

Effect of two different calcium hydroxide paste removal techniques on apical leakage: an electrochemical study

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ABSTRACT

This study evaluated the effect of two different calcium hydroxide ($\text{Ca}(\text{OH})_2$) paste removal techniques on the apical leakage of canals obturated with gutta percha cones and sealer after removing a $\text{Ca}(\text{OH})_2$ dressing using an electrochemical method.

Seventy extracted single-rooted teeth were instrumented on with Profile rotary files under NaOCl irrigation. Fifty-eight canals were filled with calcium hydroxide paste, which was then removed using one of the following two techniques. In group A, calcium hydroxide was removed using only NaOCl irrigation, and in group B, the canals were re-prepared with a Profile rotary files-one size larger than the previous instrument and were irrigated with NaOCl. In both groups, the root surfaces were coated twice with nail varnish from CEJ to an area 4 mm away from the apex after canal obturation. Apical leakage was measured using an electrochemical method for 24 days.

All the specimens showed leakage that increased markedly in the first three days. There was no significant difference between the two groups ($p > 0.05$). The effect of two calcium hydroxide paste removal techniques on the apical leakage was not different during a short period. [J Kor Acad Cons Dent 31(3):186-191, 2006]

Key words : Calcium hydroxide, Removal technique, Apical leakage, Electrochemical method

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I . INTRODUCTION

The complete filling of a root canal system is one of the most important aspects of a successful endodontic treatment. Ingle *et al.*¹⁾ reported that approximately 60% of endodontic failures are

related to incomplete filling of the root canal. The integrity of the apical seal depends on mechanical preparation, irrigation, filling technique, type of root canal sealer, and the intracanal medicament.

Since its introduction by Hermann in 1920 calcium hydroxide ($\text{Ca}(\text{OH})_2$) has been widely used in endodontics. It is a strong alkaline substance, which has a pH of approximately 12.5. In an aqueous solution, $\text{Ca}(\text{OH})_2$ dissociates into calcium and hydroxyl ions²⁾. Various biological properties have been attributed to this substance, such as antimicrobial activity³⁾, tissue-dissolving ability^{4,5)}, inhibition of tooth resorption⁶⁾, and

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induction of repair by hard tissue formation⁷⁾. Because of such effects, $\text{Ca}(\text{OH})_2$ has been recommended for use in several clinical situations^{8,9)}. Currently, this chemical substance is acknowledged as one of the most effective antimicrobial dressings during endodontic therapy.

$\text{Ca}(\text{OH})_2$ needs to be completely removed from the canal in order to obtain a hermetic seal of the permanent root canal filling^{10,11)}. It has been suggested that the $\text{Ca}(\text{OH})_2$ remnants be removed by increasing the instrumentation of the medicated canal by one or two file sizes¹²⁾. However, the effectiveness of these procedures has not been fully documented. Therefore, this study investigated the difference in apical leakage between teeth where two different $\text{Ca}(\text{OH})_2$ removal techniques were used.

II. MATERIALS AND METHODS

Seventy extracted human permanent teeth with single canals and mature apices were used in this study. The teeth were stored in a 0.9% isotonic saline at room temperature. The specimens were soaked in 5.25% NaOCl for 30 min, and the remaining periodontal tissue and calculus were removed. In order to facilitate instrumentation, the crown portion of each tooth was removed using a diamond-cutting bur.

The working length was determined by placing a #10 K file (K-flexofile, Dentsply Maillefer; Ballaigues, Switzerland) until it was just observed penetrating the foramen, after which 1 mm was subtracted and the length was then recorded. The canals were prepared using Profile rotary files

(Profile .06, Dentsply Maillefer; Ballaigues, Switzerland) to a #30 at the working length. Irrigation with 5.25% NaOCl solution was performed using a MAX-I-Probe (MAX-I-Probe, Dentsply Maillefer; Ballaigues, Switzerland) during the instrumentation.

After completing the instrumentation, the canals were dried with paper points. Fifty-eight teeth were filled with calcium hydroxide paste (Metapaste, Metadent Co., Chongju, Korea) according to the manufacturer's instructions. Twelve teeth were left as positive and negative controls. The coronal 3 mm of all the canals were sealed with Cavit. The teeth were wrapped in a water-saturated 2 × 2-inch gauze, and placed in an incubator at 37°C.

After 1 week, the Cavit was removed from the canals. In group A (29 teeth) : The canals were irrigated with 5 ml of a 5.25% NaOCl solution and a #10 patency file was used to remove the residual $\text{Ca}(\text{OH})_2$ paste. In group B (29 teeth): The canals were prepared with a Profile rotary file-one size larger (#35) than previous one used at the working length and were irrigated with 5 ml NaOCl irrigation (Table 1). In the positive control group (6 teeth) : the canals were not obturated after the canal preparation. In the negative control group (6 teeth): The prepared canals were obturated with gutta-percha and an AH-26 sealer, and two coats of nail varnish were applied to the whole root surface. All the specimens except the positive control group were obturated by a continuous wave of condensation techniques with gutta-percha points and AH-26 sealer after paper point drying.

Table 1. Classification of groups

Group	Numbers of teeth	$\text{Ca}(\text{OH})_2$ removal technique
A	29	#10 patency file 5 ml NaOCl irrigation
B	29	Profile - one size larger than MAF 5 ml NaOCl irrigation

For all specimens, the coronal gutta-percha was removed, leaving only the apical 4 mm of the root filling material. Copper wires, which were used as the experimental electrodes, were inserted into the canals in contact with the remaining gutta-percha. Approximately 0.5 cm of the insulation coat was stripped off at both ends of the wire. A small piece of the red sticky wax was adapted around the wire at the occlusal opening to stabilize the wire.

All the specimens except the negative control specimens were coated with double layers of nail varnish from the CEJ to the area 4 mm away from the apex. All the specimens were set in bottles. The copper wire was extended to the outside of the bottle cap. Stainless-steel wires were placed at the center of the caps as standard electrodes. A 0.9% NaCl solution was placed in the bottles as an electrolyte until the apical half of the roots were covered (Fig. 1).

The electrical resistance between the standard and experimental electrodes was measured using a multitester (Dagatron 2021, Dagatron Corp., Seoul, Korea). The resistance was measured once a day for 24 days. The raw data was recorded and analyzed for statistical significance using repeated measures of ANOVA.

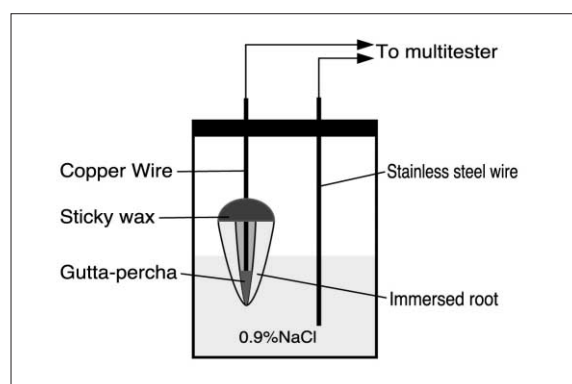


Figure 1. A schematic drawing of test system.

III. RESULTS

Increasing apical leakage with time was observed in all the groups except for the negative control group. The mean apical leakage of the data is illustrated in Fig. 2. The leakage increased markedly within the first three days. There was a slight increase in all the groups throughout the test period. No apical leakage was observed in the negative control group. The positive controls showed leakage immediately after the experiment. Group A exhibited a tendency to show more apical leakage than group B. However, there was no statistically significant difference between groups A and B ($p > 0.05$).

IV. DISCUSSION

Many studies have examined the effect of a calcium hydroxide dressing on apical leakage in root canal therapy. As a general rule, calcium hydroxide should be completely removed from the canal in order to hermetically seal the permanent root canal filling. Ricucci and Langerland¹⁰⁾ reported a case where the incomplete calcium hydroxide removal from the root canal caused endodontic failure. In addition, Lambrianidis *et al.*¹¹⁾ investi-

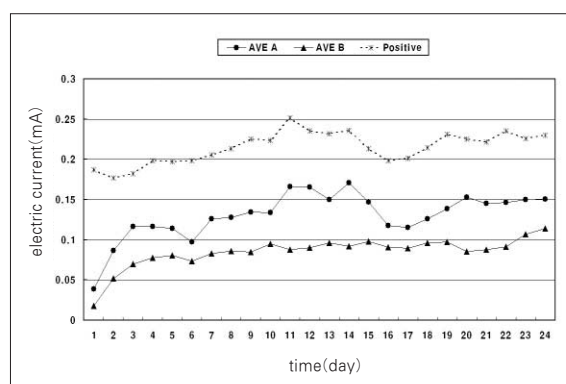


Figure 2. Apical leakage of experimental groups with time.

gated the removal efficiency of a calcium hydroxide dressing from the root canal and suggested the potential problem of calcium hydroxide retention. Webber *et al.*¹²⁾ suggested that all the calcium hydroxide remnants should be removed by increasing the instrumentation of the medicated canal to the files one or two sizes larger than the one used at the working length.

In this study, it was found that there were no significant differences in the apical leakage levels with the two removal methods studied. However, this study was conducted using the teeth with large and straight single canals so the irrigation needle could easily access the apex. In addition, the smooth canal walls prepared by the Profile make removal of calcium hydroxide by irrigation from the root canal wall easier. The effect on teeth with small and curved canals should be evaluated. Moreover, it would be better if a SEM examination or image-processing analysis could be used to compare the calcium hydroxide removal techniques.

Porkaew *et al.*¹³⁾ reported that the residual Ca(OH)_2 along the root canal walls enhanced the sealing quality of the root canal filling. Holland *et al.*¹⁴⁾ reported a similar result. Porkaew *et al.*¹³⁾ suggested two possible explanations. One explanation is that the residual Ca(OH)_2 may have been incorporated into the sealer during obturation and might have caused a decrease in the permeability of the sealer itself. Another possibility may be that Ca(OH)_2 was transported or mechanically forced into the dentinal tubules, which occluded the dentinal tubules. However, also reported that Ca(OH)_2 can react to form calcium carbonate that is absorbable, and this will most likely create voids at the root/filling interface in the long run. Therefore, the improved initial apical seal found in the short-term *in vitro* study may be temporary. In the above two studies, methylene blue (MB) dye was used as leakage tracer. In a study by Wu *et al.*¹⁵⁾, 1% MB dye solution became greatly decolored after being in contact with calcium hydroxide for 24h. Therefore, the penetration of the MB solution observed along the root canal filling following the

root canal dressing could be underestimated. Kontakiotis *et al.*¹⁶⁾ reported using the fluid transport model that no significant difference was found between the two groups where one group received calcium hydroxide dressing and the other did not.

As this study was an *in vitro* study and the test period was short, so there was insufficient time to resolve the residual calcium hydroxide, as is the case in clinical situations.

The electrochemical method was used in this experiment. Jacobson and von Fraunhofer¹⁷⁾ described this technique for measuring microleakage. Delivanis and Chapman¹⁸⁾ found this method to be effective and reliable. They reported that the electrochemical method could provide a quantitative measurement of the apical leakage and the opportunity to study over a continuous time period.

This technique is based on the principle that an electric current will flow between two pieces of metal when both are immersed in an electrolyte and are connected by an external power source. In this study, one piece of metal (stainless steel wire as the standard electrode) was immersed in a 0.9% sodium chloride solution (electrolyte), and the other piece of metal (copper wire as the experimental electrode) was placed in the coronal portion of an endodontically treated tooth. When leakage occurs, an electrolytic pathway is established between the copper and the stainless steel electrodes. The magnitude of the current that flows can be used to measure the degree of microleakage. This is because the current magnitude is controlled by the degree of electrolyte diffusion to the electrode surface, which is directly proportional to the surface area of the electrode. In this study, the magnitude of the current was measured as the electrical resistance between the standard and experimental electrodes. The advantage of this technique over previously used methods for testing leakage is that it can be monitored continuously throughout the test period and both the number of leaking teeth and the degree of leakage can be determined. The fluid filtration method present similar advantages over

the dye penetration method: the samples are not destroyed, permitting measurement over time, no tracer needed. However it showed the need for standardization to compare the results from various studies¹⁹⁾. Pommel and Jacquot²⁰⁾ compared three methods (Dye penetration, fluid filtration, electrochemical), and reported that several studies using various methods were necessary before comparing the apical leakage.

The Repeated Measures of ANOVA used in this study is the statistical method for testing difference between groups for repeated measures data. Schuur and Wu²¹⁾ described the power and the statistical related factors that determine the adequate size of samples. They reported that the use of small sample sizes might imply that a rather large difference between two mean leakage scores is not found to be significant, thereby leading to incorrect conclusion. It may be need to another study that use more samples than this time.

The use of calcium hydroxide in root canal therapy has already been established. It has many advantages, but only possible problem may be if residual Ca(OH)_2 compromises the seal. Further studies on the methods of calcium hydroxide removal in addition to the effects of residual calcium hydroxide utilizing the various evaluation methods resembling various clinical situations will be needed.

V. CONCLUSION

The technique of a one-size larger filing and irrigation with a 5.25% NaOCl solution is slightly superior to the one irrigating with a 5.25% NaOCl solution and using a #10 K-file as a patency file to remove the residual calcium hydroxide paste. However, there was no statistically significant difference between the two calcium hydroxide paste removal techniques. In addition, there was a tendency for the amount of leakage to increase with time. In a straight canal, there is no point further enlarging canals and further weakening the tooth in a vain attempt to remove the Ca(OH)_2 .

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국문초록

수산화칼슘 제제의 제거 방법이 치근단 누출에 미치는 영향에 대한 전기화학적 연구

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본 연구의 목적은 근관내 약제로 사용되는 수산화칼슘의 제거방법이 근관충전 후 치근단 미세누출에 미치는 영향을 알아보기 위함이다.

70개의 발거된 단근치를 엔진구동형 ProFile로 근관형성한 후 수용성 수산화칼슘 제제를 1주일간 적용하고 두 군으로 나누어 각기 다른 방법으로 제거하였다. A군은 NaOCl로 근관세정만을 시행하였으며, B군은 근관형성 시 사용된 file보다 한 단계 큰 크기의 ProFile을 사용하여 근관을 재형성한 후 NaOCl로 세척하였다. 근관충전 후 전기화학적 방법으로 24일 동안 치근단 누출을 측정, 비교하였다.

본 연구의 결과 수산화 칼슘 제거를 위한 두가지 방법은 근관충전후 치근단 미세누출에 있어서 차이가 없음을 알 수 있었다.

주요어: 수산화칼슘, 제거방법, 치근단 누출, 전기화학적 방법