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ORIGINAL ARTICLE

Hard tissue reaction to mineral trioxide aggregate and experimental root-end filling material in guinea pig mandibles

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KEYWORDS
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Abstract *Background/purpose:* Root-end filling materials are used to fill and seal the root apex during periradicular surgery. Mineral trioxide aggregate (MTA) is a widely-used material because of its particular characteristics. Cold ceramic (CC) is an experimental material that has been recently introduced. The purpose of this study was to compare bone tissue response to CC and MTA in an animal model.
Materials and methods: Forty-five male guinea pigs (weighing 750–850 g) were anesthetized with 10 mg/kg ketamine HCL and 12 mg/kg xylazine. A triangular incision of around 15 mm was prepared in the posterior site along the symphysis in both right and left sides of the mandible. A 3 mm × 3 mm diameter cylindrical hole was prepared in each side using a trephine. Two Teflon cylindrical tube applicators were filled with white MTA and CC and inserted into the defects separately. Histopathological evaluation of the specimens was completed after 2 weeks and 12 weeks. The extent of inflammation was recorded and analyzed using the Mann–Whitney *U* test and SPSS software version 12 at a significance level of 0.05.
Results: MTA and CC produced moderate and mild hard tissue responses respectively after 2 weeks and 12 weeks. No significant differences were found in the distribution of the responses between the two groups at either time point.

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Conclusion: Both CC and MTA demonstrated biocompatibility with minor adverse impact on hard tissue and healing recovery after 12 weeks.

Introduction

Root-end surgery as an approach to produce periradicular tissue healing is generally the final option after failure of conventional root canal therapy and nonsurgical retreatment to retain a tooth. Root-end filling materials are used to fill and seal the root-end cavity after resection of the root apex in periradicular surgery.[1] Desirable features for a root-end filling material are: (1) sealing ability; (2) bonding to dentin; (3) biocompatibility; (4) ability to stimulate healing of the periradicular tissues; (5) easy manipulation; (6) radiopacity; (7) moisture tolerance; and (8) dimensional stability.[2,3]

Although many root-end filling materials have been used to date, none of them are ideal because of some undesirable features.[4] Among them, mineral trioxide aggregate (MTA) is popular due to its particular characteristics such as good sealing ability, biocompatibility, and inducing hard tissue regeneration.[5–7] However, the literature reports negative opinions toward MTA and its physical properties such as not being easy to handle, taking a long time to set, color change, and cost.[8–10]

Cold ceramic (CC) is an experimental material for root-end filling[11–13] with a principal component of calcium oxide (Table 1) and it can be sterilized using dry heat.[11] As with MTA, CC needs moisture for setting[11] and has an initial setting time of 10 minutes (4 hours for MTA) and finally sets by 24 hours.[11] This fast set reduces the risk of dislodgement and blood contamination when used as a root-end filling material.[14] The sealing ability of CC appears promising[13] and compared with MTA it may provide a more favorable seal in a blood contaminated root-end cavity.[11] Furthermore, the cytotoxicity of CC appears comparable to MTA and less than intermediate restorative material.[13] Another study observed tissue reactions after implantation of CC and MTA in the subcutaneous tissues of rats and reported no significant difference in inflammation after 7 days and 30 days.[15]

Therefore, CC shows promise as a root-end filling material, and because literature concerning CC is sparse, this study aimed to expand the knowledge base and evaluate bone response to CC in comparison with MTA in an animal model.

Table 1 The main compositions of mineral trioxide aggregate (MTA) and cold ceramic (CC) based on weight (%).

Components	CaO	BaO	SiO_2	Bi_2O_3	H_2O and CO_2	SO_3	Al_2O_3
MTA	44.23	—	21.20	16.13	14.49	0.53	1.92
CC	48.12	18.61	16.19	—	—	10.15	3.68

Note. From "Mineral trioxide aggregate material use in endodontic treatment: a review of the literature," by H.W. Roberts, J.M. Toth, D.W. Berzins, D.G. Charlton, 2008, *Dental Materials*, 24, p. 149–64. Copyright 4021360300098, Elsevier. Adapted with permission

Materials and methods

Ethical approval was granted by the Torabinejad Dental Research Center, Isfahan University of Medical Sciences, Isfahan, Iran with identification number 287233. All procedures were conducted strictly in accordance with ethical standards and with the last update of the Helsinki Declaration.[16] The maintenance and care of the animals complied with the ethical guidelines of the Torabinejad Dental Research Center.

Forty-five male guinea pigs (English short hair breed weighing 750–850 g, derived from Pasteur Institute of Iran, Tehran, Iran) were involved in this interventional and experimental study. Each animal was anesthetized initially with 10 mg/kg ketamine HCL (Alfasan, Woerden, The Netherlands) and 12 mg/kg xylazine (Alfasan, Woerden, The Netherlands) under supervision of a veterinarian in the Torabinejad Dental Research Center. General anaesthesia was maintained using 5% halothane (Nicholas Piramal India Limited, Mumbai, India) and N_2O. Local anaesthesia was also provided in the mucobuccal fold with 3.6-mL lidocain (Daroo Pakhsh Pharmaceutical Co., Tehran, Iran). The submandibular area was shaved and the skin was disinfected with a 5% tincture of iodine. A triangular incision of about 15 mm was made between the incisor and the caudal side of the symphysis joining the two halves of the mandible on both right and left sides. The mucoperiostal flap was raised using a periosteal elevator and a 3 mm × 3 mm diameter cylindrical hole was prepared in each side using a size #3 trephine (ACE Surgical Supply Co., Brockton, MA, USA) under sterile saline irrigation.

Because Teflon causes no significant irritation to tissues,[17] two one-sided open cylindrical tube applicators (inner diameter = 1 mm; outer diameter = 2 mm; length = 2 mm) which corresponded to the defects were filled with white MTA (ProRoot, Dentsply Tulsa Dental, Tulsa, OK, USA) and CC (Shahid Sadoughi University of Medical Sciences, Yazd, Iran) under sterile conditions, separately.

The MTA tube was inserted into the left side defect so that the test material was placed adjacent to the bone. The CC tube filled the right defect in the same way. The mucoperiostal flap was replaced over the tubes and the incision was sutured with 3-0 black silk. The observation periods were 2 weeks and 12 weeks according to a study by Torabinejad et al.[18] The guinea pigs were euthanized in each time interval (24 specimens after 2 weeks and 21 specimens after 12 weeks). The mandibles were dissected out and the bone adjacent to the tubes, *in situ*, was cut into 10-mm

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