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

Mehdi Tabrizzadeh¹, Mostafa Mirshahpanah²

Contributors:
¹Professor, Department of Endodontics, Faculty of Dentistry, Shahid Sadoughi University of Medical Sciences, Yazd 89195/165, Iran; ²Endodontic Resident, Department of Endodontics, Faculty of Dentistry, Shahid Sadoughi University of Medical Sciences, Yazd 89195/165, Iran.

Correspondence:
Mirshahpanah M. Department of Endodontics, Faculty of Dentistry, Shahid Sadoughi University of Medical Sciences, Yazd 89195/165, Iran. Phone: +98-915-18766-84. Email: mostfa.Mirshah@gmail.com

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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 (CaCl₂) (as an accelerator) using scanning electron microscope (SEM).

Materials and Methods: 24 extracted human single-rooted teeth weredecoronated 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 + CaCl₂). 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 + CaCl₂ group in comparison with CEM-cement group. However, no significant differences were observed by statistical test (P = 0.79).

Conclusion: CaCl₂ 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, retreatring 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.⁶

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 (CaCl₂) 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, CaCl₂ 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 CaCl₂.

**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 (EDTA) 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 CaCl₂**: At first, 1.00 g of 10% CaCl₂ was mixed in 0.66 g of liquid using a magnetic stirrer (L82, Labinox 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) as compared to CEM-cement plus CaCl₂ (5.69 ± 3.14).

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**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).

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean±SD</th>
<th>Maximum</th>
<th>Minimum</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEM</td>
<td>3.95±1.28</td>
<td>6.03</td>
<td>1.56</td>
<td>P value: 0.79</td>
</tr>
<tr>
<td>CEM+CaCl₂</td>
<td>5.69±3.14</td>
<td>10.89</td>
<td>1.57</td>
<td></td>
</tr>
</tbody>
</table>

SD: Standard deviation, CEM: Calcium-enriched mixture, CaCl₂: 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. This cement is consisted of chemical compositions which are more similar to dentine than that of Portland cement and MTA. CEM-cement has various clinical applications including pulp capping, management of external root resorption, perforation repairs, and surgical root-end fillings. 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. 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.

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.

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.

Although several studies reported an effective sealing capacity of CEM-cement, there is no published work assessing the marginal adaptation of CEM-cement plus CaCl₂. The results of this study represented that all the samples showed the gap size of 6.78 ± 2.78 µm between MTA and dentinal wall. Baranwal noticed a mean gap of 15.88 µm with white MTA. 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 CaCl₂ 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, 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. Resin replica has been suggested to eliminate these artifacts. Since some investigators such as Torabinejad 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, CaCl₂ as an additive substance for acceleration of CEM-cement setting cannot remarkably influence the marginal adaptation of CEM to the root canal walls.

**References**

12. Mozayeni MA, Milani AS, Marvasti LA, Asgary S.


