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Original Article

Histological evaluation of ProRoot mineral trioxide aggregate and Cold ceramic as root-end filling materials in animal models

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ABSTRACT

Background: This study aimed to evaluate the reaction of the periapical tissue to Cold ceramic and mineral trioxide aggregate (MTA) following periapical endodontic surgery.
Materials and Methods: In this experimental study, a total of 12 mandibular first, second, and third premolars of two male dogs were selected. All procedures were performed under general anesthesia. The access cavities were prepared, and the length of canals was determined. Root canal treatment was performed. A week later, periradicular surgery was performed. After osteotomy, 3 mm of the root end was cut. Then, a 3-mm cavity was created by an ultrasonic. The teeth were randomly divided into two groups (n = 12). The root-end cavities were filled with MTA in the first group and with Cold ceramic in the second group. After 4 months, the animals were scarified. Histological evaluation of the periapical tissues was performed. Data were analyzed using SPSS 22 and Chi-square test and $P = 0.05$.
Results: The findings showed 87.5% and 58.3% cementum formation in MTA and Cold ceramic groups, respectively, indicating a significant difference ($P < 0.001$). In addition, the results showed 91.7% and 83.3% bone formation in MTA and Cold ceramic groups, respectively, but the difference was not statistically significant ($P = 0.6$). Furthermore, the findings revealed 87.5% and 58.3% periodontal ligament (PDL) formation in MTA and Cold ceramic groups, respectively ($P = 0.05$).
Conclusion: Cold ceramic was able to induce the regeneration of cementum, bone, and PDL; hence, it can be considered as a biocompatible root-end filling material in endodontic surgery.

Key Words: Apicoectomy, mineral trioxide aggregate, root canal filling materials

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INTRODUCTION

The main objectives of using root-end filling materials are achievement of apical seal and prevention of the spread of intracanal infection to periapical tissues.[1] Every root-end filling material should ideally be able to induce the regeneration of periradicular complex, including new bone, periodontal ligament (PDL), and cementum.[2,3] Formation of cementum on the filling material and dentinal wall of the root produces a physical and biologic coating on the root end, which acts as a barrier against the harmful residues remaining in the root canal system.[4] In endodontic surgery, after preparation of the root-end cavity, the

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root end is sealed with a filling material. This material should ideally prevent the penetration of intracanal stimulants into periapical tissues.[5]

Mineral trioxide aggregate (MTA) is a root canal sealing material that is composed of dicalcium silicate, tricalcium silicate, tricalcium aluminate, and tetracalcium aluminoferrite. MTA is an active biologic material for the bone cells that stimulates the production of interleukins due to its alkaline pH and calcium ion release.[3,6,7] MTA produces lower inflammation and provides better improvement than other common filling materials, is capable of PDL regeneration, and creates new cementum deposition on its surface.[3,4,7] The disadvantages of MTA include difficult handling and slow setting reaction, which can lead to leakage, surface degeneration, loss of marginal adaptation and consistency of the materials, potential tooth discoloration, and high cost.[8,9]

Cold ceramic is a newly introduced root-end filling material that can be used in periapical surgery.[10] Calcium oxide, silicone oxide, and barium oxide constitute approximately 93% of the chemical compounds of this material.[11,12] Initial setting time of Cold ceramic is about 15 min, and its complete setting takes 24 h.[13]

Every root-end filling material should ideally stimulate new bone formation, cementum, and PDL.[2,3,9] Although Cold ceramic showed promising result in endodontics, to the best of our knowledge, there is no study about the Cold ceramic as root-end filling material. Hence, this study aimed to evaluate the reaction of the periapical tissue to Cold ceramic and mineral trioxide aggregate (MTA) following periapical endodontic surgery.

MATERIALS AND METHODS

This experimental study was approved by the ethics committee of the university research center (IR.SSU.REC.1396.57). A total of 12 mandibular first, second, and third premolars of two male dogs aged 1–2 years weighing 20–25 kg were selected. They were kept in the animal house of the Torabinejad Dental Research Center, according to the protocol of the center. All procedures were performed under general anesthesia with intramuscular administration of 0.11 mg/kg 2% acepromazine followed by intravenous administration of 6% pentobarbital.

The access cavities were prepared, and the length of canals was determined by #15 K-file (Dentsply, Maillefer, Tulsa, OK, USA). Apical preparation was done by step-back method up to file #35 along with copious irrigation with 5 ml 2.5% sodium hypochlorite. The root canal was obturated with gutta-percha (META, Korea) and AH 26 sealer (Dentsply, Tulsa, OK, USA) by lateral condensation technique, and access cavities were restored with amalgam.

A week later, periradicular surgery was performed following general and local anesthesia as well as oral disinfection. The surgical procedure was carried out by creating a submarginal incision and a full-thickness mucoperiosteal flap on the buccal side using a vertical releasing incision in the distal third premolar to provide better access to the apical area of the canal. After osteotomy, 3 mm of the root end was cut. Then, a 3-mm cavity was created by an ultrasonic (Satelec p5; Dentsply, Tulsa, OK, USA). The teeth were randomly divided into two groups (n = 12). The root-end cavities were filled with ProRoot MTA (Dentsply, Tulsa, USA) in the first group and with Cold ceramic (Dental School, Yazd, Iran) in the second group. In the end, the mucoperiosteal flap was overturned and sutured.

After 4 months, the animals were scarified by barbiturate overdose and 10% buffered formalin perfusion. Block sections were prepared from the jaws containing the teeth by cutting discs. The samples were placed in 5% formic acid for 2 months to demineralize. Six-micrometer sections were consequently prepared from each sample in buccolingual direction. Then, the samples were evaluated by an oral pathologist to determine the development of inflammatory cells around the filling material and formation of cementum, bone, and PDL under a microscope. Data were analyzed by SPSS 22 (IBM Corp., Armonk, NY, USA) and Chi-square test and $P = 0.05$.

RESULTS

The results showed 87.5% and 58.3% cementum formation in MTA and Cold ceramic groups, respectively, indicating a significant difference between them ($P < 0.001$). Furthermore, the results showed 91.7% and 83.3% bone formation in MTA and Cold ceramic groups, respectively, but the difference was not statistically significant ($P = 0.6$).

The findings revealed 87.5% and 58.3% PDL formation in MTA and Cold ceramic groups, respectively, indicating a significant difference between groups ($P = 0.05$). Moreover, the findings showed 83.3% and 58.3% mild inflammation and 16.7% and 41.7% severe inflammation in the MTA and Cold ceramic groups, respectively, indicating no statistically significant difference between groups ($P = 0.6$) [Figures 1 and 2].

DISCUSSION

The normal periradicular complex is composed of different tissues, including cementum, PDL, and bone. A desirable characteristic of root-end filling materials is their ability to regenerate the normal and functional periradicular complex. Every root-end filling material should ideally stimulate the formation of new bone, cementum, and PDL.[5,14]

The findings of the present study showed that the cementum-like tissue formed was significantly higher in ProRoot MTA than in Cold ceramic, confirming the results of previous studies on the high potential of cementum formation on MTA.[5,15-19] Cold ceramic is also able to form cementum because the base of Cold ceramic is calcium hydroxide, has tissue compatibility, and is able to create an alkaline environment.[20,21] Therefore, the ability to induce cementogenesis from a root-end filling material with these properties is not out of expectations. The lower amount of cementum formed on the Cold ceramic can be attributed to the duration of the study. Formation of cementum in the present study took 4 months, while studies have shown that a period of 3–6 months is required for continuous formation of cementum.[2] Furthermore, low level of cementum in the Cold ceramic group might be attributed to higher inflammation induced by this material compared to MTA in the short term.[22,23] Notably, the formation of cementum is inversely correlated with periradicular inflammation. Inflammation is associated with the amount of acidic pH, which has adverse effects on the setting reaction, crystal formation, and mechanical characteristics of the material, which in turn affect the cementogenesis capacity.[2]

The amount of new bone formation was similar for both groups. Studies have shown that MTA and Cold ceramic have tissue compatibility and provide a favorable ground for new bone formation by creating an alkaline environment.[3,19,20,22,24]

In addition, the amount of PDL formation was significantly higher on MTA. The criterion for the determining of PDL in the present study was observing the development of collagen fibers which were connected to cementum and to the adjacent bone.[25] This amount of PDL formation was in line with the results of former studies on the formation of PDL when MTA was used as root-end filling martials.[19] Long term evaluating of Cold ceramic apparently resulted in a rise in PDL formation.

Inflammation can cause tissue distraction, postoperative pain, and impeding tissue healing, so the root-end materials as the other materials in endodontics should not induce inflammation. This study indicated that the amount of periradicular inflammation was low and was not significantly different between MTA and Cold ceramic groups, confirming the histologic results of previous studies.[22,26]

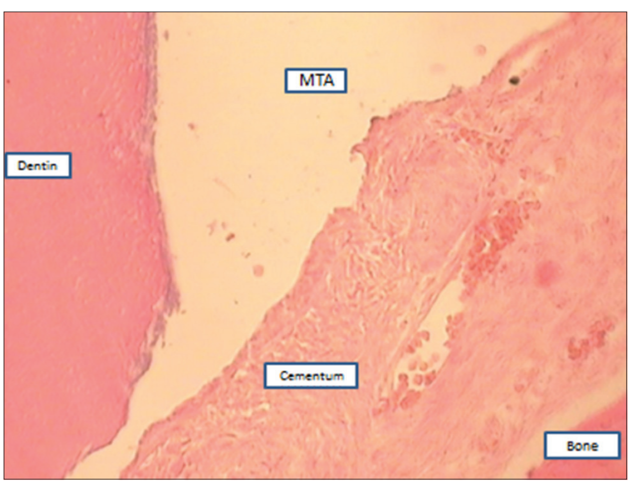

Figure 1: Root-end filling with ProRoot MTA (×100), MTA: Mineral trioxide aggregate.

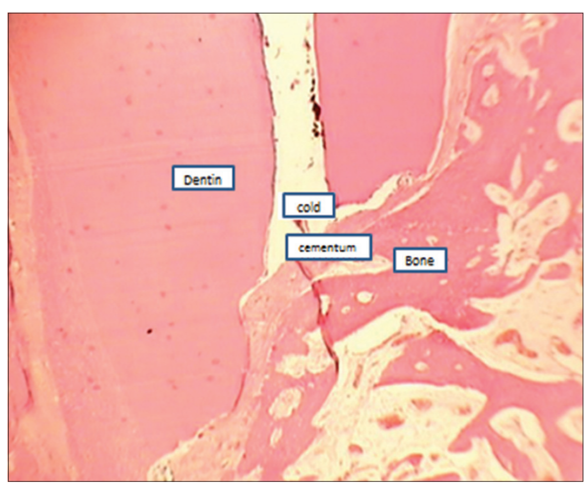

Figure 2: Root-end filling with Cold ceramic (×40).

Based on the present study, the Cold ceramic showed a suitable histological assessment; however, the limitation of the present study should be noted. Some histological characteristics were evaluated in short term in this animal model. In addition, the other characteristics of Cold ceramic as root-end material should be evaluated.

CONCLUSION

Considering the limitations of animal studies, Cold ceramic were able to induce the regeneration of cementum, bone, and PDL; hence, it can be considered as a biocompatible root-end filling material in endodontic surgery.

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Conflicts of interest

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or nonfinancial in this article.

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