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Effects of Calcium Chloride, as An Additional Accelerator Substance, on Marginal Adaptation of Calcium-Enriched Mixture cement to Dentin

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Abstract:

Background: Inadequate apical seal is a major cause of surgical endodontic failures. Therefore, the use of a suitable substance as root-end filling material that sets immediately and prevents penetration of potential contaminants into the periapical tissue is vital. The aim of present study was to compare the marginal adaptation of calcium-enriched mixture cement (CEM-cement) and CEM-cement plus calcium chloride ($CaCl_2$) (as an accelerator) using scanning electron microscope (SEM).

Materials and Methods: 24 extracted human single-rooted teeth were decoronated from the cemento-enamel junction to prepare 16 mm roots. After cleaning, shaping, and obturation, 3 mm above the apex was cut perpendicular to the long axis, and an apical cavity was prepared by an ultrasonic device. Specimens were randomly divided into two groups and were retro filled by experimental materials (CEM-cement and CEM-cement + $CalCl_2$). Next, the roots were sectioned, and SEM examination was done to determine the gap size between cavity walls and end-root materials. 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 gap size was higher in CEM-cement + $CaCl_2$ group in comparison with CEM-cement group. However, no significant differences were observed by statistical test ($P = 0.79$).

Conclusion: $CaCl_2$ as an additive substance for acceleration of CEM-cement setting cannot remarkably influence the marginal adaptation of CEM to the root canal walls.

Key Words: Calcium-enriched mixture cement, marginal adaptation, scanning electron microscopy

Introduction

Root canal treatment failure is mainly associated to persistence and/or penetration of microbial infection into the root canal system or the periradicular area.[1-3]

To eliminate the intraradicular infection, retreating the failed teeth is commonly the first choice.[4] However, periapical surgery may be considered the choice of an appropriate therapy when it would otherwise be difficult or impossible to retreat the teeth or where there was an irreversible change in the periradicular area that could not be resolved by a non-surgical approach.[5] Endodontic surgery involves exposure of the root apex, debridement of pathological lesion, periradicular curettage, root-end resection, and cavity preparation for placement of a suitable filling material.[5]

Prognosis of an endodontic surgery is influenced by several factors including the demographic and systemic condition of a patient, type of teeth, amount of bone loss, quality of previous endodontic treatment, techniques and type of materials which determines the apical seal.[6] Some studies reported that end-root materials are the key factor for the long-term success of surgical outcomes.[5,7]

Well adaptation to the root canal walls, dimensional stability, adequate bond strength, providing no leakage, and histocompatibility are some of the most important criteria of an ideal substance for root-end filling.[8,9]

There are different kinds of root-end filling materials including amalgam, composite resins, zinc oxide eugenol, zinc phosphate, polycarboxylate cement, polyvinyl cement, and mineral trioxide aggregate (MTA). However, most of these materials represented some drawbacks such as leakage, handling properties, long setting time, and incompatibility with moisture.[10]

Calcium-enriched mixture cement (CEM-cement) introduced in 2008 has been implicated as an alternative to MTA and showed promising results.[11] It composed of calcium oxide, calcium phosphate, calcium silicate, and calcium sulfate.[12] Studies showed that CEM-cement has the advantage of favorable biocompatibility, increased flow, decreased film thickness, great sealing capacity, and antimicrobial activity against endodontic pathogens.[12,13]

CEM-cement as the end-root material has been criticized for the slow setting time (though it is faster than MTA) because of the blood contamination risk during retrograde surgery which could jeopardize the marginal integrity and continuity of CEM to the root canal walls.[14]

Abbaszadegan has demonstrated that adding 10% calcium chloride ($CaCl_2$) as an additive accelerator induces faster setting of CEM-cement (decreasing the setting time from 58.3 to 33.3).[11] In addition to decreasing the setting time, $CaCl_2$ also could alter the physical or mechanical properties of CEM-cement, which may affect the sealing ability of it too.[11] Therefore, the purpose of this study was to investigate and compare the marginal adaptation of common CEM-cement with CEM-cement plus $CaCl_2$.

Materials and Methods

This study was approved by the Committee on Ethics of the School of Dentistry at the Shahid Sadoughi University of Yazd, Iran.

Teeth selection

In this lab-trail study, 24 extracted human single-rooted teeth were collected. Teeth with any evidence of root fracture or crack, root resorption, and apical dilacerations (larger than 20 degrees) were excluded from the study. All samples had direct root canals with no calcification and ended to a mature (close) apex.

Teeth were stored in a solution of 5.25% sodium hypochlorite (Chloran, Tehran, Iran) for 30 min to remove surface debris.

Root canal preparation

Selected teeth were decoronated from the cemento-enamel junction (CEJ) to create a standardized length of 16 mm. The root canal length was measured using size #15 K-file (Dentsply Maillefer, Ballaigues, Switzerland) until observing the file tip at the apical foramen.

The coronal third of the canal was enlarged by Gates-Glidden drills (Dentsply, Milford, DE, USA) sizes 1-3. Root canal shaping was done using step back technique by K file up to size #50 one millimeter short of the apical foramen. During instrumentation, canals were irrigated constantly by sodium hypochlorite 1%. After making the canals dried using paper points, they were subjected to ethylenediaminetetraacetic acid 17% (7.2 pH) (Aria dent, Tehran, Iran) for 3 min to remove the smear layer. Canals were irrigated again for the last time, dried and obturated with 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.

Root-end preparation

The apical 3 mm of the root was resected perpendicular to the long axis of the teeth using diamond disks (3M dental products, USA).

To prepare the root-end cavity, an ultrasonic device was used making a cavity of 3 mm depth. At this stage, prepared specimens were divided randomly into two groups (n = 12) as follow:

- CEM-cement: Based on manufacturer instruction to achieve a creamy consistency of CEM-cement (Yektazdandan; Bionique Dent, Tehran, Iran), 1 g of powder was first weighed to an accuracy of 0.001 and was mixed with 0.66 g distilled water. Then, specimens were apically filled by prepared paste using a carrier and condensed thoroughly with a plunger.
- CEM-cement plus $CaCl_2$: At first, 1.00 g of 10% $CaCl_2$ was mixed in 0.66 g of liquid using a magnetic stirrer (L82, Labinco BV, Breda, The Netherlands), and then this solution was mixed with 1.00 g CEM powder.[11] The prepared substance was placed in the root-end cavity by a carrier and condensed thoroughly with a plunger.

The samples were incubated for 24 h at 37°C.

Evaluation of marginal adaptation

Each tooth was horizontally resected from 1 mm above the apical part. After mounting each specimen on aluminum stub sputter under high vacuum condition, they were assessed using scanning electron microscopy (SEM) at ×200 for evaluating dentin-filling material contact. The maximum value of the width of gap was recorded in microns.

Statistical analysis

The collected data were statistically analyzed by Mann–Whitney test and using SPSS software version 18 at a significant level of 0.05.

Results

In all of the studied samples, the gap was found at the dentin-filling material interface (Figure 1). The mean interfacial adaptation was higher in CEM-cement group (3.95 ± 1.28)

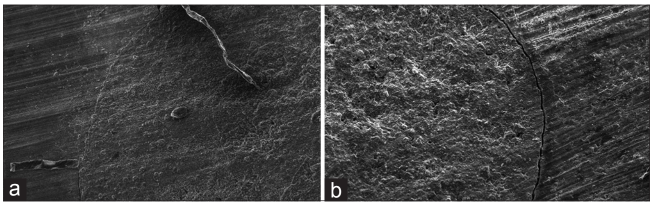

Figure 1: (a and b) Scanning electron microscopy pictures, the right image represents smaller gap between calcium-enriched mixture (CEM) and dentin in comparison with the left image which illustrates a larger gap between CEM + calcium chloride and dentin.

Table 1: Comparison of marginal adaptation between study groups (gap sizes presented in micron).

Group	Mean±SD	Maximum	Minimum	Result
CEM	3.95±1.28	6.03	1.56	P value: 0.79
CEM+$CaCl_2$	5.69±3.14	10.89	1.57	

SD: Standard deviation, CEM: Calcium-enriched mixture, $CaCl_2$: Calcium chloride than CEM-cement plus CaCl2 group (5.69 ± 3.14); however, no significant differences were reported by statistical analysis (P = 0.79). Table 1 illustrates the descriptive values of gap sizes in study groups.

Discussion

CEM-cement, developed in 2008 by Asgary, is a novel bioactive endodontic material with similar clinical applications to MTA.[15] This cement is consisted of chemical compositions which are more similar to dentine than that of Portland cement and MTA.[16] CEM-cement has various clinical applications including pulp capping, management of external root resorption, perforation repairs, and surgical root-end fillings.[16] In most of these conditions, CEM is in contact with tissue fluid or even the blood. Therefore to improve the efficiency, CEM and also other end-root materials should have the shortest setting time possible. Furthermore, they should resist solubility and disintegration in the aqueous environment.[17] To obtain an enriched mixture-cement, the powder composed of various concentrations of calcium salt, calcium oxide, calcium silicate, and calcium phosphate must be mixed with a water-based solution.[18]

Kogan investigated the effects of various additives on setting properties of MTA. They showed that NaOCl gel, K-Y Jelly, 3% and 5% CaCl2 decreased the setting time to 20-25 min. They also reported that the compressive strength of set materials was significantly lower than MTA mixed with water.[19]

Abbaszadegan reported that adding 10% CaCl2 induced faster setting time of CEM-cement and reduced its solubility. It might be related to the penetration of CaCl2 into the CEM-cement pores which could in part lead to the acceleration in hydration of the silicates and facilities the crystallization processes.[11]

Although several studies reported an effective sealing capacity of CEM-cement,[13] there is no published work assessing the marginal adaptation of CEM-cement plus $CaCl_2$. The results of this study represented that all the samples showed the gap between dentin and filling material which is in accordance with the results of previous studies (Olivira 2013,[8] Xavier 2005,[10] Costa 2009[20]). However, the mean gap size of CEM-cement, obtained in the present study, was smaller than similar studies assessing marginal adaptation of MTA. Mokhtari reported a mean gap size of 6.78 ± 2.78 μm between MTA and dentinal wall.[21] Baranwal noticed a mean gap of 15.88 μm with white MTA.[22] These large differences might be explained by different kinds of materials and/or different methodologies. Baranwal sectioned the teeth longitudinally while Mokhtari cut the specimens horizontally.

In the present study, the larger gap was found in CEM-cement plus $CaCl_2$ group in comparison with CEM-cement group, though it was not statistically significant. We choose SEM method to determine the gap size because it appeared to be an efficient and acceptable method of investigating features such as surface topography,[23,24] measuring the marginal gaps at the interface under higher image magnifications. However, SEM has some limitations that might have influence the result of studies. 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.[25] Resin replica has been suggested to eliminate these artifacts. Since some investigators such as Torabinejad[25] stated that the interfacial gap was similar between a natural tooth and the replica, we preferred to work on natural teeth.

Conclusion

Based on the results of the present study, $CaCl_2$ as an additive substance for acceleration of CEM-cement setting cannot remarkably influence the marginal adaptation of CEM to the root canal walls.

References

1. Nair PN, Sjögren U, Krey G, Kahnberg KE, Sundqvist G. Intraradicular bacteria and fungi in root-filled, asymptomatic human teeth with therapy-resistant periapical lesions: A long-term light and electron microscopic follow-up study. J Endod 1990;16(12):580-8.
2. Lin LM, Skribner JE, Gaengler P. Factors associated with endodontic treatment failures. J Endod 1992;18(12):625-7.
3. Ng YL, Mann V, Rahbaran S, Lewsey J, Gulabivala K. Outcome of primary root canal treatment: Systematic review of the literature -- Part 2. Influence of clinical factors. Int Endod J 2008;41(1):6-31.
4. Siqueira JF Jr. Aetiology of root canal treatment failure: Why well-treated teeth can fail. Int Endod J 2001;34(1):1-10.
5. Kim S, Kratchman S. Modern endodontic surgery concepts and practice: A review. J Endod 2006;32(7):601-23.
6. Zuolo ML, Ferreira MO, Gutmann JL. Prognosis in periradicular surgery: A clinical prospective study. Int Endod J 2000;33(2):91-8.
7. 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.
8. Oliveira HF, Gonçalves Alencar AH, Poli Figueiredo JA, Guedes OA, de Almeida Decurcio D, Estrela C. Evaluation of marginal adaptation of root-end filling materials using scanning electron microscopy. Iran Endod J 2013;8(4):182-6.
9. 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.
10. 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.
11. Abbaszadegan A, Sedigh Shams M, Jamshidi Y, Parashos P, Bagheri R. Effect of calcium chloride on physical properties of calcium-enriched mixture cement. Aust Endod J 2015;41(3):117-21.
12. Mozayeni MA, Milani AS, Marvasti LA, Asgary S.

Cytotoxicity of calcium enriched mixture cement compared with mineral trioxide aggregate and intermediate restorative material. Aust Endod J 2012;38(2):70-5.
13. Asgary S, Eghbal MJ, Parirokh M. Sealing ability of a novel endodontic cement as a root-end filling material. J Biomed Mater Res A 2008;87(3):706-9.
14. Oloomi K, Saberi E, Mokhtari H, Mokhtari Zonouzi HR, Nosrat A, Nekoofar MH, *et al*. Evaluation of the effect of blood contamination on the compressive strength of MTA modified with hydration accelerators. Restor Dent Endod 2013;38(3):128-33.
15. Utneja S, Nawal RR, Talwar S, Verma M. Current perspectives of bio-ceramic technology in endodontics: Calcium enriched mixture cement - Review of its composition, properties and applications. Restor Dent Endod 2015;40(1):1-13.
16. Asgary S, Shahabi S, Jafarzadeh T, Amini S, Kheirieh S. The properties of a new endodontic material. J Endod 2008;34(8):990-3.
17. Donnelly A, Sword J, Nishitani Y, Yoshiyama M, Agee K, Tay FR, *et al*. Water sorption and solubility of methacrylate resin-based root canal sealers. J Endod 2007;33(8):990-4.
18. Asgary S. Medical and dental biomaterial and method of use for the same. Google Patents US8105086; 2012 Jan 31.
19. Kogan P, He J, Glickman GN, Watanabe I. The effects of various additives on setting properties of MTA. J Endod 2006;32(6):569-72.
20. Costa AT, Konrath F, Dedavid B, Weber JB, de Oliveira MG. Marginal adaptation of root-end filling materials: An *in vitro* study with teeth and replicas. J Contemp Dent Pract 2009;10(2):75-82.
21. 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.
22. Baranwal AK, Paul ML, Mazumdar D, Adhikari HD, Vyavahare NK, Jhajharia K. An ex-vivo comparative study of root-end marginal adaptation using grey mineral trioxide aggregate, white mineral trioxide aggregate, and Portland cement under scanning electron microscopy. J Conserv Dent 2015;18(5):399-404.
23. Martell B, Chandler NP. Electrical and dye leakage comparison of three root-end restorative materials. Quintessence Int 2002;33(1):30-4.
24. Fogel HM, Peikoff MD. Microleakage of root-end filling materials. J Endod 2001;27(7):456-8.
25. 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.