A comparative analysis of microleakage of three root end filling materials – an *in vitro* study

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**Keywords**

GIC, microleakage, Miracle Mix, MTA, root-end filling.

**Abstract**

The main objective of a root end filling material is to provide an apical seal that prevents the movement of bacteria and the diffusion of bacterial products from the root canal system into periapical tissues. The aim of this study was to compare the microleakage of three root end filling materials Mineral trioxide aggregate (MTA), Glass ionomer cement (GIC) and Silver GIC (Miracle Mix) using dye penetration technique under stereomicroscope. Forty-five extracted human maxillary central incisors were instrumented and obturated with gutta percha using lateral compaction technique. Following this, the teeth were stored in saline. After one week, teeth were apically resected at an angle of 90° to the long axis of the root and root end cavities were prepared. The teeth were divided into three groups of fifteen specimens each and were filled with Group I – MTA, Group II – GIC and Group III – Miracle Mix. The samples were coated with varnish and after drying, they were immersed in 1% methylene blue dye for 72 hours. The teeth were then rinsed, sectioned longitudinally and observed under stereomicroscope. The depth of dye penetration was measured in millimeters. Microleakage was found to be significantly less in MTA (0.83 mm) when compared to GIC (1.32 mm) (p < 0.001) and with Miracle Mix (1.39 mm) (p < 0.001). No significant difference was found when microleakage in Miracle Mix was compared to that of GIC (p = 0.752). Thus we concluded that MTA is a better material as root end filling material to prevent microleakage, in comparison to GIC and Miracle Mix.

**Introduction**

One of the most important factors for a successful endodontic treatment is the complete obliteration of root canal system and development of a fluid tight seal (Ozata et al., 1993). Despite the constant evolution of concepts, new endodontic techniques and the development of more effective materials and instruments, the resolution of periapical pathosis is not achieved in certain cases (Sousa et al., 2004). In such cases, where conventional endodontic treatment is unsuccessful, surgical endodontic therapy is needed to save the tooth (Holt and Dumsha, 2000). This procedure includes exposure of the involved apex, resection of apical end of root, preparation of class I cavity and insertion of a root end filling material (Torabinejad et al., 1994).

The main objective of a root-end filling material is to provide an apical seal that prevents the movement of bacteria and the diffusion of bacterial products from the root canal system into the periapical tissues (Fogel and Peikoff, 2001). It has been proposed that an ideal root-end filling material should adhere to the preparation walls forming a tight seal in the root canal system (Ingle and Bakland, 2002). It should be easy to manipulate, radiopaque, dimensionally stable, and nonabsorbable. Also an ideal root-end filling material should not be affected by presence of moisture. It should be adhesive to dentin, nontoxic, well tolerated by the periradicular tissues and promote healing (Dorn and Gartner, 1990). Many materials have been introduced for this purpose in endodontic surgery such as gutta-percha, amalgam, Cavit, intermediate restorative material (IRM), Super EBA, glass ionomers, composite resins, carboxylate cements, zinc phosphate cements, zinc-oxide eugenol cements, and Mineral trioxide aggregate (MTA). However, no filling material satisfies all the requirements of an ideal material (Ingle and Bakland, 2002).

MTA has been investigated as a potential alternative restorative material to the presently used materials in endodontics. Several *in vitro* and *in vivo* studies have shown that MTA...
prevents microleakage, is biocompatible, and promotes regeneration of the original tissues when placed in contact with the dental pulp or periapical tissues (Torabinejad and Chivian, 1999). MTA has not shown to exhibit mutagenicity (Kettering and Torabinejad, 1995). Its adaptation and properties are not affected by moisture as seen in various studies where it has been proved that there was no significant difference in its retention when a dry or wet cotton pellet was used during its packing into the cavity. (Slyuyk et al., 1998). These properties of MTA make it a suitable root end filling material.

When non-adhesive materials are used for apical sealing, a microscopic space always exists between the restoration and the tooth which leads to microleakage (Torabinejad et al., 1995). Microleakage is defined as flow of oral fluid and bacteria into the microscopic gap between a prepared tooth surface and a restorative material. The quality of apical seal obtained by root end filling materials has been assessed by the degree of dye penetration, radioisotope penetration, electrochemical means and fluid filtration techniques. All of these techniques have been shown to have a variety of shortcomings. The dye penetration method used for measuring sealing ability is the most popular and is easily performed. Various dyes that can be used include India ink, basic fuchsin, silver nitrate with developer and methylene blue. According to the various studies conducted, methylene blue has been proved to be a useful aid in endodontics (Ahlberg et al., 1995). The objective of this study was to compare the microleakage of three root end filling materials MTA, Glass ionomer Cement (GIC) and Silver GIC (Miracle Mix) using dye penetration technique under stereomicroscope.

Materials and methods

Study samples
This was a comparative experimental study, which involved 45 extracted teeth consisting of three groups, each with 15 samples.

Sample processing
Forty-five freshly extracted human maxillary central incisors with completely formed apices and straight canals were stored in normal saline until use. The teeth were cleaned ultrasonically and sectioned at Cemento-enamel junction using a diamond disc before root canal preparation. Preoperative radiographs were taken and access cavities were prepared using an Endo Access Bur. The pulp tissue was extirpated with a barbed broach. K-File (Dentsply Maillefer, USA) was used to confirm canal patency. The working length was determined with the help of radiographs.

Canals were cleaned and shaped using step back technique, 3% sodium hypochlorite and 17% EDTA (Pulpdent Corporation, USA) were used as irrigants. All the canals were enlarged up to No. 50 K-file (master apical file) at the apical foramen. The specimens were stored in normal saline until obturation. Canals were dried using absorbent paper points and master cone selection was confirmed with radiographs. Canals were obturated with gutta percha by lateral compaction technique. Radiographs were taken to confirm the quality of obturation and the access cavities were sealed with composite resin restorative material after 24 hours.

The teeth were then stored in saline for 1 week. They were resected apically at 90° angle axis to the long axis of the root using cross cut fissure bur (556, Mani, Japan) removing 3 mm of the apex. The 3 mm deep retrograde cavity was prepared using straight fissure diamond bur (SF 41, Mani, Japan) the cavities were irrigated with saline and dried. The teeth were randomly divided into 3 groups of 15 specimens each:

- **Group I** - Mineral trioxide aggregate (Pro Root MTA, Dentsply, Tulsa, Okla, USA).
- **Group II** – Glass ionomer cement (GC Fuji II, GC Corporation, Tokyo, Japan).
- **Group III** – Miracle Mix (MM, GC Corporation, Japan).

These materials were manipulated according to the manufacturer’s instructions and the cavities were filled using a Messing’s carrier. Specimens were stored in moist cotton at room temperature. They were coated with three coats of nail varnish except at the apical 1 mm of the resected root, and then were allowed to dry (Figure 1). The specimens were suspended in 1% methylene blue for 72 hours. Following this, the roots were rinsed for 15 minutes under tap water. The teeth were split longitudinally with a diamond disc using a water coolant. The depth of dye penetration was examined under stereomicroscope (30X) and microleakage associated with different root end filling materials was evaluated in millimetres as shown in Figures 2, 3 and 4.

Statistical data analysis

Statistical software SPSS 12.0 was used for analyzing the data and for generating the graphs and tables. One way ANOVA test was used to generate the numerical data. Results with \( p < 0.05 \) were considered significant.

Results

Table 1 shows microleakage values for different groups. Comparison of microleakage showed maximum peak value of 0.83 mm with a standard deviation of 0.36 for MTA, 1.32mm with a standard deviation of 0.14 for GIC and 1.39 with a standard deviation of 0.25 for Miracle Mix. Graphical representation is shown in the form of cluster graph (Figure 5). Results of one-way ANOVA test for leakage showed \( p < 0.001 \), which is statistically significant. Microleakage was found to be significantly less in MTA (0.83 mm) when compared to GIC (1.32 mm) \( (p < 0.001) \) and with Miracle Mix (1.39 mm) \( (p < 0.001) \) No significant difference was found when microleakage in Miracle Mix was compared to that of GIC \( (p = 0.752) \).
Microleakage of root end filling materials

Figure 1 Resected specimen after coating with nail varnish (MTA - Mineral trioxide aggregate, GIC- Glass inomer cement, MM - Miracle Mix).

Figure 2 Photomicrograph showing microleakage of MTA as seen under stereomicroscope (30X).

Figure 3 Photomicrograph showing microleakage of GIC as seen under stereomicroscope (30X).

Figure 4 Photomicrograph showing microleakage of MM as seen under stereomicroscope (30X).

Figure 5 Cluster graph showing the range of variation among dye leakage values of three materials (mm).

Table 1 Comparison of microleakage (mm) for three different materials

<table>
<thead>
<tr>
<th>Materials</th>
<th>Mean ± SD</th>
<th>Range</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTA</td>
<td>0.83±0.36</td>
<td>0.18-1.26</td>
<td>0.63-1.03</td>
</tr>
<tr>
<td>GIC</td>
<td>1.32±0.14</td>
<td>1.00-1.57</td>
<td>1.25-1.40</td>
</tr>
<tr>
<td>Miracle Mix</td>
<td>1.39±0.25</td>
<td>1.16-2.00</td>
<td>1.26-1.53</td>
</tr>
</tbody>
</table>

Significance by ANOVA: F=20.449, p<0.001

Discussion

Numerous substances have been used as root end filling materials. The choice of a root-end filling material could be governed by biocompatibility, apical sealability, handling properties and long term clinical success (Johnson, 1999). Most in vitro studies evaluate leakage of the apical seals, but the correlation between dye leakage around root-end filling materials and their clinical performance is uncertain. The clinical significance of microleakage in apical surgery has not been elucidated. However it seems logical that the lesser leakage would prevent migration of bacteria and toxins into the periradicular tissue (Johnson, 1999).

Studies on physical and chemical properties of MTA have shown that calcium and phosphorus are the main ions present in this material. These are also the principal ions of dental hard tissues; therefore MTA may prove to be biocompatible when used in contact with cells and tissues (Bates et al., 1996; Torabinejad et al., 1995). MTA also induces hard tissue barrier, similar to that obtained in apexification procedures. This would minimize interaction between material and host tissues. Also it is a more radiopaque material than conventional gutta percha and dentin, thus is easily distinguishable on radiographs when
used as a root end filling materials (Bates et al., 1996).

Our results showed that all materials exhibited microleakage but there was significantly less leakage in MTA (0.83 mm) when compared to Miracle Mix (1.39 mm) and GIC (1.32 mm). This result was congruent with previously done studies where MTA has been proved to be better than other materials (Aqrabawi, 2000; Chong et al., 2003: Chong et al., 1995: Nakata et al., 1998: Perez et al., 2003: Shipper et al., 2004: Sousa et al., 2004). All these properties, favour its use as a root end filling material hence MTA was selected as one of the material for this study.

Glass ionomer cement is a material with universal properties. It is a dentin substitute. Its ability to bond chemically to tooth structure possesses an excellent marginal seal. Studies have shown that glass ionomer cement possesses antibacterial activity due to slow releases of fluoride (Inoue et al., 1991).

In a confocal microscopic study the adaptation and sealing ability of a light cured glass ionomer as a retrograde root filling material was compared with conventional glass ionomer cement and amalgam. The results showed that sealing ability of light cured GIC was better than amalgam, also which of conventional GIC was better than amalgam (Chong et al., 1991). Hence, it was used in this study.

Silver GIC was the third material chosen for this study and its qualities were compared with other current materials being used. A comparison of apical microleakage between retrograde fillings with amalgam and with silver glass ionomer cements using a dye penetration method showed that silver-glass ionomer cements and varnish were less cytotoxic than amalgam. It was concluded that silver-glass ionomer cement can be considered an alternative retrograde filling material. Silver GIC has been proved to be better than conventional amalgam; hence it was selected for this study (Pissiotis et al., 1991).

Silver GIC demonstrated more microleakage than GIC and MTA and these results were statistically significant to the previously conducted studies (Ozata et al., 1993). In vitro microleakage studies were conducted to compare reverse filling with zinc free amalgam and silver GIC and the results indicated that silver GIC demonstrated significantly less leakage than zinc free amalgam placed with cavity varnish (Schwartz and Alexander, 1988).

In this study it was found that GIC shows lesser microleakage than Miracle Mix though no statistical difference was found (p=0.752). This result was congruent with previous studies where GIC was compared with amalgam and silver GIC and was found to be better than the other two materials (Ozata et al., 1993). The results of this study showed MTA to have least microleakage which is in congruence with study comparing GIC, MTA Super EBA and amalgam using fluid transport model (Aqrabawi, 2000).

**Conclusion**

This study concludes that MTA is a better material as root end filling material to prevent microleakage in comparison to GIC and Miracle Mix. However, further in vivo studies are required to find the best root canal filling material.

**References**


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behave differently when in contact with ProRoot MTA and White MTA. *Int Endod J*, 36(8): 564-570.


