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Original research

INFLUENCE OF CAVITY DESIGN ON CALCIUM HYDROXIDE REMOVAL FROM ROOT CANAL IRREGULARITIES

ABSTRACT

Objectives: Conservative endodontic cavity (CEC) design has recently developed to maintain the stability of tooth and provided an alternative to traditional endodontic cavity (TEC) design. The purpose of this study was to assess the influence of cavity design on calcium hydroxide ($Ca(OH)_2$) removal from artificial grooves in the coronal and apical parts of root canals.

Materials and Methods: Fourty extracted human mandibular premolars with single canals were randomly assigned to CEC or TEC groups (n=20). Following cavity preparation, the root canals were instrumented with ProTaper Universal rotary system up to F3 file and then, each tooth was sectioned longitudinally. Two standardized grooves were prepared in the coronal and apical parts of 1 root half. $Ca(OH)_2$ was placed into the grooves and the root halves reassembled. After 1 week, each root canal was enlarged with a #40 H-file. Irrigation was performed with the sonic activation of 5 mL 2.5% sodium hypochlorite and 5 mL 17% ethylenediaminetetraacetic acid solutions using the medium size tip (25/04) of EndoActivator System at medium speed for 30 seconds between each 2.5 mL irrigant. The remaining $Ca(OH)_2$ in the grooves was evaluated using a stereomicroscope with x25 magnification and the images were scored using a 4-scoring scale by 2 examiners. Data were analyzed using the Mann-Whitney U and Wilcoxon tests.

Results: $Ca(OH)_2$ remnants were found in both groups. There was no significant difference between the CEC and TEC groups in terms of $Ca(OH)_2$ removal efficacy ($p>0.05$). The grooves in the coronal and apical parts of the roots presented similar amount of $Ca(OH)_2$ remnants in both groups ($p>0.05$).

Conclusions: Based on the present findings, the cavity design had no effect on the removal of $Ca(OH)_2$ from root canal irregularities.

Keywords: Calcium hydroxide, cavity preparation, endodontics, minimally invasive, root canal.

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INTRODUCTION

Calcium hydroxide (Ca $(OH)_2$) is a commonly used intracanal medicament in patients undergoing root canal treatment with multiple visits for disinfection purposes.[1,2] Ca $(OH)_2$ has various advantages including its biocompatible, antibacterial, regenerative and therapeutic properties.[3] However, complete removal of Ca $(OH)_2$ from the root canal system is recommended before permanent root canal obturation, because the remnants may negatively influence the sealer penetration into the dentine tubules.[4,5] Furthermore, Ca $(OH)_2$ remnants may impair the physical properties of root canal sealers by accelerating their setting reaction, decreasing working time, reducing flow and increasing film thickness.[6,7]

Appropriate access cavity preparation is of great importance for successful root canal treatment. The traditional endodontic cavity (TEC) design includes the complete removal of pulp horns and pulp chamber roof to obtain straight-line access to the canal orifices.[8] The tooth structure removal during access cavity preparation can decrease the resistance of endodontically treated teeth to fracture.[9,10] Recently, conservative endodontic cavity (CEC) design has been introduced to decrease the amount of tooth structure removal. In this minimally invasive approach, some of the chamber roof and pericervical dentine are preserved.[10] Pericervical dentine is located 4 mm below and 4 mm above the alveolar crest, is responsible for distribution of functional mechanical stresses inside tooth and its presence plays an important role for long-term survival.[11]

In several studies, mechanical aspects of cavity design were investigated and CECs were found to increase the fracture strength of teeth compared to TECs.[12,13] Moreover, the effect of CEC design on root canal localization, root canal transportation, root canal instrumentation and debridement efficacy has been assessed.[8,14] However, it is not known whether the Ca $(OH)_2$ removal from root canals might be affected by the cavity design. Therefore, the purpose of the current study was to assess the effect of TEC and CEC designs on the Ca $(OH)_2$ removal from simulated irregularities in the coronal and apical parts of root canals. The null hypothesis was that there would be no influence of the cavity type on the removal of Ca $(OH)_2$ from irregularities located either in the coronal or apical parts of root canals.

MATERIALS AND METHODS

The present study included 40 freshly extracted single-rooted human mandibular premolar teeth with round canals, closed apices, similar length and dimensions after Hacettepe University Non-interventional Clinical Research Ethics Board approval (no: GO 18/397). Inclusion criteria included teeth devoid of caries, resorption, fracture, and defects. The presence of a single-root canal for each tooth was confirmed with periapical radiographs.

The teeth were numbered and randomly allocated (using the website http://www.random.org) into 2 groups (n=20) according to the following cavity designs:

a) The CEC Group: The access cavities in this group were prepared with a mosquito 392 bur (Spring Health Diamonds, St Louis Park, MN, USA) in a high-speed handpiece under water cooling. CECs were prepared as described earlier.[12] Accordingly, initial access was created at 1 mm buccal to the central fossa, and then the cavities were enlarged apically without performing buccolingual and mesiodistal enlargement. Lingual shelf, pericervial dentine and a part of the pulp chamber roof were maintained (Figure 1A).

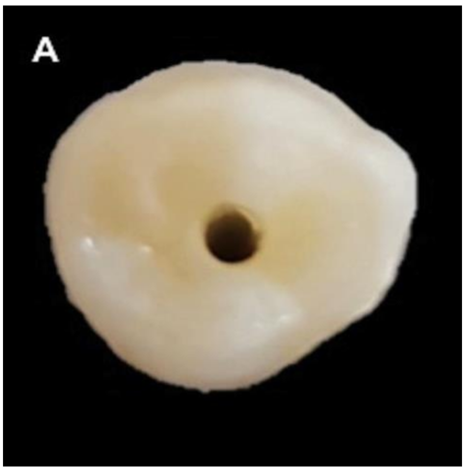

Figure 1. Photographs demonstrating the cavity designs (A) CEC design.

b) The TEC Group: Each access cavity in this group was prepared using an LA Axxess diamond bur (SybronEndo, Glendora, CA, USA) in a high-speed handpiece under water cooling. The pulp chamber roof was removed and outline of each cavity was modified until straight-line access to root canals could be obtained (Figure 1B).

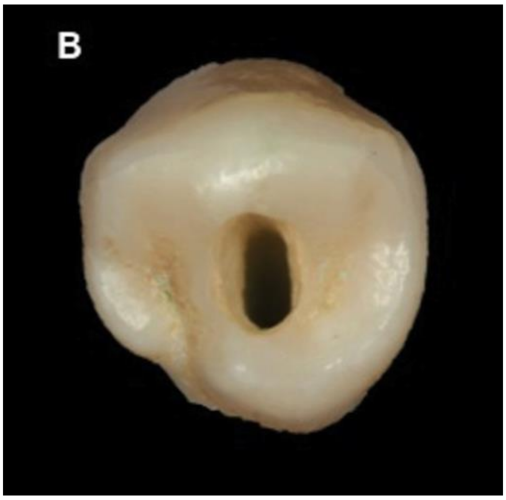

Figure 1. Photographs demonstrating the cavity designs (B) TEC design.

Following the access cavity preparation, working length (WL) was determined by introducing #15 K-file to the canal foramen and subtracting 0.5 mm. A periapical radiograph was taken to confirm the accuracy of the WL. Then, the root canals were prepared with ProTaper Universal rotary system (Dentsply Maillefer, Ballaigues, Switzerland) up to F3 file. A 30-G side-vented needle (Max-i-probe, Dentsply, Rinn, Elgin, IL, USA) was inserted until 1 mm short of the WL and irrigation was performed with 3 mL 2.5 % NaOCl solution between each instrument. The teeth were placed in tubes (Eppendorf-Elkay, Shrewsbury, MA, USA) with a silicone material (Optosil; Heraeus Kulzer, Hanau, Germany) to obtain an individual mold for each tooth.[15] Each tooth was then removed from its mold and split longitudinally into 2 halves with a disc (Multicut diamond disc/354, Edenta Ag Dental Products, Haupstrasse, Switzerland), allowing subsequent reassembling. A previously described protocol was applied for the preparation of grooves to simulate root canal irregularities.[16] Briefly, two longitudinal grooves (0.5-mm deep, 0.2-mm wide and 3 -mm long) were prepared in the coronal or apical root canal wall of one tooth half. The groove in the apical part was created at 2 mm from the apex. The groove in the coronal part was created at 9 mm from the apex.[16] Debris was removed from the grooves using a toothbrush. Final irrigation was performed using 5 mL 17% EDTA for 60 seconds and 5 mL 2.5% NaOCl for 60 seconds, respectively. Each irrigant was delivered with a 30-G side-vented needle (Max-i-probe, Dentsply) inserted 1 mm short of the WL. $Ca(OH)_2$ was prepared by mixing the powder (Merck, Darmstadt, Germany) and distilled water at a powder to liquid ratio of 1:1.5, and the standardized grooves were filled with $Ca\ (OH)_2$.[17] Thereafter, the specimens were carefully reassembled, secured with sticky wax under an operating microscope and positioned in their silicone molds. A temporary filling material (Cavit; ESPE, Seefeld, Germany) was placed in the access cavities.

After 7-day storage at 37°C and 100% humidity, each root canal was instrumented with an F4 file (ProTaper Universal, Dentsply Maillefer) at the WL. Then, a 40 H-file was used in a circumferential filing action. Then, the root canals were flushed with 5 mL 2.5% NaOCl for 60 seconds and 5 mL 17% EDTA for 60 seconds. Both irrigants were sonically activated using the medium size tip (25/04) of EndoActivator System (Dentsply, Tulsa Dental Specialties, Tulsa, OK, USA) at medium speed for 30 seconds between each 2.5-mL irrigant. The sonic tip of EndoActivator System was placed at 2 mm from the WL and activated. Five mL of distilled water was applied as a final irrigant. Finally, the root canals were dried with paper points.

The tooth halves were removed from the eppendorf tubes and separated. The remaining amount of $Ca\ (OH)_2$ in the grooves was evaluated using a stereomicroscope with x25 magnification (Olympus BX43; Olympus Co, Tokyo, Japan). Each image was scored using a previously described evaluation scale.[16] Accordingly, score 0, the groove is completely empty; score 1, less than 50% of the groove is filled with $Ca\ (OH)_2$; score 2, more than 50% of the groove is filled with $Ca\ (OH)_2$; and score 3, the groove is entirely covered with $Ca\ (OH)_2$ (Figure 2).

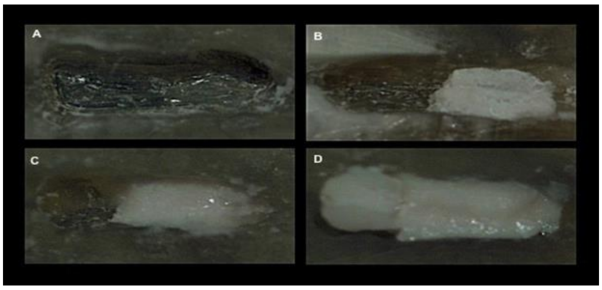

Figure 2. Representative images of scores (A) Score 0, (B) Score 1, (C) Score 2 and (D) Score 3.

The scoring was performed independently by two calibrated endodontists which were blinded to the groups. When a disagreement occurred, the two examiners reevaluated the image and final decision was given on consensus. Calculation of the percentage of score reduction was performed according to the following formula:[16]

$$\text{Percentage of score reduction} = \frac{\text{score before Ca(OH)2 removal} - \text{score after Ca(OH)2 removal}}{\text{score before Ca(OH)2 removal}} \text{ x } 100\%$$

Data were statistically analysed using the Mann-Whitney U and Wilcoxon signed rank tests at the 95% level of confidence ($p<0.05$). The analyses were performed using a software program (SPSS 23 software; IBM SPSS Inc, Chicago, IL, USA).

RESULTS

The results regarding the amount of Ca $(OH)_2$ are presented in Table 1.

Table 1 Score of Ca $(OH)_2$ before and after removal (n=20)

Groups	Before	After	
		Mean	SD
TEC-Coronal	3.00	2.06^{a*}	1.25
TEC-Apical	3.00	2.59^{b*}	0.71
CEC-Coronal	3.00	1.59^{a+}	1.23
CEC-Apical	3.00	2.24^{b+}	0.66

Different superscript letters indicate significant differences between the cavity designs for the same root part.
Different superscript symbols indicate significant differences between the root parts for each cavity design.

Figure 3 shows the distribution of percentage score reduction of $Ca(OH)_2$ remnants in the grooves of the samples for each group. $Ca(OH)_2$ remnants were found in both groups. No significant difference was found between the CEC and TEC groups in terms of $Ca(OH)_2$ removal efficacy ($p>0.05$). The grooves in the coronal and apical parts of the roots presented similar amount of $Ca(OH)_2$ remnants in both groups ($p>0.05$).

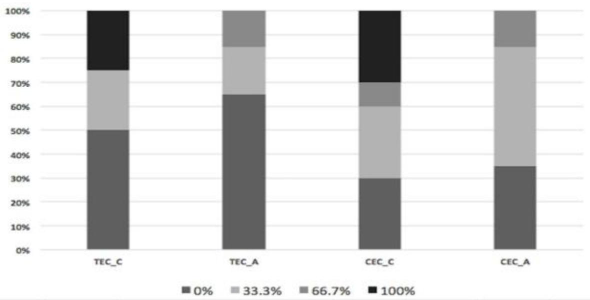

Figure 3. The distribution of percentage score reduction of $Ca(OH)_2$ remnants in the grooves of the samples for each group.

DISCUSSION

The use of minimally invasive procedures in endodontics has become increasingly popular due to the maintenance of tooth structure and stability.[18] In the present study, the effect of TEC and CEC designs on $Ca(OH)_2$ removal from root canals were compared. It has been well established that the removal of $Ca(OH)_2$ from irregular canal walls is difficult.[16] To simulate such irregularities, artificial grooves were prepared similar to previous studies.[16,19] This model also allowed to standardize the groove location and size and the amount of $Ca(OH)_2$ placed in the groove.

Based on the present findings, the null hypothesis was accepted because the cavity design had no significant effect on the removal of $Ca(OH)_2$ from irregularities located either in the coronal or apical parts of root canals. Similar to this result, no difference was found between the CEC and TEC designs in the amount of tissue remnants in the root canals after root canal preparation and irrigation procedures in a previous study.[8] On the other hand, the CEC design was associated with more remaining obturation material in a previous study that evaluated the removal of root canal filling materials from oval shaped canals.[20] The different results in the studies can be related to the anatomical variations among the teeth used. In the present study, teeth with single and round canals were used. The influence of cavity design on $Ca(OH)_2$ removal from root canals could be different in cases of teeth with more complex anatomy.

A variety of irrigation regimens and techniques are used for the removal of intracanal medicaments.[16,17,21] The most commonly described method for the $Ca(OH)_2$ removal is preparation of the root canal using a master apical instrument at the WL and irrigation using NaOCl and EDTA.[16] In the present study, the root canals were enlarged to the next file size and the irrigants were sonically activated to enhance the $Ca(OH)_2$ removal.[21-24] Several methods were used to evaluate the remaining amount of $Ca(OH)_2$ in root canals including digital photographs[25], stereomicroscopy[26], scanning electron microscopy[27] and micro-computed tomography.[28] In the current study, a stereomicroscope was used to evaluate the amount of $Ca(OH)_2$ remnants in root canals. This method requires the sectioning of roots for evaluation. The destructive nature of the process is a limitation, however sectioning the roots before $Ca(OH)_2$ placement allowed the irregularities to be completely filled and prevented $Ca(OH)_2$ losses that could occur during root cleavage. The stereomicroscope images were evaluated using a previously described scoring method,[16] which is widely used in recent studies.[15,17,19,29,30] Imaging software programs can also be used to calculate the percentage ratio of $Ca(OH)_2$ covered surface area to the total area.[31] However, a scoring scale was used as it could be difficult to automatically select the areas covered with $Ca(OH)_2$ using a software due to the similar color of the medicament and dentine.

Complete removal of $Ca(OH)_2$ from root canals could not be achieved, similar to previous studies.[29,30] There was no significant difference between the grooves in the coronal and apical root canal thirds in terms of $Ca(OH)_2$ removal. Previously, some studies reported superior $Ca(OH)_2$ removal in the apical root part compared to the coronal part[29,30], while others found $Ca(OH)_2$ remnants mainly in the apical region.[32,33] In addition to the differences in cavity designs, variations in test parameters such as final diameter of root canal preparation, irrigant volume, irrigant activation method, needle size and needle penetration depth may be the cause of conflicting results in the literature. Although the difference was not significant, the percentage of score reduction was higher both in coronal and apical irregularities of the samples which had CECs. This may be attributed to the close contact of the Endoactivator tip with the crown dentine which could enhance the effect of sonication through the root canal. The closer proximity between the tip and dentine may lead to higher hydrodynamic shear stresses and improve fluid exchange within the root canal.[34]

CONCLUSIONS

In conclusion, the cavity design had no effect on the Ca $(OH)_2$ removal from root canal irregularities. In both cavity types, it was not possible to obtain complete removal of Ca $(OH)_2$. Further techniques should be developed to remove Ca $(OH)_2$ from the root canal more efficiently. To adapt the CEC design in clinical practice, it must not be less effective than the TEC design. In the light of the present findings, the CEC design can be an alternative to its traditional counterpart. However, more studies are required to assess the effect of access cavity design on the long-term clinical success.

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CONFLICTS OF INTEREST STATEMENT

The authors declare that they have no conflict of interest.

Kavite Tasarımının Kalsiyum Hidroksitin Kök Kanal Düzensizliklerinden Uzaklaştırılmasına Etkisi

Giriş: *Konservatif endodontik kavite (KEK) tasarımı son zamanlarda dişlerin mekanik stabilitesini korumak için geliştirilmiştir ve geleneksel endodontik kavite (GEK) tasarımına bir alternatif olarak yerini almıştır. Bu çalışmanın amacı, kavite tasarımının, kalsiyum hidroksitin (Ca(OH)*$_2$*) kök kanallarının koronal ve apikal kısımlarında hazırlanan yapay oluklardan uzaklaştırılmasına olan etkisini araştırmaktır.* ***Gereç ve Yöntemler:*** *Kırk adet çekilmiş tek kanallı insan alt küçük azı dişleri, rastgele KEK ve GEK gruplarına* *ayrıldı (n=20). Kaviteler hazırlandıktan sonra, kök kanalları ProTaper Universal döner eğe sistemi ile F3 eğesine kadar genişletildi ve her diş uzunlamasına kesildi. Kök parçalarından birinin koronal ve apikal kısımlarında 2 adet standart oluk hazırlandı. $Ca(OH)_2$ olukların içine yerleştirildi ve kök yarıları yeniden birleştirildi. Bir hafta sonra, her bir kök #40 H-tipi el eğesi ile genişletildi. İrrigasyon 5 mL %2,5'luk sodyum hipoklorit ve 5 mL %17'lik etilendiamintetraasetik asit solusyonlarının, EndoActivator sisteminin orta hızda, orta boy uç (25/04) ile her 2,5 mL irrigant arasında 30 saniye süreyle kullanılmasıyla gerçekleştirilen sonik aktivasyonu ile yapıldı. Oluklarda kalan Ca $(OH)_2$ miktarı bir stereomikroskop kullanılarak x25 büyütme ile değerlendirildi ve görüntüler 2 araştırmacı tarafından 4-skorlu skala kullanılarak skorlandı. Veriler Mann-Whitney U ve Wilcoxon testleri kullanılarak analiz edildi.* ***Bulgular:*** *Her iki grupta da $Ca(OH)_2$ kalıntıları bulundu. KEK ve GEK grupları arasında $Ca(OH)_2$'in uzaklaştırılma etkinliği açısından anlamlı fark yoktu ($p>0,05$). Köklerin koronal ve apikal kısımlarındaki oluklar her iki grupta da benzer miktarda $Ca(OH)_2$ kalıntıları gösterdi ($p>0,05$).* ***Sonuçlar:*** *Çalışmanın bulgularına göre, kavite tasarımının $Ca(OH)_2$'in kök kanal düzensizliklerinden uzaklaştırılması üzerinde etkisi yoktu.* ***Anahtar kelimeler:*** *Endodonti, kalsiyum hidroksit, kavite preparasyonu, kök kanalı, minimal invaziv.*

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