Effect of Calcium Hydroxide as a Temporary Filling for Post Space on Apical Leakage of Epoxy Resin-Based Sealer

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Abstract

The aim of this study was to examine whether calcium hydroxide (Ca(OH)2) paste as a temporary filling affected on the apical leakage in teeth that were obturated by epoxy resin-based (ER) sealer after immediately preparing post space.

Sixty extracted single-rooted mandibular first premolars were cut instrumented by Mtwo® file system to size of 40/0.04 at working length. Then, teeth were randomized into four experimental groups. The first two groups were obturated by gutta percha with zinc oxide eugenal (ZOE)-based sealer. Post space was immediately prepared. The first subgroup of ZOE-based sealer was left empty and the second subgroup were filled with Ca(OH)2 paste. In another two groups were done the same methods with ER-based sealer. All samples were immersed in 2% methylene blue solution for 72 hours. Then, all teeth were placed in acrylic resin block and cut longitudinally in bucco-lingual direction. Linear dye penetration was observed along root canal filling and root dentin interface under 10X microscope. Teeth which were obturated by ER-based sealer with Ca(OH)2 paste showed more apical leakage than without Ca(OH)2 paste with linear dye penetration of 2.51±1.11 mm. and 0.81±0.58 mm. respectively. However, there was no significant different between with Ca(OH)2 group and without Ca(OH)2 group.

Using Ca(OH)2 paste as a temporary filling material for immediate post space preparation may have detrimental effect to apical leakage when using ER-based sealer.

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Introduction

In many cases, post are required in endodontically-treated teeth due to loss of gross coronal tooth structure[1-4]. Delaying post space preparation may provide proper root canal sealing because root canal filling materials still occupy throughout the length of radicular pulpal space[5]. However, the risk of misdirection post drilling can be occurred during post space preparation[6,7] especially when it had been done by another dentist due to lack of internal or external anatomy of involved tooth. This situation could be demoted prognosis of teeth due to perforation or weaken the root structure by decreasing root dentin thickness[7-9]. The immediate post space preparation may decrease these catastrophic events. Moreover, the sealing ability of complete setting root canal sealer is not compromised by mechanical force loading against the apical root canal filling during post space preparation[10].

Immediate post space preparation can be performed by mechanical drilling by various engine-driven burs such as Gate-Glidden drills or Peeso drills. However, warm vertical condensation technique by heat carrier and root canal pluggers may suitable method because warm vertical compaction technique provides better obturation in three dimensional than lateral condensation[11] and provide greater sealing ability[12]. Essentially, the root canal filling is removed until it remains at least 4 mm. from apical stop for providing adequate sealing[13, 14].

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The other advantage is the immediate post space preparation reduces the visit of treatment. However, the major disadvantage of immediate post preparation is the empty prepared post space is risk to contaminate by leakage of temporary restoration during the dental appointments. Thus, the proper temporary filling material should be occupied the whole prepared space and adapted to root dentin wall to prevent this such adverse event[15]. Zinc oxide-calcium sulfate-based filling is suggested to use as temporary filling material in prepared canal due to its excellent sealing property[16]. However, to use this material may prevent the adaptation between resin cement and root dentin wall if the temporary filling has been remained. Moreover, the evidence showed that zinc oxide-calcium sulfate temporary filling might generate crack or fracture on dentin wall due to hygroscopic expansion when it had been contaminated with oral fluid[17]. Microorganisms also accumulate and penetrate through material[18, 19] and increase the risk of failure treatment. Thus, calcium hydroxide ($Ca(OH)_2$) is proposed to use as temporary filling after preparing post space[20] due to its high alkalinity[21] and bactericidal activity[22]. However, the negative effect on the sealer properties especially sealing ability after placing $Ca(OH)_2$ on non-setting sealer after post space is concerned. Gimbel and colleagues demonstrated that $Ca(OH)_2$ as a temporary filling material in post space did not dampen the sealing ability of apical root filling when using by zinc oxide eugenol-based (ZOE) sealer[20], the prototype of root canal sealer that has been used for a hundred years and also utilized as a standard sealer to compare the new materials. At present, many types of root canal sealer are developed, epoxy resin-based (ER) sealer is one of root canal sealer that wildly used. Not only a good physical properties but also provides a good seal to the root canal[23] especially when compare to ZOE sealer[24,25]. Moreover, ER sealer reduced the incidence of tooth fracture comparing with ZOE sealer[26,27], penetrated and adapted to dentinal tubules better than ZOE sealer[28]. Several studies demonstrated that immediately post space preparation of tooth that had been obturated by ER sealer showed less leakage when compared to those prepared after the sealer was fully set because the sealing ability was not damaged by mechanical forces during preparation the post space[10, 29]. Thus, it is reasonable to prepare post space immediately when using epoxy resin-based sealer. At present, there was no study showing the effect of $Ca(OH)_2$ on apical leakage when using ER sealer. The aim of this study was to evaluate whether $Ca(OH)_2$ paste as a temporary filling material in immediately prepared post space affect the apical sealing when using ER sealer.

Materials and methods

Collection and Preparation of Samples

Extracted intact sixty single-rooted mandibular first premolars were collected and stored in 0.1% thymol solution. Then, the teeth were cleaned and stored in distilled water at 4 ◦c before using[30]. Coronal crown portions were removed with D8 diamond burs (Intensive, Lugano-Grancia, Switzerland) at the cemento-enamel junction. The working length was established with a #15 K-file (Dentsply Maillefer, Ballaigues, Switzerland) at short 0.5 mm. from apical foramen. When the working length of each were recorded, each of tooth was prepared by using Mtwo® nickel-titanium rotary instruments sequentially (VDW, Munich, Germany) to size 40/0.04 at working length. Canals were irrigated with 1 ml of 2.5% sodium hypochlorite (NaOCl) during instrumentation after using each instrument and the smear layer was removed by flushing with 2 ml of 17% ethylene diamine tetra acetic acid (EDTA) for 1 minuet. The shaped and cleaned canal was dried with paper points. Teeth were randomly divided into 4 groups (n=15).

Each group was enrolled randomly and performed as follows:

A) Group ER: ER sealer + empty post space
B) Group ER-C: ER sealer + $Ca(OH)_2$ paste
C) Group ZOE: ZOE sealer + empty post space
D) Group ZOE-C: ZOE sealer + $Ca(OH)_2$ paste

All samples were obturated with lateral condensation technique with ZOE (Pulp Canal Sealer™ EWT®, Kerr corporation, Brea, CA, USA) or ER sealer (AH plus®, Dentsply Sirona, Charlotte, NC, USA). After the completion of the canal obturation of each tooth, radiograph was taken for affirming the completeness of root canal filling. If voids of root canal filling were present, root canal filling will be removed and refilled. Then, post space will be immediately prepared with warm vertical compaction by using heat carrier and endodontic pluggers. The root canal filling was left 4 mm from apical stop. The final

radiograph was taken to confirm the quality of root canal filling. Group ER-C and ZOE-C were only filled with $Ca(OH)_2$ paste (ApexCal®, Ivoclear Vivadent, Schaan, Liechtenstein). The Negative control group was obturated with sealer (ZOE or ER) and coated and filled with nail varnish entire of the prepared post space (n = 2/ group). Positive control group was obturated without sealer and then performed the post space preparation (n = 2). Access opening was sealed with zinc oxide-calcium sulfate-based temporary filling material, Cavit® (3M, Maplewood, MN, USA) 3 mm. and stored in 37°C, 100% humidity incubator for 72 hours.

After Cavit® and $Ca(OH)_2$ had been removed, all experiment samples were coated with 2-layered nail varnish entirely on outer root surface. 2% methylene blue solution was carefully injected into the post space by using 27-gauge syringe to avoid air bubble entrapment, then, gently immersed samples into 2% methylene blue for another 72 hours. Next, cleaning the sample with distilled water and used paper points to dry the root canal. Each sample was placed in clear acrylic blocks and cut longitudinally from bucco-lingual direction (Accutom-50, Struer, Denmark). Linear dye penetration was determined by photograph taking under 10x stereomicroscope (SZH10, Olympus, Tokyo, Japan). Each sample was measured 2 times on the different days by 2 examiners. This study performed in accordance with the Declaration of Helsinki and had been approved by The Board of Ethics Committee of Human Research Involving Sciences, Thammasat University, No.3 (COE No. 029/2561). Statistical analysis was done by Mann-Whitney U test (SPSS version 22, IBM, Armonk, NY, USA) was performed to compare between 2 groups. The significant level was set at $P<0.05$.

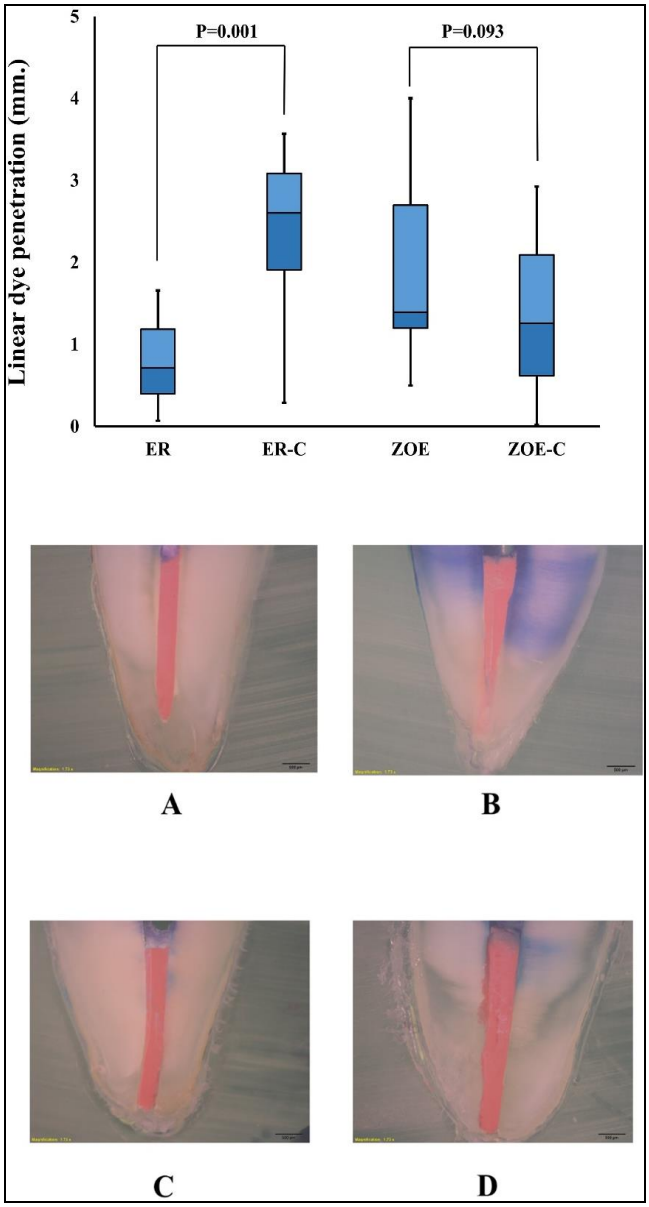

Figure 1. Effect of calcium hydroxide paste on linear dye penetration of epoxy resin based sealer and zinc oxide eugenol based sealer**.**
A) epoxy resin-based sealer without calcium hydroxide paste;
B) epoxy resin-based sealer with calcium hydroxide paste;
C) zinc oxide eugenol-based sealer without calcium hydroxide paste;
D) zinc oxide eugenol-based sealer with calcium hydroxide paste, black bar line at lower right of each photograph indicate to 500 µm.

Results

All samples demonstrated apical leakage (Figure 1). The mean and standard deviation of linear dye penetration was 0.81±0.58, 2.51±1.11, 1.74±0.94 and 1.33±0.98 mm. in group ER, ER-C, ZOE and ZOE-C respectively. Linear dye penetration was not observed in negative control group. Whereas, the positive control showed penetration of dye throughout the length of root canal filling (data not shown).

In ER sealer group (ER and ER-C) that filled with $Ca(OH)_2$ paste as temporary filling demonstrated more linear dye penetration than without $Ca(OH)_2$ paste group significantly approximately 2 mm. (P=0.001). However, the linear dye penetration between with and without $Ca(OH)_2$ paste in ZOE sealer group (ZOE and ZOE-C) did not different significantly (P=0.93) (Figure 1).

Discussion

According to the previous study which conducted the experiment without information of using EDTA as the final irrigation, the effect of smear layer might lead the misinterpretation of the results[20]. However, the result of this study confirmed that apical leakage was not affected by $Ca(OH)_2$ paste in ZOE sealer group which consistent to the previous study by Gimbel and his colleagues[20]. Smear layer removal might not be effect to sealer adaptation ability or physical and chemical properties when using $Ca(OH)_2$ paste as temporary filling in the post space. On the other hand, ER sealer group showed $Ca(OH)_2$ paste had detrimental effect on apical leakage. This leakage might be the result from moisture of $Ca(OH)_2$ paste[31] rather than pH of $Ca(OH)_2$ itself to be the cause of sealer's adaptation failure[31,32]. The hydrophilic of ER sealer may cause the water droplet entrapment between sealer and root dentin[33]. Moreover, water absorption of epoxy resin can disrupt the hydrogen bond and lead to irreversible damage to hydrolyzing linkages during polymerization[34]. Like other ZOE based materials, ZOE sealer is set by acid-base reaction which requires water for accelerator[35]. Thus, moisture from $Ca(OH)_2$ did not effect to apical leakage. The other factor that may had negative effect on ER sealer was calcium ion that releasing from $Ca(OH)_2$ paste in this study. However, calcium ion not only cause the apical leakage but also increase bond strength in root canals when obturate with ER sealer[36]. Thus, both calcium and hydroxyl ion may not affect to sealing ability of ER sealer when use as intra canal medication[37]. The next study should investigate the high ratio of $Ca(OH)_2$ power to liquid or hard pack $Ca(OH)_2$ paste for using as temporary filling in prepared post space. The results from this study suggested that the apical part root canal filling should be left at least 6 mm. rather than 4 mm. when using ER sealer if $Ca(OH)_2$ paste is chosen as a temporary filling in post space. However, $Ca(OH)_2$ paste should not be left after removing, because the remaining $Ca(OH)_2$ paste could inhibit the cement adaptation during post insertion. sonication by ultrasonic or sonic tips may utilize for improving the $Ca(OH)_2$ paste removal[38].

Dye penetration method is still controversy[39] especially when using methylene blue solution in root canal filling leakage study[40-42], due to its chemical interaction with other substances such as dentin or sealer and the molecular size is less than bacteria in root canal which may lead to misinterpretation of the obtained results. There has been proposed that bacteriological test, live bacteria might be the most appropriate technique because this method could mimic the clinical leakage situation. However, the result interpretation of such method is a qualitative data, only one or few microrganisms give the positive result[43]. Moreover, it need time for live bacteria penetrates throughout root canal filling to reveal the positive in culture medium[44]. Nevertheless, the objective of this study was to investigate the leakage of the porosity or failure of sealer adaptation from interaction between $Ca(OH)_2$ and ER sealer before post insertion which could performed immediately as soon as possible in the next dental appointment. Thus, bacteriological method might not suitable for this study. Unlike the long term exposure of root canal filling to oral environment situation, bacteriological method is more appropriate. Dye penetration was more suitable for the objective of this study. Although using methylene blue have been suspicious as mention above, it demonstrated the same leakage as rhodamin B, the inert fluorescence dye that was not interact with dentin and other substances, when using ER sealer[41]. This dye is easy to apply and cost effective for preliminary investigation. Thus, this study used methylene blue for leakage observation. However, the high pH that might decolonization of methylene blue might be concerned[42], thus, leakage might be greater in both of ER and ZOE group that used $Ca(OH)_2$.

Conclusions

Using Ca(OH)2 as a temporary filling material for the post space have detrimental effect to resistance of apical leakage when using ER sealer. Root canal filling should be left at least 6 mm. Adequate tooth isolation technique should be restricted during restoration procedure in prepared post space for prevention of microorganism contamination.

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Declaration of Interest

The authors report no conflict of interest.

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