Received: 22nd March 2015 Accepted: 13th July 2015 Conflicts of Interest: None

Source of Support: Nil

Original Research

Comparing the Marginal Adaptation of Cold Ceramic and Mineral Trioxide Aggregate by Means of Scanning Electron Microscope: An *In vitro* Study

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How to cite the article:

Mokhtari F, Modaresi J, Javadi G, Davoudi A, Badrian H. Comparing the marginal adaptation of cold ceramic and mineral trioxide aggregate by means of scanning electron microscope: An *in vitro* study. J Int Oral Health 2015;7(9):7-10.

Abstract:

Background: Long-term success of endodontic surgeries is often influenced by the type of root-end filling material (RFM). The aim of present study was to compare the marginal adaptation of two different RFM, cold ceramic (CC) and mineral trioxide aggregate (MTA), using scanning electron microscope (SEM).

Materials and Methods: About 20 extracted human single-rooted teeth were collected and stored into sodium hypochlorite 5.25%. The teeth were decronated from the cemento-enamel junction to prepare 16 mm roots. The working length was measured, and 1/3 coronal of the canal was prepared by Gates-Glidden drills. Apical flaring was followed by K file size # 40-70 based on step back technique. After filling of the canals, 3 mm above the apex was cut at 90° to the long axis. Furthermore, 3 mm of the filling was removed from the apical part using the ultrasonic device. All of the prepared specimens were divided into two groups and were retro filled by MTA and CC. The roots were cut horizontally from 1 mm above the apical part, and dentin-filling material interface was observed by SEM. Finally, the collected data were analyzed by Mann-Whitney test and using SPSS software version 18 at a significant level of 0.05.

Results: The mean interfacial adaptation was higher in CC group. However, no significant differences were observed by statistical test ($P = 0.35$).

Conclusion: Both CC and MTA had similar marginal adaptation as RFM however *in vivo* studies are recommended for better determination.

Key Words: Cold ceramic, mineral trioxide aggregate, root end filling material, scanning electron microscope

Introduction

Endodontic retreatment of teeth, which were failed at previous non-surgical dental treatment, might bring about 84-56% successful rate.[1,2] By the help of recent advances in surgical techniques, equipment and materials, endodontic surgery have turned to a more predictable procedure in cases that the non-surgical endodontic treatment has failed or is contraindicated.[3-5] A prospective study showed that several factors such as gender, tooth position, type of lesion and root-end filling materials (RFM), are determining factors for clinical outcomes.[6] The long-term success of endodontic surgeries is often influenced by the type of RFM.[2,5] Well adaptation to the root canal walls, dimensional stability, sufficient bond strength, providing no leakage, and biocompatibility are some of the most important criteria of an ideal RFM.[7-9]

Amalgam, cavity, composite resins, glass ionomer cements, gold foils, Gutta-percha, mineral trioxide aggregate (MTA), polycarboxylate cement, polyvinyl cement, and zinc oxide-eugenol-based cements are/were used as a root filling materials. However, most of these materials demonstrated some flaws in: Solubility, leakage, biocompatibility, handling properties, incompatibility with water etc.[10] For instance, amalgam has been used as RFM for years. Its potential problems are initial leakage, its mercury and tin contents, its sensitive to moisture, requiring the undercut cavity preparation.[11]

MTA has been implicated as an alternative to amalgam and showed promising results. Histological and radiographic evaluation have shown that the MTA is an appropriate material for periradicular tissues as it induces healing responses.[12] MTA has been criticized for the following two characteristics: Difficulty of its handling and slow setting,[13] which can cause leakage,[14] surface degradation,[15,16] the loss of marginal integrity and continuity.[17]

The sealing quality of the filling materials is evaluated through several methods such as penetration of color markers,[18] different solutions,[19] microorganisms,[20] and electromechanical techniques.[21] Scanning electron microscope (SEM) is also a suggested technique to evaluate the marginal adaptation and the sealing ability of the common RFM.[22,23]

An experimental RFM with a ceramic base, called cold ceramic (CC), has been introduced and has shown favorable properties.[24,25] Its main composition is calcium hydroxide and

presents a biocompatible substance in the existence of humidity during setting.[24] Recent studies have shown its superior sealing ability than amalgam,[24] and comparable tissue reaction than MTA.[25]

Since an RFM must match closely with the walls of the root canals, the aim of this study is to evaluate the marginal adaptation of CC and MTA by means of SEM.

Materials and Methods

In this experimental study, 20 extracted human single-rooted teeth were collected. The inclusion criteria were: Existence of a root canal, no cracks, fractures, cavity or root resorption. All the roots had direct root canals with no calcification and ended to a mature (close) apex. The teeth were stored into sodium hypochlorite 5.25% (Chloran, Tehran, Iran) for 30 min to remove surface debris. The teeth were decronated from the cemento-enamel junction (CEJ) to prepare 16 mm roots. The working length was measured using K-files (Dentsply Maillefer, Ballaigues, Switzerland) size #15 until observing the file tip at the apical foramen. 1/3 coronal of the canal was prepared by Gates-Glidden drills (Dentsply, Milford, DE, USA) from size 1 up to 3. Apical flaring was followed by K file size # 40 and continued to size # 70 based on step back technique. Canal irrigation was done using sodium hypochlorite 1% after each instrumentation. Then the canals were dried using paper points and subjected to ethylenediaminetetraacetic acid 17% (7.2 pH) (Aria dent, Tehran, Iran) for 3 min to remove the smear layer. After final irrigation (by sodium hypochlorite 1% and normal saline), the dried canals were filled by Gutta-percha and AH26 sealer (Dentsply De-Trey, Konstanz, Germany) based on lateral condensation technique. The specimens were then incubated for 5 days at 37°C and 100% humidity. Nearly 3 mm above the apex was cut at 90° to the long axis by using diamond disks (3M dental products, USA). Then, 3 mm of the filling was removed from the apical part using ultrasonic device and all the prepared specimens were divided randomly into two groups (n = 10) as follow:

MTA: The specimens were apically filled by ProRoot MTA (Dentsply Tulsa Dental, Tulsa, OK) based on manipulation instruction of the manufacturer.

CC: The specimens were apically filled by CC based on manipulation instruction of the producer.

The samples were incubated for 24 h at 37°C and roots were cut horizontally from 1 mm above the apical part for evaluating dentin-filling material contact using SEM analysis. Finally, the collected data were statistically analyzed by Mann-Whitney test and using SPSS software version 18 at a significant level of 0.05.

Result

In all of the studied specimens, the gap was observed at the dentin-filling material interface. The mean interfacial adaptation was higher in CC group (5.17 ± 2.01) than MTA group (6.78 ± 2.78) however, no significant differences were reported by statistical analysis (P = 0.35).

Discussion

Various methods are introduced for evaluating the sealing ability of root end materials, such as: Infiltration test,[11,26-28] Fluid transport,[29] Biocompatibility test,[4,10-12,19] and SEM.[17,30] In general, there is no evidence to prove that the use of a particular method is better than the other methods. However, linear measuring of a tracer penetration through the filling material, is a more common method.[31]

This study aimed to evaluate the marginal adaptation of two RFMs (Pro-Root MTA and CC) using SEM images. The results showed that the marginal adaptation of both materials was similar.

By the way, SEM has some limitations that might have impacts on the result of studies. Conventional preparation of biological samples might induce some artifacts. Hyper bar evacuation might cause cracks in hard tissue samples, loss of integrity and separation of the filling material, expansion or contraction of both dentin and filling material, etc. Therefore, to eliminate these artifacts producing resin replica has been suggested.[32-34] Torabinejad *et al.*[33] stated that the interfacial gap was similar between a natural tooth and the replica. This magnifies that natural tooth might be appropriate too.

Researches have shown that the deposited apatite crystals at the MTA-dentin interface improves the sealing ability of MTA.[11] Furthermore, other special characteristics of MTA, such as its biocompatibility, have made it a gold standard for comparing other dental materials.[35,36] Torabinejad et al. compared MTA marginal adaptation with some other commercial RFM by means of SEM. Their results indicated that MTA had the best adaptation than amalgam, Super-EBA, and IRM.[37] Similar SEM result was reported by another study in which MTA had better marginal adaptation.30 Peters compared marginal adaptation of Super-EBA and ProRoot MTA as RFM. Furthermore, created microcracks were examined before and after occlusion pressure.[17] Both materials showed excellent marginal adaptation before applying force. After occlusal pressure, continuity of margins decreased slightly but remains high enough.

In the present study, 3 mm of the apical part was cut to establish similarity to clinical situations and to eliminate possible anomalies (anatomical or iatrogenic). In a study by Lamb *et al.*, marginal leakage was significantly higher in 2 mm MTA plugs than 3 mm ones when examined by infiltration technique.[38] Furthermore, the cutting procedure was tried to be at an angle close to 90°, as much as possible, to reduce the number of exposed dentinal tubules and possible leakage routes.[39] Andelin *et al*. claimed that sectioning the apical part does not influence the sealing ability of MTA if it was set enough.[40]

Since there is no ideal dental material, with the best properties, the CC was compared to MTA as a gold standard. The CC is biocompatible, as well as MTA,[25,41-43] with low setting time,[44] and higher sealing ability than amalgam.[44] Hasheminia et al. evaluated the sealing ability of MTA and CC in different storage environments. They concluded that CC provided a better apical seal in blood contaminated environment than MTA. The result for dry and saliva contaminated environment was similar for both MTA and CC.[45]

Conclusion

By considering *in vitro* limitation, the results of this study reflected that both CC and MTA had similar marginal adaptation as RFM. However, more studies on other features of CC including *in vivo* studies are required to determine more precise suggestion for clinical application.

Acknowledgments

The current study was based on a thesis with ID number of 3463 which has been approved by Ethical Research Committee of Shahid Sadoughi University of Medical Science.

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