Comparative evaluation of microleakage of mineral trioxide aggregate and Geristore root-end filling materials in different environments: An in vitro study

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Abstract

Aim: The aim of this in vitro study was to evaluate and compare the microleakage of mineral trioxide aggregate (MTA) and Geristore root-end filling materials in different environments.

Materials and Methods: After removing the anatomical crowns of ninety extracted human maxillary central incisors, their root canals were instrumented and obturated. The apical 3 mm of each root was resected, and a standardized root-end cavity was prepared using an ultrasonic tip. The roots were alienated into three equal subgroups for each material and the root-end filling was performed in different environments namely dry, saliva contaminated, and blood contaminated. Samples were immersed in 0.2% Rhodamine B dye for 48 h. Roots were sectioned longitudinally and examined under a fluorescent microscope to measure the linear dye penetration. The results were statistically analyzed using analysis of variance and Tukey’s honestly significant difference post hoc test.

Results: The Geristore dry group illustrated the lowest linear leakage, while the MTA saliva-contaminated group illustrated the highest leakage. In dry environment, linear dye penetration of both MTA and Geristore groups did not show any significant difference. However, statistically significant difference was observed between MTA and Geristore groups in blood- and saliva-contaminated environments.

Conclusion: Geristore showed better results in saliva- and blood-contaminated environments; hence, Geristore may be used as an alternative to MTA for root-end filling.

Keywords: Rhodamine-b; root-end filling materials; sealing ability; ultrasonic retro-tips

INTRODUCTION

Success of endodontic treatment mainly relies on complete elimination of microorganisms and the three-dimensional sealing of the root canal system. In spite of new endodontic techniques and development of more effective materials and instruments, the resolution of periapical lesion is not achieved in certain cases. In cases where conventional endodontic treatment fails, endodontic surgery becomes the last resort for salvaging the affected tooth. The main intention of root-end filling is to offer an apical seal that inhibits the penetration of microorganisms and their byproducts into the periradicular tissues from the root canal system. Therefore, the apical seal is the most important factor in achieving success in surgical endodontics.

Previously, amalgam was widely used as a root-end filling material, but it has certain drawbacks such as microleakage.

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nonadhesiveness, and release of mercury ion which led to the development of a number of other materials. Among the various root-end filling materials tested, mineral trioxide aggregate (MTA) had shown good sealing ability and biocompatibility during previous in vitro and in vivo studies. In the recent years, various materials such as Bioaggregate, Biodentine, Geristore, Cements Endodontico Rapido cement, Endosequence Root Repair Material, and Endocem have been introduced with the aim to fulfill the requirements of an ideal root-end filling material.

Microleakage is the most common cause responsible for the failure of endodontic treatment. A variety of methods have been employed to assess the sealing ability of root-end filling such as radioisotope penetration, degree of dye penetration, fluid filtration techniques, electrochemical methods, bacterial penetration, scanning electron microscopy, and capillary flow porometry. The dye penetration method used for measuring sealing ability is the most popular. Various dyes that can be used include India ink, basic fuchsin, silver nitrate, methylene blue, and Rhodamine B.

Achieving a dry apical field is not always attainable during endodontic surgery. Clinically, it is predictable that the root-end cavity preparations and filling materials will be contaminated by any moisture including saliva and blood as they are placed.

This study intended to evaluate the sealing ability of Geristore and MTA root-end filling materials linearly to its furthest extent coronally within the tooth in dry and blood- and saliva-contaminated environments and to find the sealing ability of these materials.

**MATERIALS AND METHODS**

This study was approved by the Scientific and Ethical Committee. A total of ninety maxillary central incisors that were extracted for periodontal reasons were selected for this study. Criteria for tooth selection included a single root without curvature, no visible root caries, fracture, or cracks. The roots were cleaned of attached tissues and calculus, washed, debrided with 5.25% NaOCl (Span reagents), and were then stored in normal saline until use. The crowns were sectioned at the cementoenamel junction using a diamond disc under constant water irrigation to a standardized length of 15 mm [Figure 1a].

After removal of crown from the cementoenamel junction, the working length was determined and the canals were prepared using K-files (Maillefer, Dentsply, Switzerland), and apical enlargement of each canal was carried out to a #35 file, 0.5 mm short of working length and the rest of the canal was flared using step back technique to #50 file. The canals were copiously irrigated with 5.25% NaOCl and normal saline at regular intervals.

Figure 1: Coronated samples leaving 15 mm of tooth length (a), samples positioned for dye penetration (b), and longitudinal section of samples (c)

After the preparation, root canal was thoroughly dried with paper points and obturation was done with lateral compaction technique using gutta percha (Maillefer, Dentsply) and AH Plus sealer (Maillefer, Dentsply). The access cavity was subsequently etched, primed, and filled with composite (Tetric N-Ceram, Ivoclar, Vivadent). The teeth were then placed in a microbiological culture incubator at 37°C and 100% humidity for 5 days to simulate the oral environment.

Root-end resections were performed by sectioning the apical 3 mm of the apex at a 90° angle to the long axis of the root using a straight fissure bur in a high-speed handpiece under water spray. Root-end cavity of 3 mm depth was prepared by an ultrasonic retrotip (AS3D - Satelac) using light brushing motion. The prepared teeth were randomly divided into two equal experimental groups (group 1 and 2) of 45 teeth each. Each group was further divided into three subgroups (A, B, and C).

The root-end filling materials were mixed according to manufacturer’s instruction and the cavities in subgroups A, B, and C were filled in dry and saliva- and blood-contaminated environments, respectively. Blood was obtained using a 27G needle from one of the colleagues, immediately before root-end filling. Saliva was obtained from one of the colleagues and collected in a container. The samples were incubated for 24 h at 37°C and 100% humidity. Then, all tooth surfaces were coated by two layers of nail varnish except for the area corresponding to the resected root-end surface.

A 0.2% solution of Rhodamine B dye (Sigma Aldrich) was prepared by dissolving 0.2 g of dye in 100 ml of distilled water. All the samples were suspended in dye solution for 48 h [Figure 1b]. Thereafter, the samples were removed, rinsed for 15 min under running tap water, and air dried. Nail varnish was removed with a scalpel and the roots were grooved on the lingual and buccal surfaces down to the
RESULTS

The mean values for linear dye penetration in each subgroup are shown in Table 1. Geristore dry group showed the lowest apical dye penetration among all the subgroups. However, the greatest leakage was seen in MTA saliva-contaminated subgroup.

The linear dye penetration (mean ± standard deviation) of both MTA and Geristore groups in dry environment did not show any significant differences. However, in blood- and saliva-contaminated environments, the difference between MTA and Geristore groups was statistically significant.

DISCUSSION

The objective of periradicular surgery apart from removing the periapical lesion is to achieve a hermetic apical seal, using a well-adapted root-end filling material. Microleakage is one of the main factors that is responsible for endodontic treatment failure. Majority of failures involving surgical treatment with root-end filling are associated with the poor sealing ability of the material. Spider et al. reported that the success of periradicular surgery is attained not only by applying the correct procedure and indications, but also by the use of biocompatible retrograde filling material, which provides good apical seal and in turn prevents the penetration of periapical fluids into the root canal system.

Several methods in vitro have been used to assess the sealing ability of root-end filling materials. The dye leakage evaluation is the most commonly used technique and it is the simplest method for assessment of microleakage of root-end filling materials. As stated by Delivanis and Chapman, dyes do not allow continuous measurement of leakage in the same specimen, since they allow measuring the degree of leakage up to the moment when the teeth are removed from the solution, only. However, according to Taylor and Lynch, this is a highly sensitive technique that requires standardization.

In this study, Rhodamine B has been used which is a fluorescent dye. The fluorescent dye has been chosen as in normal visible dye, results may vary due to change in the quality of light, because of which the presence of dye sometimes cannot be easily observed. On the other hand, in a fluorescent dye, the presence can easily be made out because of the specific fluorescence. Therefore, there is no need to search for the dye, the dye shows itself. This fluorescent dye is also appreciably more sensitive than a conventional dye. Another reason to use Rhodamine B dye over methylene blue (one of the most commonly used dyes) is due to its smaller and more surface-active molecules. Methylene blue undergoes changes in the presence of materials rich in calcium oxide that leads to increased pH, which can cause discoloration of the surfaces marked by methylene blue dye.

Geristore introduced by Den-Mat Corporation, USA, is a hydrophilic, nonaqueous, polyacid-modified composite resin composed of fluoride-releasing glass (barium, fluorosilicate) and a polymerizable organic matrix combined with a photoinitiator. The reported advantages of resin ionomers are increased adhesion to tooth structure, insolubility in oral fluids, dual cure potential, low polymerization shrinkage, low coefficient of thermal expansion, radiopacity, release of fluoride, self-adhesive nature (no need for retentive cavity design), and biocompatibility.

Studies have indicated that Geristore is biocompatible and has great clinical success, when used in the repair of subosseous and subgingival defects and in guided tissue regeneration. Results of observational studies evaluating the effect of various root-end filling materials on gingival fibroblast cells showed greater cell attachment to Geristore as compared to MTA. Other in vivo studies indicate that in comparison to intermediate restorative material (IRM),

Table 1: The extent of linear dye penetration (µm) of mineral trioxide aggregate and Geristore in different environments

| Group     | Environment | Mean ± SD  |
|-----------|-------------|------------|
| MTA       | Dry         | 133.20 ± 0.45 |
|           | Saliva      | 133.47 ± 0.16 |
| Geristore | Dry         | 115.69 ± 0.25 |
|           | Saliva      | 118.90 ± 0.38 |
|           | Blood       | 120.63 ± 0.51 |

SD: Standard deviation, MTA: Mineral trioxide aggregate
During endodontic surgery, achieving a dry apical field is not always attainable. This study intended to compare the test materials on the basis of the sealing ability in blood- and saliva-contaminated environments, i.e., usually a simulation of the virtual conditions. Throughout endodontic surgery, many means are employed to control the moisture and blood in the surgical site. So far, with all the measures, the aim of a dry field is not always attainable. MTA is a calcium silicate-based material that sets in the presence of moisture. Geristore being a hydrophilic resin bonds in the presence of moisture.

In the present study, MTA showed minimum leakage in dry environment followed by blood and saliva; however, the results were nonsignificant. This is in accordance with a study by Torabinejad et al. and Farhad et al.

No significant differences observed in different environments might be attributed to the superior marginal sealing ability of MTA resulting from its hydrophilic properties and formation of an interfacial layer between the material and dentin. The interfacial layer reduces the risk of marginal percolation and gives promising long-term clinical success. Kubo et al. found that the further hydration of MTA powder by moisture can result in an increase in compressive strength and decrease in leakage. Sarkar et al. demonstrated that MTA can precipitate hydroxyapatite crystals in the presence of fluid which may be relevant in minimizing leakage thereafter.

Geristore under three different environments also showed no significant change. This might be due to the fact that Geristore is self-adhesive with low polymerization shrinkage and has a low co-efficient of thermal expansion that provides excellent marginal integrity, and also it is hydrophilic and bonds in the presence of moisture and blood.

Greer et al. found that Dyract and Geristore were identical or superior to IRM and comparable to Super-EBA in their ability to reduce apical leakage when used as root-end filling materials. However, Geristore could not be compared in previous studies due to lack of research with similar associations. In spite of that, results are promising and better than MTA. Thus, based on the results of the present study, it is reasonable to state that Geristore is more efficient in preventing microleakage of Rhodamine B dye than MTA in different environments.

Intergroup comparison between MTA and Geristore in dry environments depicted no significant difference between the two materials. Minimum microleakage was observed in Geristore followed by MTA. Intergroup comparison between MTA and Geristore in blood- and saliva-contaminated environments depicted a high statistically significant difference between the two materials. The maximum microleakage was observed in MTA followed by Geristore.

Intergroup comparison between MTA and Geristore in blood-contaminated environments depicted a high statistically significant difference between the two materials. The minimum microleakage was observed in Geristore followed by MTA.

Under the limitations of this study, the sealing ability of Geristore showed better results with that of MTA in saliva- and blood-contaminated environments, whereas both the materials showed no significant difference in dry environment and hence Geristore may be used as an alternative to MTA for root-end filling; however, there should be further and more extensive studies to corroborate these findings.

Additional research is needed to study the effect of the combination of blood and saliva contamination in different clinical conditions on apical leakage of root-end filling materials. The quest to find a material that shows least/no microleakage continues.

**CONCLUSION**

Within the limitations of this in vitro study, it can be concluded that MTA and Geristore provide equally effective sealing of the root end in dry environment. Geristore is a better root-end filling material providing an effective apical seal than MTA in blood- and saliva-contaminated environments. Since achieving a dry apical field is not always possible during endodontic surgery, Geristore seems to be providing a better solution, although more studies and long-term clinical trials are required to prove the viability of results.

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**Conflicts of interest**

There are no conflicts of interest.

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