Original Article

In vitro comparative study of sealing ability of Diadent BioAggregate and other root-end filling materials

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Abstract

Aim: This *in vitro* study evaluated and compared sealing ability of Diadent BioAggregate (DBA) as a new root-end filling material (REFM) versus amalgam, intermediate restorative material (IRM) and white mineral trioxide aggregate (WMTA).

Materials and Methods: Crowns of sixty extracted human maxillary incisors were sectioned at the cemento-enamel junction (CEJ). All the roots were instrumented and obturated with gutta-percha and resin sealer. Obturated roots were divided randomly into 2 control groups and 4 experimental groups of 10 samples each. In the negative control group (group I), roots were kept without any further preparation. In the positive and experimental groups roots, were apically resected and root-end cavities were prepared and filled with: (a) gutta-percha (group 2-positive control group); (b) amalgam (group 3); (c) IRM (group 4); (d) WMTA (group 5); (e) DBA (group 6). Apical leakage was assessed using dye penetration technique. Data were submitted to statistical analysis by the one-way analysis of variance (ANOVA) and Tukey's test.

Results: Significant difference of sealing ability was found among 4 tested groups. DBA followed by MTA showed the highest sealing ability.

Conclusions: DBA with its high sealing ability can be considered a possible alternative to MTA.

Keywords: Antibacterial activity; BioAggragate; dye penetration; retrograde filling; root-end filling materials

INTRODUCTION

Most endodontic failures occur as a result of the leakage of irritants from pathologically involved root canals into the periapical tissues.[1,2] When non-surgical attempts prove unsuccessful or are not feasible, surgical endodontic therapy is needed to save the tooth.[3] This involves exposure of the involved root apex, resection of its apical end, root-end class I cavity preparation and insertion of appropriate root end filling material.[4] The main objective of a root-end filling material (REFM) is to provide an apical seal that prevents the movement of bacteria and the diffusion of their products from the root canal system into the periapical tissues.[5] Different materials have been introduced for this purpose. However, no root-end filling material satisfies ideal requirements, therefore, development of a novel REFM is a constant concern for many researchers.[1,6] Diadent BioAggregate (DBA) is a relatively new bioceramic based material which is similar to MTA and recommended for perforation repair and root-end filling.[7,8] The present study aimed to compare the *in vitro* dye leakage for DBA versus amalgam, IRM and MTA as a root-end filling material.

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MATERIALS AND METHODS

Sixty recently extracted human maxillary central incisors were selected for the current study. Following extraction, the teeth were cleaned and stored in normal saline. Criteria for teeth selection included: a single root canal without curvature; no visible root caries, fracture or cracks on examination with a 4x magnifying glass; no signs of internal or external resorption or calcification; and, completely formed apex. Preoperative radiographs were exposed to confirm the canal anatomy. The coronal portion of the selected teeth was sectioned at cemento-enamel junction (CEJ) using a diamond disc. After access cavities were prepared, a size 10 K-file (Dentsply Maillefer, Ballaigues, Switherland) was introduced into the canal until the tip was visible at the apical foramen. The working

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length was determined by subtracting 0.5 mm from this measurement. This same file was used as a patency file during preparation. The maximum size of the initial file that fitted at ≤ 1 mm from the apex was size 20. Roots in which initial files were larger than size 20 were excluded from the study and replaced with new roots.

Root canals were prepared using step-back technique until reaching a master apical file size 45. The canals were irrigated between instruments with 2 ml of 3% sodium hypochlorite (NaOCl) Finally, the root canal was irrigated with 5 ml of 3% NaOCl, followed by irrigation with 5 ml of 17% Ethylenediaminetetraacetic acid (EDTA) solution (pulpdent Corporation, USA) and a final rinse with 5 ml of 3% NaOCl. Canals were obturated with gutta-percha and AH plus sealer (Dentsply Maillefer, Ballaigeus, Swaziland) using lateral compaction technique. Excess gutta-percha was removed with a heat-carrier and remaining gutta-percha was vertically condensed at the canal orifices . with a hand plugger. Radiographs were taken to confirm the quality of obturation and the canal orifices were sealed with glass ionomer cement (GIC) filling material. All samples were stored at 37 ± 1°C and 100% relative humidity for 7 days. The obturated samples were randomly divided into 2 control and 4 experimental groups of 10 roots each. In the negative control group (group 1), no further preparation was done and the entire specimen including the root canal orifice and the apical foramen was completely coated with three layers of nail varnish to prevent the dye leakage into the root canal system. The apical 3 mm of the obturated roots in the other groups were resected at the apical endat 90° to the long axis using a cross cut fissure bur (556, Mani, Japan). A standardized 3 mm deep and 0.8 mm wide retrograde cavity was prepared using a straight fissure diamond bur (SF 41, Mani, Japan) following the morphology of root canal.[9] The cavities were irrigated with EDTA which was followed by saline, and the cavity was then dried. The root-end cavities in groups 2-6, were filled with softened gutta-percha (positive control group), amalgam (Marvalloy, DMP Ltd. Metal Processing, Athens, Greece), IRM (Caulk Dentsply (Milford, DE, USA), White Mineral Trioxide Aggregate (ProRoot MTA, Dentsply (Tulsa, OK, USA), and Diadent BioAggregate (DiaRoot, Diadent, Burnaby, Canada), respectively. These materials were manipulated according to the manufacturers' instructions and the cavities were filled using a Messing's carrier. The roots were then wrapped in a wet gauze and placed in an incubator at 37°C for 48 hours to allow complete set of the root-end filling materials.

The roots in groups 2-6 were then coated with three layers of nail varnish except at the apical 1 mm of the resected root, and were then allowed to dry.Apical leakage was evaluated using methylene blue dye penetration technique. The apical third of each root was suspended in 2% methylene blue dye solution for 72 hours at 37°C and 100% humidity. Thereafter, the roots were removed, rinsed for 15 minutes under tap running water, and air dried. Nail varnish was removed with a scalpel and samples were embedded into transparent acrylic resin in order to permit a vertical sectioning of the root. Following setting of the resin, the acrylic blocks were sectioned vertically in a bucco-lingual direction into two halves using diamond discs under copious irrigation with cold water.

A metallic ruler with half millimeters scale was placed directly adjacent to each root half and photographed using a Canon DSLR digital camera. All the images were then imported in Adobe Photoshop CS2 (Adobe Corporation, USA). The metallic ruler that appeared in each image was used to measure the depth of dye penetration along the interface of the root-end filling, and at the root canal wall on both the sides of each root half [Figure 1].

Statistical analysis

Data were submitted to statistical analysis using Statistical Package for Social Sciences (SPSS) program version 17.0 (SPSS Inc., Chicago, IL, USA). Descriptive statistics comprised calculation of mean and standard deviation followed by one-way analysis of variance (ANOVA) and Tukey's test. Results with P value < 0.05 were considered statistically significant.

RESULTS

All samples in the positive control group showed maximum microleakage throughout the retrograde cavities, thus confirming that REFM was necessary to prevent microleakage; in contrast, all negative controls showed no microleakage, thus confirming that nail polish prevented microleakage. Descriptive statistics of microleakage for groups 3-6 are presented in [Table 1]. Comparison of these four groups regarding dye penetration measurements (ANOVA) results in significant differences ($P = 0.001$). The results of Tukey's test revealed that microleakage was significantly less in DBA when compared to WMTA, IRM and amalgam ($P \leq 0.05$).

DISCUSSION

An ideal material for root-end restorations should prevent

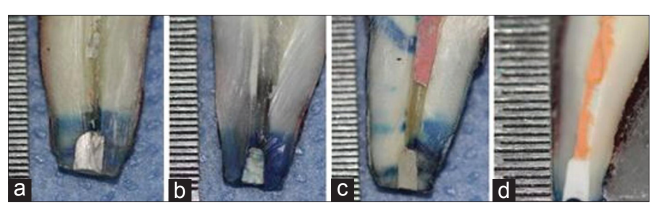

Figure 1: Dye penetration along the margin of the retrograde filling materials and tooth structure: (a) Amalgam, (b) IRM, (c) WMTA, (d) DBA

Table 1: Comparison of microleakage (mm) for four different materials used in the study

Tested materials	Mean	SD	ANOVA F-Ratio	*P* value
Amalgam	2.5[a]	0.08	5258.2	0.001
IRM	1.4[b]	0.08		
WMTA	0.8[c]	0.06		
DBA	0.6[d]	0.03		

Values within the same column with different superscript are significant at 0.05 level; IRM: Intermediate restorative material; WMTA: White mineral trioxide aggregate' DBA: Diadent BioAggregate

leakage of microorganisms and their products into the surrounding tissues.[10] Apical seal of root-end filling materials (REFM) is the single and most important factor in achieving success in surgical endodontics.[11] Numerous substances have been used as root-end filling materials and the choice of these materials could be determined by their apical sealability, biocompatibility, handling properties and long term clinical success records.[12] The clinical significance of microleakage in apical surgery has not been clearly explained However it seems logical that the lesser leakage would prevent migration of bacteria and toxins into the periradicular tissue.[13]

In the current study, methylene blue dye penetration method was selected to study microleakage because it is inexpensive and easy to manipulate, as well as it a has high degree of staining and a molecular weight even lower than that of bacterial toxins.[12] In spite of these advantages, the *in vitro* penetration of dye into canals should not be considered to be directly comparable with the *in vivo* leakage of irritants out of the root canal system. Instead, dye penetration should be considered as an indicator of the potential for leakage, because a filling material that does not allow penetration of small molecules, such as dyes, has the potential to prevent leakage of larger substances, such as bacteria and their byproducts.[14]

All the samples in the negative control group did not show apical leakage and this indicates that nail varnish is effective in leakage prevention. In the positive control group, all samples showed full leakage along the gutta-percha indicating the need of a material that effectively seals the retrograde cavities. Under the experimental conditions of this *in vitro* study, our results showed that all materials used in this study exhibited microleakage, but there was significantly less leakage in DBA (0.60 mm) when compared to WMTA (0.80 mm), IRM (1.4 mm) and amalgam (2.5 mm).

Amalgam and IRM are popular materials that were recommended by many clinicians to fill retrograde cavities in apical surgery, and hence were used in this study as the control materials. Amalgam showed the highest significant linear leakage among the tested materials, and this may be due to its initial setting contraction and its bad marginal sealing, especially during setting in wet conditions.[2] This was in agreement with the finding of Chong *et al.* who showed that all of the amalgam root-end fillings leaked with the maximum dye leakage scores.[2] Regarding IRM, it had a significantly less leakage than amalgam, and this was in agreement with the previous studies which reported that IRM seals better than non-zinc amalgam.[15]

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.[16] Further, it is more radiopaque in nature than the conventional gutta-percha and dentin, and thus easily distinguishable on radiographs when used as a root-end filling material.[16] Due to all these properties, MTA was selected as one of the test materials for this study. The results of the current study showed that the microleakage of MTA was significantly less as compared to amalgam and IRM. These findings agree with the results of previous dye leakage studies which have been performed on MTA using various different types of dyes.[1,4,17] The better performance of MTA may be due to its superior marginal sealing ability resulting from its hydrophilic properties,[18] and formation of an interfacial layer between the material and dentin.[19] It was found that the further hydration of MTA powder by moisture can result in an increase in the compressive strength and decrease leakage.[20] In addition, it was also demonstrated that MTA has the ability to precipitate hydroxyapatite crystals in the presence of a fluid which may be relevant in minimizing leakage thereafter.[21] However, some studies revealed that MTA did not resist leakage and had significantly more leakage than IRM and Super ethoxy benzoic acid (EBA).[5,22] The cause of these conflicts may be due to differences in the methods of investigation.

As DBA is a relatively new material, there are only few studies available about this material. According to the present study, DBA showed the least amount of micro leakage; surprisingly, even when compared to MTA, though both have nearly the same components. Our results are in agreement with the results of previous studies which indicated that ceramic based materials ensure much better apical seal than IRM, amalgam or Super EBA materials, and this excellent seal is combined with excellent biocompatibility and significant stimulation of periodontal regeneration.[7,23] The hermetic seal associated with this bioaggregate could be explained by the following: (1) It has nano-sized particles that achieve excellent adhesion to the dentinal walls of the root canal, (2) It is hydrophilic in nature demonstrating setting expansion.[24] The presence of a gel-like calcium silicate hydrate as the main structural component in both the MTA and DBA, provides strength, hardness and sealing properties to the set material.[8]

CONCLUSION

Within the limitation of this study, DBA can be considered a possible alternative to the original MTA due to its better sealing ability. However, MTA still remains as one of important materials used in retro-filling of the root canals. However, further *in vivo and in vitro studies* are required to find the best root end filling material in dental practice.

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