Original Article

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

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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

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 plugger (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 H_2O 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, pre-treatment 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]

Table 1: Mean and standard deviation of bubble microleakage (10^{-4}×µL/min/CmH_2O)

Powder/ liquid ratio	Mean (10^{-4}×µl/min/CmH_2O)	Standard deviation	*p* Value
1.13	38.370	6.217	0.001
2.27	31.560	7.729	
1.13	38.370	6.217	0.00
3.40	23.083	6.966	
2.27	31.560	7.729	0.00
3.40	23.083	6.966	

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 microleakage significantly. These results are consistent with the results of the present study. Shahravan *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

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.

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