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A comparative evaluation of sealing ability of four root end filling materials using fluid filtration method: An *in vitro* study

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Abstract

Aim of the Study:

The aim of this study was to compare and evaluate the sealing ability of four root end filling materials mineral trioxide aggregate (MTA)-Plus, Biodentine, MTA (MTA Angelus) and glass ionomer cement (GIC) using fluid filtration method.

Materials and Methods:

Forty-four extracted, human single-rooted teeth were collected. The crown of each tooth was decoronated 2 mm above the cementoenamel junction. Canals were negotiated, instrumented, obturated using lateral compaction method. The access cavities were sealed with Cavit. Root end resection and apical root end cavity preparations of 4 mm were made in each specimen. The selected roots were then randomly divided into four groups ($n = 11$) and restored as follows. Group 1 – GIC, Group 2 – MTA (MTA Angelus), Group 3 – Biodentine, and Group 4 – MTA Plus. The apical microleakage of each specimen was assessed using fluid filtration method at 72 h, 1 month and 3 months. Microleakage in each specimen was recorded in mm (millimeter) and converted to $\mu\text{l}/\text{min}/\text{cm H}_2\text{O}$.

Results:

MTA Angelus showed least microleakage followed by Biodentine and MTA Plus. Least sealing ability was seen with GIC. There was statistically significant difference between all the materials at various time intervals.

Conclusion:

MTA Angelus showed superior sealing ability as a retrograde filling material followed by Biodentine and MTA Plus.

Keywords: Biodentine, fluid filtration method, glass ionomer cement, mineral trioxide aggregate angelus, mineral trioxide aggregate plus, root end filling

INTRODUCTION

The objective of endodontic therapy is to clean, shape, and fill the root canal system three dimensionally. However, various factors are responsible for failure of root canal treatment. Such cases are treated nonendodontically or surgically.[1] Endodontic surgery usually involves exposure of the apex, root resection, root-end preparation, and root-end filling.[2] Several materials have been proposed as root-end fillings, including amalgam, zinc-oxide-eugenol cements, glass ionomer cements (GIC), gutta-percha, intermediate restorative material, super ethoxybenzoic acid (Super EBA), resin composite and mineral trioxide aggregate (MTA).[1,3,4] An ideal root end filling material should be biocompatible, nontoxic, easy to manipulate, radiopaque, dimensionally stable, and adhere to dentin.[3] Good apical seal such that there is no tissue fluid movement into the root canal system from apex is also one of the important properties a root end filling material should possess.

Various studies have been conducted to evaluate the sealing ability of the material. GIC which bonds to tooth dentin has shown poor sealing ability when it was contaminated with moisture at the time of placement of cement.[4]

In 1993, MTA was developed at Loma Linda University. Studies by Torabinejad *et al.* and Fischer *et al.* proved MTA to be superior with better marginal adaptation.[5] It has been proved to seal off all the pathways between the root canal and periradicular tissues. Studies have also shown that MTA has poor handling properties.[1,4]

Recently, two new materials were introduced into the market, namely, MTA Plus (compounded by Prevest Denpro, Jammu City, India for Avalon Biomed Inc USA) and Biodentine (Septodont, Saint Maur des Fosses, France). Manufacturers claim that these materials have good handling properties (faster setting time) and biological properties and can also be used for root-end filling.[6,7] Manufacturers also claim that these materials evoke a positive tissue response to promote regeneration of the periodontium.[6]

Hence, the purpose of this study is to compare and evaluate the sealing ability of these two new root-end filling materials with MTA Angelus and GIC for apical seal using fluid filtration method.

MATERIALS AND METHODS

Forty-four extracted single-rooted maxillary central incisors were selected for the study. The selected teeth were evaluated for fractures and surface cracks. Teeth with fractures and cracks were discarded. The teeth were decoronated 2 mm above cemento-enamel junction, using diamond disk at a plane perpendicular to long axis of the tooth. All the samples were subjected to standard endodontic root canal treatment. The root canals were cleaned and shaped by standardized technique using K files and reamers till size 60. Irrigation was performed using 3% sodium hypochlorite, saline, and hydrogen peroxide. The canal was obturated by lateral condensation technique using AH Plus sealer and guttapercha. The coronal access was sealed with Cavit. Apical 3 mm of each root was resected using a high-speed tapered fissure bur. Retrograde cavity preparation of 4 mm was done using a KIS ultrasonic tip. The teeth were then randomly divided into following four groups and restored, respectively, with as follows:

- Group 1 ($n = 11$) - GIC
- Group 2 ($n = 11$) - MTA (MTA-Angelus)
- Group 3 ($n = 11$) - Biodentine
- Group 4 ($n = 11$) - MTA Plus.

The external surfaces of the roots were coated with nail polish, except at the resected root surface. All the roots were then placed in gauze saturated with saline solution for 72 h. The apical microleakage of each specimen was assessed using fluid filtration method. This system involves the evaluation of fluid transport in specimens calculated by the movement of air bubble which is created in the apparatus. After evaluation at first- and second-time interval, the specimens were placed in gauze saturated with saline.

Microleakage testing apparatus (fluid filtration model)

This fluid filtration model is equipped with an air tank which has a manometer with precise adjustment of pressure. The pressure ranged from 10 to 20 psi, at 1 atmosphere. A specific plastic tube was connected to the air source, and the end part was connected to an Erlen. Two holes were made on the Erlen's cap, one for the entrance of air and the other for emersion in fluid. Micropipette (0.1cc) was fixed and its end was connected to a three-valve tube by a latex pipe (0.5 cm in diameter). The upper side of the three-valve tube was connected to a syringe, which was used to create an air bubble through the micropipette. The lower side was used to connect specimens.

Specimens were tested for microleakage at 72 h, 1 month, and 3 months. Microleakage in each specimen was recorded in mm (millimeter) and converted to $\mu\text{l}/\text{min}/\text{cm H}_2\text{O}$ using the formula $v = \pi r^2 L/100$.

The results were tabulated at each time interval and statistically analyzed using Kruskal–Wallis test and Mann–Whitney U-test. The significance level was set at $P \leq 0.05$. SPSS (Statistical Package for Scientific Studies) for Windows version 20.0[®] was used for the statistical analysis of this study.

RESULTS

SPSS (Statistical Package for Scientific Studies) for Windows version 20.0[®] was used for the statistical analysis of this study. The nature and distribution of variables indicated that analysis by nonparametric methods were appropriate. The microleakage scores at different time interval, i.e., at 72 h, 1 month, and 3 months were recorded and analyzed using Kruskal–Wallis test and Mann–Whitney U-test.

Results showed that there was statistically significant difference between the materials at all-time intervals, i.e., 72 h, 1 month, and 3 months with *P* value 0.000, 0.000, 0.000, respectively [Table 1].

Table 1
Kruskal-Wallis test

At 72 h, there was statistically significant difference between MTA Plus with MTA Angelus and GIC with *P* value (0.028 and 0.000), respectively [Table 2]. There was statistically significant difference between GIC with MTA Angelus and Biodentine with *P* value (0.000 and 0.000), respectively [Table 2]. There was no statistically significant difference between Biodentine with MTA Plus and MTA Angelus with *P* value (0.60 and 0.056), respectively [Table 2]. At 1 month, there was statistically

significant difference between MTA Plus and GIC with P value (0.000), respectively [Table 2]. There was statistically significant difference between GIC with MTA Angelus and Biodentine with P value (0.000 and 0.000), respectively [Table 2].

Table 2

Mann-Whitney U-test at 72 h, 1 month and 3 months

At 3 months, there was statistically significant difference between MTA Plus and GIC with P value (0.001), respectively [Table 2]. There was statistically significant difference between GIC with MTA Angelus and Biodentine with P value (0.000) and (0.001), respectively [Table 2].

DISCUSSION

Sealing ability refers to the materials ability to resist microleakage through the entire thickness of the material.[8] Inadequate apical seal leads to microleakage and is one of the major causes of surgical endodontic failure. Microleakage is defined as the movement of bacteria, fluids, molecules, or ions between the tooth and restorations of any type.[9] Various techniques for assessing microleakage have been developed and utilized. Most modern techniques utilize different principles involving biological, chemical, electrical, physical, or radioactive components.[10] These include the use of dyes, radioactive isotopes, air pressure, fluid filtration, bacteria, neutron activation analysis, artificial caries, scanning electron microscopy, calcium hydroxide, and other methods.[11,12,13,14,15]

Fluid filtration method was used in this study to evaluate the microleakage of the root end materials. The study used the fluid filtration model with the specifications: Pressure adjusted between 10 and 20 psi, 1 atmospheres or 15–30 cm H₂O. This system involves the evaluation of fluid transport in specimens which is calculated by the movement of air bubble created in the apparatus.

The period to record the fluid transport ranged from 1 min to 3 h. Longer period was used in this study as it increases the accuracy of the measurement without leading to exaggerated results.[16] The readings recorded were expressed as $\mu\text{l}/\text{min}/\text{cm H}_2\text{O}$.

In the present study, all the materials showed microleakage. Conventional GIC (ESPE AG Germany) showed significantly more leakage than MTA Angelus (Angelus, Londrina, PR, and Brazil), Biodentine (Septodont, Saint Maur des Fosses, France) and MTA Plus (compounded by Prevest Denpro, Jammu City, India for Avalon Biomed Inc USA) at all the time intervals. The reason could be lack of bonding because of contamination with moisture.[4] The results obtained in this study is similar to study conducted by de Bruyne *et al.*[17]

The microleakage with Biodentine was similar when compared with MTA Angelus and MTA Plus. The reason could be shorter setting time (12 min), hydrophilic nature of the material, and mild expansion of the material on setting.[18,19,20]

The samples of MTA Plus showed more leakage at 72 h but negligible difference at 1 month and 3 months interval when compared with MTA Angelus and Biodentine. The effect of wet curing retarded the setting time as in this study which could be the possible reason for significant leakage at initial

hours (72 h).[21] MTA Plus which composes tricalcium silicate and bismuth oxide has a setting time of 1.2 h.[21] Hydration and setting of the material explains the minimal leakage at later time intervals (1 and 3 months). The microstructure, elemental make-up and hydration reaction of MTA Plus produces an alkaline pH and releases calcium ions in solution, indicating that it is expected to be bioactive.[6]

MTA Angelus showed least microleakage among the tested materials at all the time intervals. This is because MTA Angelus consists of fine hydrophilic particles that absorb water during hydration of powder. Therefore, the material expands during solidifying which yields superior adaptation to dentine. [22] This result is supported by the study conducted by Xavier *et al.* where superior sealing ability and better marginal adaptation with MTA Angelus than super EBA and Vitremer was observed.[23]

Thus, the study concludes that MTA Angelus had superior sealing ability. The two new bioactive materials MTA plus and Biodentine were also efficient in providing long-term seal to the root canal system.

CONCLUSION

Within the limitations of the present study, it is concluded long-term evaluation and comparison of sealing ability of root-end filling materials using fluid filtration model was possible. MTA Angelus showed superior sealing ability as a retrograde filling material followed by Biodentine and MTA Plus.

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Conflicts of interest

There are no conflicts of interest.

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