Comparison of Microleakage of CEM Cement Apical Plug in Different Powder/Liquid Ratio in Immature Teeth Using Fluid Filtration Technique

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KEY WORDS
Calcium-Enriched Mixture Cement;
Concentration;
Dental leakage;

ABSTRACT
Statement of the Problem: Sealing ability is one of the most important factors for successful endodontic treatment. Some studies have shown that the powder to liquid ratio can influence the properties of dental materials. Subsequently, this may happen for those used for sealing in endodontics.

Purpose: The purpose of this research was to assess the microleakage of calcium-enriched mixture (CEM) cement apical plug in different powder to liquid ratio.

Materials and Method: Ninety-six extracted human single root and single canal teeth were decoronated. Working length was determined using ≠15 k-file. Canal preparation was performed using step back method. Samples were divided into 3 groups randomly. CEM cement was placed into the canal with 1.13, 2.27 and 3.40 powder to liquid ratio in the group 1, 2 and 3, respectively. After complete setting of CEM cement, the micro leakage value was evaluated using fluid filtration method. Data were analyzed using ANOVA and Scheffe tests.

Results: The bubble movement in three groups showed a statistically significant difference (p < 0.001). Minimum and maximum bubble movements were observed in the group with powder to liquid ratios of 3.40 and 1.13 respectively.

Conclusion: Increased CEM Cement powder to liquid ratio will increase the sealing ability of this material as apical plug. Considering the conditions of this study, the powder to liquid ratio of 3:40 provided the best sealing ability.

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Introduction
The main purpose of each step of root canal therapy is achievement of a proper seal to prevent the invasion of microorganisms into the periapical areas. [1] The lack of an adequate seal is the main cause of endodontic treatment failure. [2] This problem is a major challenge to the treatment of necrotic immature teeth; precise control of the working length during the procedure is reduced and there is no apical stop for condensation of the gutta-percha. [3-6] Apexification methods traditionally used to treat necrotic immature teeth have disadvantages such as long duration of treatment and increasing of tooth cervical fractures susceptibility due to long-term use of calcium hydroxide. [7-10] The use of an artificial apical plug is one alternative to apexification. [11-14]

Mineral trioxide aggregate (MTA) is commonly used in this method because of its favorable properties such as tissue compatibility, excellent sealing ability, osteo induction, and good marginal adaptation. Some of its disadvantages are its high cost, long setting time, and...
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need for moisture while setting. [3, 15-18] CEM cement, introduced by Asgari in 2006, is also commonly used. It consists of calcium compounds such as calcium oxide, calcium carbonate, calcium silicate, calcium sulfate, calcium hydroxide, and calcium chloride. This cement releases calcium hydroxide during and after setting. [16, 19-20] CEM cement and MTA have similar sealing abilities, biocompatibility, and pH, but CEM cement offers better antibacterial properties and lower film thickness and setting time than MTA. [20-24] Several studies have reported the cementogenesis ability of CEM cement. [12, 21]

Because sealing ability is a critical component of successful apical plug treatment, studies have assessed this property for MTA and CEM cement [12, 25] Some studies have shown that dental material properties can be influenced by the powder-to-liquid ratio. [25-27] Oraie et al. [25] found that MTA shows better sealing ability at a higher powder-to-liquid ratio. Al-Khenziani and Fridland [26] concluded that the anti-bacterial properties, solubility, and porosity of MTA related to the powder-to-liquid ratio. There is lack of data for determination of the effects of different powder-to-liquid ratio of CEM cement on sealing ability; thus, the present study was conducted to investigate this issue.

Materials and Method

Ninety-six extracted single-root and single-canal human teeth were selected. The inclusion criteria included lack of severe caries or coronal restoration, lack of root caries or root fracture, lack of dilaceration, lack of internal or external resorption or canal calcification. The exclusion criteria were teeth that were cracked or fractured during the investigation. All teeth were placed in 5.25% sodium hypochlorite solution for 1 hour to control and destroy infected soft tissue and periodontal tissue remnants. They were then maintained in normal saline solution until the onset of the procedure. The teeth were decoronated using a diamond disc (010; Tizkavan; Iran) to produce a standardized 13-mm root length.

To determine the working length, #15 K-file (DentsplyMaillefer; Switzerland) was inserted into the canal until its tip was observed at the apical foramen. Canal preparation was performed through the step-back method. The canals were cleaned up to the working length using #40 K-file and enlarged using #80 K-file. After the use of each instrument, the canals were rinsed with 1 ml sodium hypochlorite 5.25%.

To reconstruct the open apex, the apical foramen was enlarged using a #1-4 Peeso reamer (Dentsply Maillefer; Switzerland) to an apical foramen size of 1.3 mm. The root canals were then filled with 1 ml of 17% ethylenediamine tetraacetic acid (EDTA; Ariadent; Iran) for 3 minutes to remove the smear layer, after which the canals were rinsed with 5 ml of normal saline solution and dried with paper cones.

Three canals were used as the positive control group and were filled with gutta-percha (Diadent; Korea) without sealer. The negative control group contained three teeth for which the apex had been covered by sticky wax (Kerr; Germany). All teeth surface in negative group and other teeth were coated with two layers of nail polish up to 2 mm of apex. The remaining roots were divided randomly into three groups. [3]

In the group 1, the canals were completely dried using a paper point (Ariadent; Iran). CEM cement was mixed at a powder-to-liquid ratio of 1.13 and was placed into the canal using a MTA carrier (Dentsply Maillefer; Switzerland). Then the CEM cement was condensed using #3 and #4 hand pluggers (Dentsply Maillefer; Switzerland) with the help of a rubber stop to an entry length that was 5 mm shorter than the working length. [3] Glass slabs were used to prevent extrusion of CEM cement during condensation. Additional material was removed and the apical plug with 5 mm thickness was left.

The thickness and density of the apical plug was assessed using radiography. After inserting a wet paper point into the canal, the access cavity was filled with a temporary restoration (Coltosol; Ariadent; Iran). Samples were incubated at 37°C and 100% humidity for 24 h. After 24 hours, the temporary restoration was removed, complete setting of CEM cement was assessed using hand pluggers (Dentsply Maillefer, Ballaigues, Switzerland) and the rest of the canal space was filled by lateral condensation technique with gutta-percha (Diadent; Korea) and AH-26 sealer (DentsplyDeTrey; Germany). [13]

In the groups 2 and 3, all steps of the process were the same as the group 1 except for the powder-to-liquid ratio, which were 2.27 in the group 2 and 3.40 in the group 3. After preparation of the samples, microleakage
was evaluated using the liquid filtration method as described by Moradi et al. [28] The apical part of teeth were connected to a plastic tube. A plastic three valve adaptor was connected to the other side of the plastic tube, a scaled pipette (HBG, Germany) and a syringe (for create a small air bubble). Other side of scaled pipette connected to a regular water pressure of 20cm H2O to displace air bubble. All spaces of plastic tubes and pipette were filled with distilled water. The movement of the air bubble was observed and the volume of the fluid transport was measured. The micro-leakage of each sample was measured three times and the average number was employed as the micro-leakage value. Data were analyzed using SPSS 17 software and the ANOVA and Scheffe tests.

Results
During the course of examination, no movement of bubbles occurred in the negative control group. The positive control group showed the greatest bubble displacement. The mean average and standard deviation of the bubble movement in the study groups are summarized in Table 1. There was a significant difference in bubble movement between groups (p< 0.001). Minimum bubble movements occurred in the group 3 (powder-to-liquid ratio= 3.40) and maximum movement occurred in the group 1 (powder-to-liquid ratio= 1.13). Paired comparison of the groups for average bubble movement showed a significant difference between groups (Table 1).

Discussion
The use of an apical plug is a common and successful approach to endodontic treatment of necrotic immature teeth. The sealing ability of the apical plug is a major factor affecting treatment results. [11-13, 18, 29-30] The sealing ability of materials used as apical plaque are affected by factors such as dentinal wall thickness, preparation with chelating material, thickness of the apical plug, condensation method and the concentration of materials. The present study evaluated the sealing ability of CEM cement plugs at three powder-to-liquid ratios. [26-27, 31]

The sealing ability of the apical plug has been previously evaluated using different methods. [32-33] The fluid filtration method was used in the present study because it offers high sensitivity, and is independent to molecular tracer, which subsequently reduces errors. Moreover, it does not require destruction of samples, allowing them for long-term review. [3, 28, 34-37] The authors did not find any previous study that examined the characteristics of CEM cement at different concentrations. In the present study, powder-to-liquid ratios of 1.13, 2.27, and 3.40 were compared. The powder-to-liquid ratio of 2.27 is the consistency that used commonly in clinical settings.

The results showed that there were significant differences in bubble movement for the different powder-to-liquid ratios, with the maximum movement recorded at 1.13 and the minimum at 3.40. Al-Hezaimi et al. [26] reported that reducing the powder-to-liquid ratio of MTA had a negative effect on its anti-fungal properties. Oraie et al. [25] demonstrated that increasing the powder-to-liquid ratio of MTA would reduce the micro-leakage significantly. These results are consistent with the results of the present study. Shahran et al. [31] reported that the histologic response of pulp after pulp capping treatment with different powder-to-liquid ratios of MTA showed no significance differences. The disparity in these results may be caused by differences in the material studied (MTA versus CEM cement) and different treatment methods (apical plug versus pulp capping). Fridland et al. [27] reported that by decreasing the powder-to-liquid ratio, the porosity and solubility of MTA would be increased. These results are all rational explanations for the results of the present study. Because the chemical compositions of MTA and CEM cement are similar, it can be assumed that the decrease in the powder-to-liquid ratio of CEM cement also increased the porosity and solubility of this material and increased the micro-leakage; however, further study is necessary to confirm this theory.

Conclusion
The results of the present study indicated that increasing

| Powder/liquid ratio | Mean (10^4 µL/min/CmH2O) | Standard deviation | p Value |
|---------------------|--------------------------|--------------------|---------|
| 1.13                | 38.370                   | 6.217              | 0.001   |
| 2.27                | 31.560                   | 7.729              |         |
| 3.40                | 23.083                   | 6.966              | 0.00    |
| 2.27                | 31.560                   | 7.729              |         |
| 3.40                | 23.083                   | 6.966              |         |
the powder-to-liquid ratio of CEM cement increases the sealing ability of this material in an apical plug. Under the study conditions, a powder-to-liquid ratio of 3.40 provided the best sealing ability. Further study using different methods should be performed to confirm these results.

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Conflict of Interest
The authors disclose no potential conflicts of interest.

References
[1] Srivastava AA, Srivastava H, Prasad AB, Raisingani D, Soni D. Effect of Calcium Hydroxide, Chlorhexidine Digo gluconate and Camphorated Monochlorophenol on the Sealing Ability of Biocement Apical Plug. J Clin Diagn Res. 2016; 10: ZC43-ZC46.
[2] Mirhadi H, Moazzami F, Rangani Jahromi S, Safarzade S. The Effects of Alkaline pH on Microleakage of Mineral Trioxide Aggregate and Calcium Enriched Mixture Apical Plugs. J Dent (Shiraz). 2016; 17: 16-20.
[3] Tabrizizade M, Asadi Y, Sooratgar A, Moradi S, Sooratgar H, Ayatollahi F. Sealing ability of mineral trioxide aggregate and calcium-enriched mixture cement as apical barriers with different obturation techniques. Iran Endod J. 2014; 9: 261-265.
[4] Shabahang S. Treatment options: apexogenesis and apexification. Pediatr Dent. 2013; 35: 125-128.
[5] Moazami F MF, Sahebi F. Apical microleakage of obturated canals with apical Plug and customized cone techniques in open apices models. Shiraz Univ Dent J. 2007; 15: 10-20.
[6] Camp JH. Diagnosis dilemmas in vital pulp therapy: treatment for the toothache is changing, especially in young, immature teeth. Pediatr Dent. 2008; 30: 197-205.
[7] Purra AR, Ahangar FA, Chadagal S, Farooq R. Mineral trioxide aggregate apexitization: A novel approach. J Conserv Dent. 2016; 19: 377-380.
[8] Nicoloso GF, Pötter IG, Rocha RO, Montagner F, Casagrande L. A comparative evaluation of endodontic treat- ments for immature necrotic permanent teeth based on clinical and radiographic outcomes: a systematic review and meta-analysis. Int J Paediatr Dent. 2017; 27: 217-227.
[9] Khalilak Z, Vali T, Danesh F, Vatanpour M. The Effect of One-step or Two-step MTA Plug and Tooth Apical Width on Coronal Leakage in Open Apex Teeth. Iran Endod J. 2012; 7: 10-14.
[10] Silva RV, Silveira FF, Nunes E. Apexitization in non-vital teeth with immature roots: report of two cases. Iran Endod J. 2015; 10: 79-81.
[11] Escribano-Escrivá B, Micó-Muñoz P, Manzano-Saiz A, Giner-Lluesma T, Collado-Castillanos N, Muwaquet-Rodríguez S. MTA apical barrier: In vitro study of the use of ultrasonic vibration. J Clin Exp Dent. 2016; 8: c318-c321.
[12] Ayatollahi F, Tabrizizadeh M, Hazeri Baqlad Abad M, Ayatollahi R, Zarebidoki F. Comparison of Microleakage of MTA and CEM Cement Apical Plugs in Three Different Media. Iran Endod J. 2016; 11: 198-201.
[13] Vu M, Palamara J, Parashos P. Behavior of mineral trioxide aggregate apical plugs and rootfillings under cyclic loading. J Investig Clin Dent. 2017; 8: doi: 10.1111/jicd.12226.
[14] Corbella S, Ferrara G, El Kabbaney A, Taschieri S. Apexification, apogenesis and regenerative endodontic procedures: a review of the literature. Minerva Stomatol. 2014; 63: 375-389.
[15] Khademi AA, Shekarchizade N. Evaluation of coronal microleakage of mineral trioxide aggregate plug-in teeth with short roots prepared for post placement using bacterial penetration technique. Indian J Dent Res. 2016; 27: 295-299.
[16] Asgary S, Akbari Kamrani F, Taheri S. Evaluation of antimicrobial effect of MTA, calcium hydroxide, and CEM cement. Iran Endod J. 2007; 2: 105-109.
[17] Chong BS, Pitt Ford TR, Hudson MB. A prospective clinical study of Mineral Trioxide Aggregateand IRM when used as root-end filling materials in endodontic surgery. 2003. Int Endod J. 2009; 42: 414-420.
[18] Asgary S, Parirokh M, Eghbali MJ, Brink F. Chemical differences between white and gray mineral trioxide aggregate. J Endod. 2005; 31: 101-103.
[19] Shojaee NS, Adl A, Sobhnamayy F, Khademi A, Hamedi M. In Vitro Evaluation of Different Solvents for Retrieval of MineralTrioxide Aggregate and Calcium-Enriched Mixture. Iran Endod J. 2016; 11: 223-227.
[20] Asgary S, Kemal Çalışkan M. Vital Pulp Therapy of a Mature Molar with Concurrent Hyperplastic Pulpitis, Internal Root Resorption and Periradicular Periodontitis: A Case Report. Iran Endod J. 2015; 10: 284-286.

[21] Ramazani N, Sadeghi P. Bacterial Leakage of Mineral Trioxide Aggregate, Calcium-Enriched Mixture and Biodentine as Furcation Perforation Repair Materials in Primary Molars. Iran Endod J. 2016; 11: 214-218.

[22] Asgary S, Nosrat A, Seifi A. Management of inflammatory external root resorption by using calcium-enriched mixture cement: a case report. J Endod. 2011; 37: 411-413.

[23] Asgary S, Eghbal MJ, Ehsani S. Periradicular regeneration after endodontic surgery with calcium-enriched mixture cement in dogs. J Endod. 2010; 36: 837-841.

[24] Asgary S, Eghbal MJ, Parirokh M, Torabzadeh H. Sealing ability of three commercial mineral trioxide aggregates and an experimental root-end filling material. Iran Endod J. 2006; 1: 101-105.

[25] Oraie E, Ghassemi AR, Eliasifar G, Sadeghi M, Shahranvan A. Apical Sealing Ability of MTA in Different Liquid to Powder Ratios and Packing Methods. Iran Endod J. 2012; 7: 5-9.

[26] Al-Hezaimi K, Al-Hamdan K, Naghshbandi J, Oglesby S, Simon JH, Rotstein I. Effect of white-colored mineral trioxide aggregate in different concentrations on Candida albicans in vitro. J Endod. 2005; 31: 684-686.

[27] Fridland M, Rosado R. Mineral trioxide aggregate (MTA) solubility and porosity with different water-to-powder ratios. J Endod. 2003; 29: 814-817.

[28] Moradi S, Lomée M, Gharechahi M. Comparison of fluid filtration and bacterial leakagetecniques for evaluation of microleakage in endodontics. Dent Res J (Isfahan). 2015; 12: 109-114.

[29] Asgary S, Shahabi S, Jafarzadeh T, Amini S, Kheirieh S. The properties of a new endodontic material. J Endod. 2008; 34: 990-993.

[30] Morse DR, O’Lernic J, Yesilsoy C. Apexification: review of the literature. Quintessence Int. 1990; 21: 589-598.

[31] Shahranvan A, Jalali SP, Torabi M, Haghdoost AA, Gorjestani H. A histological study of pulp reaction to various water/powder rations of white mineral trioxide aggregate as pulp-capping material in human teeth: a double-blinded, randomized controlled trial. Int Endod J. 2011; 44: 1029-1033.

[32] Nikhil V, Jha P, Suri NK. Effect of methods of evaluation on sealing ability of mineraltrioxide aggregate apical plug. J Conserv Dent. 2016; 19: 231-234.

[33] Veríssimo DM, do Vale MS. Methodologies for assessment of apical and coronal leakage of endodontic filling materials: a critical review. J Oral Sci. 2006; 48: 93-98.

[34] Adel M, Nima MM, Shivaie Kojoori S, Norooz Oliaie H, Naghavi N, Asgary S. Comparison of endodontic biomaterials as apical barriers in simulated open apices. ISRN Dent. 2012; 2012: 359873.

[35] Javidi M, Naghavi N, Roohani E. Assembling of fluid filtration system for quantitative evaluation of microleakage in dental materials. Iran Endod J. 2008; 3: 68-72.

[36] Ahlberg KM, Assavanop P, Tay WM. A comparison of the apical dye penetration patterns shown by methylene blue and india ink in root-filled teeth. Int Endod J. 1995; 28: 30-34.

[37] Shemesh H, Souza EM, Wu MK, Wesselinck PR. Glucose reactivity with filling materials as a limitation for using the glucose leakage model. Int Endod J. 2008; 41: 869-872.