lubricant was

used with each file. Irrigation was performed using 1ml of 2.5% NaOCl and 1ml of 17% EDTA was used after each file. A final irrigation was done using 2 ml of 17% EDTA for one minute followed by 5ml of distilled water. All samples were obturated using single cone technique using Gutta-Percha. The teeth were divided into two equal groups (n=20) according to root canal sealer used in obturation: **Group (A):** The teeth were obturated using MM-Seal. **Group (B):** The teeth were obturated using MTA Fillapex. For all samples, the coronal three millimeters of roots were horizontally sectioned and used for bond strength test. The remaining apical portions of each group were further divided into: **(A₁ & B₁):** The apical portions of 10 specimens for each group were used for dye penetration evaluation. **(A₂ & B₂):** The apical portions of the other 10 specimens for each group were used for Scanning Electron Microscope evaluation. All specimens were stored in an incubator (100% humidity at 37°C) for seven days ⁽¹⁾ to allow the sealer to set.

Push-out bond strength procedure:

The coronal portion just below the cement-enamel junction of each root was sectioned perpendicular to its long axis to create 3.00± 0.1 mm slices using double coated diamond disc with water coolant. Each root slice was embedded in acrylic resin and mounted in custom made loading fixture using sticky wax. The filling material was loaded with a 1mm diameter cylinder plunger using universal testing machine until bond failure occurred. The bond strength was determined in Newton by using Nexygen computer software program, which blotted a load/time curve during compression testing. To express the bond strength in Mpa, the load at failure recorded in Newton was divided by the area of the bond interface as calculated by the following formula ⁽²⁾.

$A = 2 \pi r \times h$ where π is constant 3.14, r radius of root canal and h is a thickness of the slice in millimeters.

Analysis of Failure Modes

After the push out test, the slices were examined with stereomicroscope to determine the mode of failure. Each sample was evaluated and placed into one of three failure modes: Type (I): adhesive (failure at the sealer–dentin interface or sealer–core interface). Type (II): cohesive (failure within the sealer or dentin). Type (III): mixed (failure in both the sealer and dentin).

Dye Penetration Method

The outside of the teeth was coated with two layers of nail varnish except the apical 2mm then immersed vertically in 2% methylene blue solution for seven days at 37°C in labeled sealed containers. After being removed from the dye solution, the specimens were washed with copious water, dried and the nail varnish was scraped away from the root surface with a scalpel then sectioned labio-palatally in a longitudinal direction with a diamond disc under running water. Linear apical leakage measured from the apex to the coronal extent of the methylene blue dye penetration for each specimen. Images were taken by a stereomicroscope at magnification 10X, transferred to a computer and linear penetration of the dye was measured using Image JI.410 free software.

Scanning Electron Microscope evaluation

The remaining ten apical portions of the roots were sectioned longitudinally. The sectioned specimens were immersed in 6% hydrochloric acid (HCl) for 30 seconds. The specimens were further immersed in 1% sodium hypochlorite (NaOCl) for 30 minutes then rinsed by copious amount of distilled water and dehydrated through immersion in 99.9% ethyl alcohol for 30 seconds then left to dry for 24 h⁽³⁾. Prepared samples were then mounted in aluminum stubs, vacuum dried, coated with 20µm of gold and examined under the Scanning Electron Microscope with magnification (2000x). Sections were evaluated for adaptation of the filling material to the canal walls.

RESULTS

Results of Push-Out Bond Strength test

The values obtained by push-out test, in Newton were transformed into MPa. According to one-way ANOVA, there were statistically significant difference ($p < 0.0001$) between MM-Seal and MTA Fillapex sealer. MM-Seal sealer exhibited the highest bond strength values (1.58 ± 0.86 MPa) than those of MTA Fillapex sealer (0.24 ± 0.1 MPa) (fig.1).

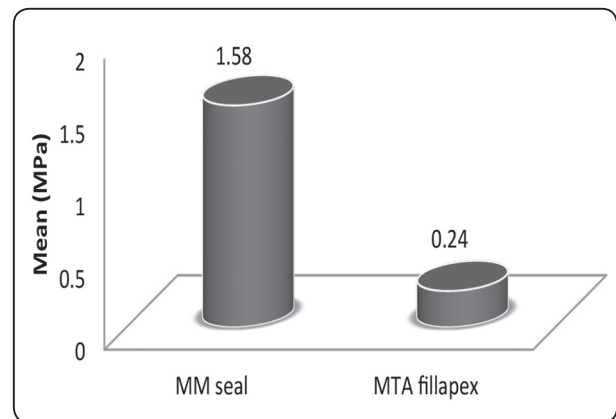


Fig. (1): A bar chart of push-out bond strength mean values in MPa for both groups.

-Analysis of failure modes

Stereomicroscopic examination revealed that the bond failure was the predominance of the cohesive failure for MM-Seal and mixed failure for MTA Fillapex. Adhesive failure occurred in both groups, with greater prevalence for MTA Fillapex.

-Results of apical leakage

Analysis of data using one-way ANOVA showed statistically significant difference ($p < 0.05$) between MM-Seal and MTA Fillapex sealer. Dye penetration was observed in both two groups, MM-Seal showed less mean (0.47 ± 0.24 mm) than MTA Fillapex (0.62 ± 0.34 mm) **table (1)**.

TABLE (1): Means, standard deviations and ANOVA value of apical leakage:

Group	Mean	S.D	ANOVA value
MM-Seal	0.47	0.24	P<0.05
MTA Fillapex	0.62	0.34	

Adaptation:

The Two Way ANOVA results **table (2)** showed that, there are significant difference between the mean values of middle and apical samples (P<0.05) at the same group but there were no statistically significant difference between the two filling materials (P>0.05).

TABLE (2): Mean gap (micrometer) and standard deviation in groups and samples.

Group \ Samples	MM-Seal	MTA Fillapex	P.value
	Mean± SD	Mean± SD	
Middle	1.07±0.87 ^a	2.17±1.27 ^a	1.203*
Apical	4.54±1.89 ^b	6.17±3.98 ^b	0.505*

* P>0.05: no significance difference between the two materials. Different letters indicate statistically significant differences between the middle and apical samples.

Tubular penetration

MM-Seal showed better tubular penetration than MTA Fillapex (fig.2&3), However, there were no statistically significant differences at the middle and apical segments between the two filling materials (P >0.05).

DISCUSSION

The optimal outcome in obturation is to maximize the volume of the core material and minimize the amount of sealer between the inert core and the canal wall⁽⁴⁾.

In this study, the push-out test method was used to test the dentin bond strength of the sealers to the dentinal wall of the canals⁽⁵⁾ because the test has been shown to be effective, reproducible and allow accurate standardization of the specimens. It has been suggested that this test provides a better evaluation of bond strength than the conventional shear test because in the push-out test, fracture occurs parallel to the dentin-bonding interface, which makes it a true shear test for parallel-sided samples^(1,6).

The results of bond strength were in agreement with^(1,7,8,9) who found that MTA Fillapex had the lowest bond strengths compared to epoxy resin

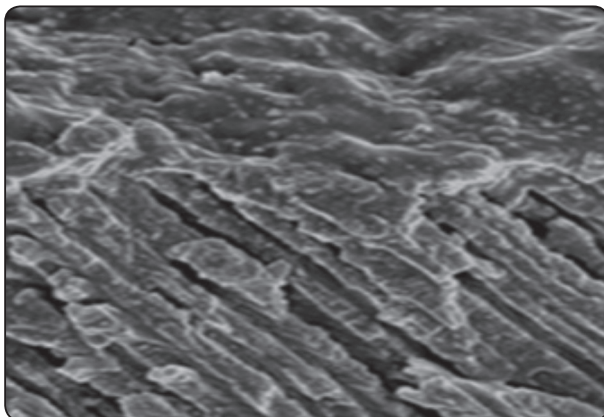


Fig. (2): Micrograph showing good adaptation& penetration of MM-Seal into dentinal tubules in middle third.

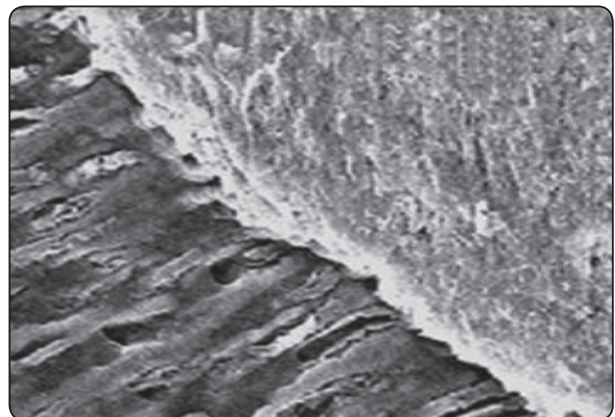


Fig. (3): Micrograph showing good adaptation & penetration of MTA Fillapex into dentinal tubules in middle third.

based sealer (AH Plus). This result might be related to the low adhesion capacity to dentinal tubules because of the formation of apatite by MTA, over its own surface ⁽¹⁰⁾. MTA Fillapex, also has resin among its constituents, which may undergo polymerization shrinkage upon setting, thereby resulting in a reduced strength of the bond with the canal wall.

The results of this study were in disagreement with *Assmann et al (2012)*⁽¹¹⁾ who found no significant difference between MTA Fillapex and AH Plus, where MTA Fillapex contains resins as one of its components, and the mechanism of adhesion of resins enhanced by removal of smear layer, which facilitated the penetration of resins into the dentinal tubules.

In this study, the dye penetration was used because of its simplicity, ease to perform and it does not require sophisticated materials ⁽¹²⁾. Longitudinal sectioning of roots and linear measurement of dye penetration were used to measure apical leakage. Longitudinal sectioning method enables examination of the exposed filling material and any dye penetration into the material and at the interface of the dentinal wall ^(13, 14, 15&16).

This result came in accordance with ^(16&17) who tested also an epoxy resin based sealer (AH 26 & AH Plus) and found significant differences in apical sealing ability between epoxy resin based sealer (AH 26 & AH Plus) and MTA Fillapex and sealing ability of epoxy resin based sealers were higher than MTA Fillapex root canal sealer.

The result of this study came in disagreement with *Moradi et al (2009)*⁽¹⁸⁾ who found that MTA Fillapex had a better apical seal compared to epoxy resin based sealer AH26 due to the expansion during setting of MTA Fillapex.

Scanning Electron Microscope was used in the study to assess the adaptation of sealer to the root canal dentin because it has large depth of field,

higher resolution and better magnification at the interface. The SEM uses electromagnets rather than lenses allowing the researcher to have more control over the degree of magnification, thereby providing strikingly clear images ⁽¹⁹⁾.

SEM was used in the present study to assess the tubular penetration of the tested materials and their adaptation to the root canal walls ⁽²⁰⁾.

In this study, MM-Seal showed better tubular penetration than MTA Fillapex. This result can be explained because the resin nature of these sealers. Although MTA Fillapex is constantly called as MTA-based sealer, however its composition is predominantly resinous, especially salicylate resin. This result comes in accordance with ⁽²¹⁾ who found that there was no significant difference in the dentinal penetration between MTA Fillapex and AH Plus.

The results of the tubular penetration were in disagreement with *Daniela et al (2014)* ⁽²²⁾ who found that there was significant differences between epoxy resin based sealer (AH-26) and MTA Fillapex sealer. This related to the higher flowability of epoxy resin based sealer than MTA Fillapex. Root canal filling materials should have low surface activity or an adequate surface active reagent in order to be able to penetrate dentinal tubules ⁽²³⁾.

Regarding the adaptation of the filling to the canal wall, MM-Seal showed superior adaptation to the canal walls than MTA Fillapex. This might be related to higher adhesion and expansion of epoxy resin based sealer than MTA Fillapex.

CONCLUSION

Under the limits of the present study it was concluded that:

1. Both tested obturating materials had good bond strength; however, MM-Seal root canal sealer performed better than MTA Fillapex.

2. Dye penetration that represents the leakage profile was apparent more with MTA Fillapex root canal sealer.
3. Effective dentinal penetration also was with MM-Seal.
4. The position of the root segments has influence on its performance. The gaps in the middle root segments were lesser than that formed in the apical root segments as the tubular penetration was deeper in the middle root segments.

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