An In Vitro Comparison of Apical Leakage of Biocalex, White MTA, Gray MTA, and Amalgam as Root-End Fillings

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Abstract:
Objective: In a cavity prepared through endodontic surgery, application of a material to provide apical seal and prevent bacterial and tissue exudates is of great importance. The purpose of this study was to compare the sealing ability of Biocalex with white MTA, gray MTA, and amalgam as root-end fillings.

Materials and Methods: Sixty-six single-rooted extracted human teeth were cleaned, shaped, and obturated with gutta-percha. The root apices were resected and 3 mm deep retrograde cavity was prepared. The teeth were assigned randomly into four groups of 15 teeth each and retrofilled with Biocalex, gray MTA, white MTA, and amalgam. Six teeth served as positive and negative controls. All root surfaces, except the ending part, were covered with two layers of nail polish. The roots were then stored in 2% methylene blue for 72 hours and embedded in polyester resin. The teeth were sectioned buccolingually and maximum extent of dye penetration was evaluated through a stereomicroscope. Statistical analysis was carried out by one way ANOVA and Tukey test.

Results: Biocalex showed significantly less leakage compared to the other three materials P<0.05. White MTA showed significantly lower amount of leakage as Compared to gray MTA and amalgam P<0.05.

Conclusion: The findings of this study showed that retrograde filling with Biocalex can achieve proper sealing ability and this material can be used as an alternative for MTA and amalgam.

Key Words: Dental Leakage; Endocal 10; mineral trioxide aggregate

INTRODUCTION
For teeth with unsuccessful root canal therapy, retrograde filling through endodontic surgery is a widely accepted technique to treat persistent periapical infections and to obtain an apical seal [1]. Sealing ability and biocompatibility of retrograde filling materials have been the subject of many in vitro and in vivo studies. Although amalgam has been considered as a good retrofilling material for many years, it has some disadvantages including corrosion, delayed expansion, marginal leakage and tattoo. Some alternatives have been suggested such as gutta-percha, cavit, composite resins, glass-ionomer cements, and recently, Mineral Trioxide Aggregate (MTA). MTA Originally developed by Torabinejad et al [2], gray MTA mainly consists of calcium silicate, bismuth oxide, calcium carbonate, calcium sulfate, and calcium aluminate. Gray MTA has been reported to be biocompatible in studies using cell culture techniques and connective tissue reactions [3,4]. Recently, a variation of the original formula of gray MTA was introduced. The chemical composition of this material, which is often called white MTA, is very simi-
lar to the original with less than 6% difference in components [5]. In vitro sealing ability and biocompatibility studies comparing root-end filling materials have shown MTA to be superior to other commonly used materials. Moreover, MTA has several advantages over existing root-end filling materials: It is easy to mix; it can be applied on wet field, and it is easy to remove any excess [2]. On the other hand, the most commonly cited disadvantage of MTA is its handling properties. MTA is more difficult to place in the root-end cavity than most other materials.

Biocalex 6.9 (currently known as Endocal 10) is a calcium oxide material with more than 30 years background application in European countries [6], but is now being used in North America since its recent FDA approval of Endocal 10. Studies have shown that Biocalex 6.9 possesses specific properties resulting in enhanced biocompatibility and sealing ability [7-10]. Guigand et al [7] showed that calcium oxide-based materials change into calcium carbonate in the presence of carbon dioxide produced by protein degradation and into calcium hydroxide on contact with residual water, suggesting that they may have properties similar to calcium hydroxide. Minana et al [8] demonstrated that when calcium oxide reacts with water, hydroxyl ions diffuse through the dentinal tubules to the surface of the root.

The purpose of this in vitro study was to compare the sealing ability of Biocalex with white MTA, gray MTA, and amalgam as retrofills.

MATERIALS AND METHODS
The study was done on sixty-six single rooted human teeth. Examining the teeth under a stereomicroscope showed absence of cracks. Radiographs were taken to ensure absence of multiple canals, calcifications, or curvature. The clinical crown of each tooth was cut at the cemento-enamel junction using a #701 fissure bur in a high-speed hand piece and water spray. Working length of each canal was determined by placing a #15 K file (Dentsply Maillefer, Ballaigues, Switzerland) apically in the canal until it exited from the apical foramen. After enlarging the apical foramen to the size of #40 K file, using standard step-back technique and 5.25% NaOCl as irrigant we performed canal preparation. Then the canals were dried with paper points and obturated with lateral condensation technique and AH26 (Maillefer, Dentsply) sealer. The access cavities were filled with light-cured glass ionomer and then the apical 3mm of the teeth (except three of them as negative control) were sectioned perpendicular to the long axis of the root with a #701 fissure bur in a high-speed hand piece and water coolant. Retrograde cavity preparation was made in each root with a #1 round bur in a high-speed hand piece and water in a depth of 3 mm. The teeth were randomly divided into four groups of 15 teeth each. In group 1, the apical preparations were filled with Biocalex (Future Dentistry Inc. France) according to the manufacturer's instructions. In group 2 and 3, the cavities were filled with white or gray MTA (Pro Root MTA, Dentsply Tulsa Dental, Tulsa, OK, USA) which was mixed with distilled water and condensed into the preparations using MTA plugger. In group 4, the cavities were filled with amalgam (coltene/whaledent AG, Australia). All of the teeth were then wrapped in moist gauze and stored in incubator at 37°C temperature and 100% humidity for 72h. Then two coats of nail polish were applied to the external surface of experimental groups except for the resected root-end and then the teeth were completely immersed in methylene blue dye. The apical preparations of the three remained teeth were filled with gutta-percha as positive control. The entire root surfaces of the teeth without root-end preparation (negative controls) were covered with two coats of nail polish. After 72h the teeth were rinsed in tap water, dried and embedded in polyester resin and then sec-
tioned longitudinally. The sections were observed under a stereomicroscope and linear dye penetration was measured and compared among the study groups. One way ANOVA and Tukey test served for statistical analyses. The significance level was defined to be 0.05.

RESULTS

No leakage was detected in the negative controls and maximum leakage (complete penetration) was observed in the positive controls. Among the groups, the teeth retrofilled with Biocalex had the least and teeth retrofilled with amalgam had the most amount of dye penetration. The difference between groups was significant according to one-way ANOVA test (P<0.05).

Multiple comparisons using Tukey test revealed a significant difference between Biocalex and the other three groups (P<0.05). The test also showed that white MTA had significantly less leakage than gray MTA and amalgam (P<0.05); but no statistically significant difference existed between gray MTA and amalgam (P>0.05) (Table 1).

DISCUSSION

In the present in vitro study, the teeth retrofilled with Biocalex showed significantly less leakage compared to the teeth retrofilled with other tested materials. Higher leakage level of gray MTA, compared to white MTA was also significant.

The most accepted and extensively used retrofilling material over the last century has been amalgam. Initially providing tight apical seal, this material is easy to manipulate, readily available, well tolerated by soft tissues, and radio-opaque. On the other hand, it has some disadvantages such as potential for mercury and other ions release, slow setting, dimensional instability, eventual leak from corrosion, and staining the overlying soft tissues causing a tattoo [11]. The leakage data obtained in this study agreed with the finding of Chong et al [12] who showed that all of the amalgam root-end fillings leaked with the maximum dye leakage scores.

As previously stated, both types of MTA are nearly similar in their compositions except for the presence of iron compound in the gray MTA [13,5]. Although most of the research the findings on MTA have been on the gray MTA, some comparative studies also exist. Ferris et al [14], studying the ability of both types of MTA to seal off the perforation sites, found no significant difference between the two materials. Study on tissue response compared by subcutaneous implantation of dentine tubes filled with gray MTA and white MTA also showed no obvious observable difference between the two [15,16]. The results of our study, however, showed that the amount of leakage and therefore the sealing ability of white MTA is significantly better than gray MTA. According to some studies, Biocalex (Endocal 10) has the ability to provide a tight seal because it consists of heavy calcium oxide mixed with zinc oxide and a solution of ethylene glycol in distilled water [6]. It has been reported that calcium oxide penetrates dentinal tubules and reduces the dentin-material interface to a minimum allowing stable micromechanical intratubular attachment [7,17]. This phenomenon maximizes hermetic sealing properties during canal obturation [7].

Table 1. Mean leakage of retrofilling materials, derived from dye penetration in 60 extracted teeth.

<table>
<thead>
<tr>
<th>Retrofilling Material</th>
<th>Number</th>
<th>Mean</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biocalex (Endocal 10)</td>
<td>15</td>
<td>2.36</td>
<td>1.039</td>
<td>0.7</td>
<td>4.2</td>
</tr>
<tr>
<td>White MTA</td>
<td>15</td>
<td>4.00</td>
<td>1.202</td>
<td>1.7</td>
<td>7.2</td>
</tr>
<tr>
<td>Gray MTA</td>
<td>15</td>
<td>6.65</td>
<td>1.780</td>
<td>4.4</td>
<td>9.2</td>
</tr>
<tr>
<td>Amalgam</td>
<td>15</td>
<td>7.76</td>
<td>1.420</td>
<td>4.2</td>
<td>10.1</td>
</tr>
</tbody>
</table>

SD=Standard deviation, Min=Minimum, Max=Maximum, MTA=Mineral Trioxide Aggregate
The other property of this material, which may contribute to its enhanced sealing ability, is its expansion upon setting [18]. The chemical combination of one molecule of calcium oxide with one molecule of water to form calcium hydroxide increases expansion in volume during the chemical reaction [18]. The chemical expansion allows the calcium hydroxide to go through accessory and lateral canals, apical deltas, and dentinal tubules and to obturate the canal at the same time [18]. However, the chemical reaction that occurs during combination of calcium oxide (CaO) with water and residual CO2 results in the formation of CaCO3 (limestone) that is a hard-set cement and insoluble in water. Previous studies also have reported some other specific properties of Biocalex, including the promotion of significant intratubular calcium diffusion [7,8] and biocompatibility [10,17]. The present study demonstrated that the Biocalex has the potential of being used as a root-end filling material because it provided a tight seal. Thus, Biocalex may be an alternative to other materials for root-end filling but further investigations is necessary to determine the suitability of this material for in vivo use.

CONCLUSION
It is concluded that retrograde filling with Biocalex can be considered as an alternative to other retrofilling materials.

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REFERENCES