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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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.3,4 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.5 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.6-9

Amalgam, cavity, composite resins, glass ionomer cements, gold foils, Gutta-percha, mineral trioxide aggregate (MTA), polycarboxylate cement, polvinyl 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, incomaptibility 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...
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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 fractures, cavities 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,11,24-28 Fluid transport,29 Biocompatibility test,30,10-12,19 and SEM.4,17,30 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.17 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 microracks 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 with low setting time and higher sealing ability than amalgam. Hashemina 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.

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.

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References
1. Bergenholtz G, Lekholm U, Milthon R, Heden G, Odesjö B, Engström B. Retreatment of endodontic fillings. Scand J Dent Res 1979;87(3):217-24.
2. Kim S, Kratchman S. Modern endodontic surgery concepts and practice: A review. J Endod 2006;32(7):601-23.
3. Rubinstein RA, Kim S. Long-term follow-up of cases considered healed one year after apical microsurgery. J Endod 2002;28(5):378-83.
4. Zuolo ML, Ferreira MO, Gutmann JL. Prognosis in periradicular surgery: A clinical prospective study. Int Endod J 2000;33(2):91-8.
5. Song M, Jung IY, Lee SJ, Lee CY, Kim E. Prognostic factors for clinical outcomes in endodontic microsurgery: A retrospective study. J Endod 2011;37(7):927-33.
6. Cohen S, Burns RC, Hargreaves KM, Berman LH. Pathways of the Pulp. St. Louis: Elsevier, Mosby; 2006.
7. Mamootil K, Messer HH. Penetration of dentinal tubules by endodontic sealer cements in extracted teeth and in vivo. Int Endod J 2007;40(11):873-81.
8. Gartner AH, Dorn SO. Advances in endodontic surgery. Dent Clin North Am 1992;36(2):357-78.
9. Gutmann JL, Pitt Ford TR. Management of the resected root end: A clinical review. Int Endod J 1993;26(5):273-83.
10. Dorn SO, Gartner AH. Retrograde filling materials: A retrospective success-failure study of amalgam, EBA, and IRM. J Endod 1990;16(8):391-3.
11. Torabinejad M, Watson TF, Pitt Ford TR. Sealing ability of a mineral trioxide aggregate when used as a root end filling material. J Endod 1993;19(12):591-5.
12. Tawil PZ, Trope M, Curran AE, Caplan DJ, Kirakozova A, Duggan Dij, et al. Periapical microsurgery: An in vivo evaluation of endodontic root-end filling materials. J Endod 2009;35(3):357-62.
13. Lee ES. A new mineral trioxide aggregate root-end filling technique. J Endod 2000;26(12):764-5.
14. Reeh ES, Combe EC. New core and sealer materials for root canal obturation and retrofiling. J Endod 2002;28(7):520-3.
15. Yatsushiro JD, Baumgartner JC, Tinkle JS. Longitudinal study of the microleakage of two root-end filling materials using a fluid conductive system. J Endod 1998;24(11):716-9.
16. Davis JL, Jeansson BG, Davenport WD, Gardiner D. The effect of irrigation with doxycycline or citric acid on leakage and osseous wound healing. J Endod 2003;29:31-5.
17. Peters CI, Peters OA. Occlusal loading of EBA and MTA root-end fillings in a computer-controlled masticator: A scanning electron microscopic study. Int Endod J 2002;35(1):22-9.
18. Starkey DL, Anderson RW, Pashley DH. An evaluation of the effect of methylene blue dye pH on apical leakage. J Endod 1993;19(9):435-9.
19. Siqueira JF Jr, Roccas IN, Abad EC, Castro AJ, Gahyva SM, Favieri A. Ability of three root-end filling materials to prevent bacterial leakage. J Endod 2001;27(11):673-5.
20. Mangin C, Yesilsoy C, Nisslan R, Stevens R. The comparative sealing ability of hydroxyapatite cement, mineral trioxide aggregate, and super ethoxybenzoic acid as root-end filling materials. J Endod 2003;29(4):261-4.
21. Martell B, Chandler NP. Electrical and dye leakage comparison of three root-end restorative materials. Quintessence Int 2002;33(1):30-4.
22. Stabholz A, Friedman S, Abed J. Marginal adaptation of retrograde fillings and its correlation with sealability. J Endod 1985;11(5):218-23.
23. Gondim E, Zaia AA, Gomes BP, Ferraz CC, Teixeira FB, Souza-Filho FJ. Investigation of the marginal adaptation of root-end filling materials in root-end cavities prepared with ultrasonic tips. Int Endod J 2003;36(7):491-9.
24. Modaresi J, Yavari SA, Dianat SO, Shahrabi S. A comparison of tissue reaction to MTA and an experimental root-end restorative material in rats. Aust Endod J 2005;31(2):69-72.
25. Modaresi J. Perforation repair comparing experimental new material “cold ceramic” and amalgam. Asian Dent 2004;11:6-7.
26. Lee SJ, Monsef M, Torabinejad M. Sealing ability of a mineral trioxide aggregate for repair of lateral root perforations. J Endod 1993;19(9):541-4.
27. Estrela C, Bammann LL, Estrela CR, Silva RS, Pecora JD. Antimicrobial and chemical study of MTA, portland cement, calcium hydroxide paste, sealapex and dycal. Braz Dent J 2000;11(1):3-9.
28. Milani AS, Shakouie S, Borza N, Sighari Deljavan A, Asghari Jafarabadi M, Pournaghi Azar F. Evaluating the effect of resection on the sealing ability of MTA and CEM cement. Iran Endod J 2012;7(3):134-8.
29. Wu MK, Kontakiotis EG, Wesselink PR. Long-term seal provided by some root-end filling materials. J Endod 1998;24(8):557-60.
30. Xavier CB, Weismann R, de Oliveira MG, Demarco FF, Pozza DH. Root-end filling materials: Apical microleakage and marginal adaptation. J Endod 2005;31(7):539-42.
31. Wu MK, Wesselinck PR. Endodontic leakage studies reconsidered. Part I. Methodology, application and relevance. Int Endod J 1993;26(1):37-43.
32. Reyes-Carmona JF, Felippe MS, Felippe WT. Biomineralization ability and interaction of mineral trioxide aggregate and white portland cement with dentin in a phosphate-containing fluid. J Endod 2009;35(5):731-6.
33. Torabinejad M, Smith PW, Kettering JD, Pitt Ford TR. Comparative investigation of marginal adaptation of mineral trioxide aggregate and other commonly used root-end filling materials. J Endod 1995;21(6):295-9.
34. Abdal AK, Retief DH. The apical seal via the retrosurgical approach. I.A. preliminary study. Oral Surg Oral Med Oral Pathol 1982;53(6):614-21.
35. Torabinejad M, Hong CU, Pitt Ford TR, Kaiyawasam SP. Tissue reaction to implanted super-EBA and mineral trioxide aggregate in the mandible of guinea pigs: A preliminary report. J Endod 1995;21(11):569-71.
36. Torabinejad M, Hong CU, Pitt Ford TR, Kettering JD. Cytotoxicity of four root end filling materials. J Endod 1995;21(10):489-92.
37. Torabinejad M, Parirokh M. Mineral trioxide aggregate: A comprehensive literature review – Part II: Leakage and biocompatibility investigations. J Endod 2010;36(2):190-202.
38. Lamb EL, Loushine RJ, Weller RN, Kimbrough WF, Pashley DH. Effect of root resection on the apical sealing ability of mineral trioxide aggregate. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2003;95(6):732-5.
39. Nair PN. Pathogenesis of apical periodontitis and the causes of endodontic failures. Crit Rev Oral Biol Med 2004;15(6):348-81.
40. Andelin WE, Browning DF, Hsu GH, Roland DD, Torabinejad M. Microleakage of resected MTA. J Endod. 2002;28(8):573-4.
41. Sonarkar S, Purba R. Bioactive materials in conservative dentistry. Int J Contemp Dent Med Rev 2015;2015:Article ID: 340115. doi: 10.15713/ins.ijcdmr.47.
42. Khandelwal A, Karthik J, Nadig RR, Jain A. Sealing ability of mineral trioxide aggregate and Biodentine as root end filling material, using two different retro preparation techniques – An in vitro study. Int J Contemp Dent Med Rev 2015;2015:Article ID: 150115. doi: 10.15713/ins.ijcdmr.48.
43. Chakraborty A. Will portland cement be a cheaper alternative to mineral trioxide aggregate in clinical use?: A comprehensive review of literature. Int J Contemp Dent Med Rev 2015;2015:Article ID: 110215. doi: 10.15713/ins.ijcdmr.69.
44. Modaresi J, Aghili H. Sealing ability of a new experimental “cold ceramic” material compared to glass ionomer. J Clin Dent 2006;17(3):64-6.
45. Hasheminia SM, Nejad SL, Dianat O, Modaresi J, Mahjour F. Comparing the sealing properties of mineral trioxide aggregate and an experimental ceramic based root end filling material in different environments. Indian J Dent Res 2013;24(4):474-7.