

Elimination of Calcium Hydroxide from Simulated Internal Resorption Cavities Using EDDY

Kalsiyum Hidroksitin EDDY Kullanılarak Yapay İç Rezorpsiyon Kavitelerinden Uzaklaştırılması

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Keywords

Calcium hydroxide, irrigation, root resorption, sonic, ultrasonic, root canal

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Abstract

Objective: Calcium hydroxide (CH) is a preferred interappointment medicament to increase antimicrobial activity in intracanal irregularities such as internal root resorption (IRR). This study aimed to compare the effectiveness of EDDY, passive ultrasonic irrigation (PUI), sonic irrigation, CanalBrush (CB), manual dynamic irrigation (MDI) and syringe irrigation (SI) in the elimination of CH from IRR cavities.

Materials and Methods: One hundred and twenty-eight single-rooted teeth with straight root canals were prepared using rotary instruments and split longitudinally. A standardized artificial IRR cavity was prepared in the middle third of each half of the specimens. For the negative control group, four teeth were selected which did not receive any further treatment. The remaining roots were filled with CH and distributed into a positive control (n=4) group and 6 experimental groups (n=20): SI; MDI; PUI; EDDY; CB, and Rispisonic (RS). Five-mL 5% sodium hypochlorite and 5 mL 17% ethylenediaminetetraacetic acid were used as irrigants. The quantity of CH remnants was scored. Results of the scoring were analyzed using statistical analyses.

Results: None of the tested methods could create cavities free of CH. PUI and EDDY were found to be significantly more effective than the other investigated methods (p<0.05). SI was significantly less efficient compared to the other tested groups (p<0.05).

Conclusion: The activation of irrigants increased the elimination of CH from the IRR cavities. Among the investigated activation regimens, PUI and EDDY was more effective than CB, MDI, RS.

Öz

Amaç: Kalsiyum hidroksit (KH), internal kök rezorpsiyonu (İKR) gibi kanal içi düzensizliklerdeki antimikrobiyal aktiviteyi artırmak için seanslar arasında tercih edilen bir medikamandır. Bu çalışmanın amacı, yapay İKR boşluklarından KH'nin uzaklaştırılmasında EDDY, pasif ultrasonik irrigasyon (PUI), sonik irrigasyon, CanalBrush (CB), manuel dinamik irrigasyon (MDI) ve geleneksel iğne irrigasyonunun (ii) etkinliğini karşılaştırmaktır.

Gereç ve Yöntemler: Düz kök kanallı 128 tek köklü diş, döner aletler ile genişletildi ve uzunlamasına ortadan ayrıldı. Numunelerin her bir yarısının orta üçte birlik kısmında standart yapay bir İKR kavitesi hazırlandı. Negatif kontrol grubu için dört

diş seçildi ve herhangi bir tedavi uygulanmadı. Geri kalan kökler KH ile dolduruldu ve bir pozitif kontrol (n=4) ve 6 deney grubuna (n=20) dağıtıldı; İİ, MDİ, PUİ, EDDY, CB ve Rispisonic (RS). İrrigant olarak 5 mL %5 sodyum hipoklorit ve 5 mL %17 etilen diamin tetra asetik asit kullanıldı. KH kalıntıları skorlandı. Skorlama sonuçları istatistiksel testler kullanılarak analiz edildi.

Bulgular: Araştırılan protokollerin hiçbiri, İKR kavitelelerinden KH'yi tamamen ortadan kaldıramadı. PUİ ve EDDY diğer tekniklerden önemli ölçüde daha fazla etkiliydi (p<0,05). İİ, diğer test edilen gruplardan anlamlı derecede daha az verimliydi (p<0,05).

Sonuç: İrrigantların aktivasyonu, simüle edilmiş İKR kavitelelerinden KH'nin eliminasyonunu artırmıştır. İncelenen aktivasyon tekniklerinden PUİ ve EDDY, KH'nin uzaklaştırılmasında CB, MDİ ve RS'den daha etkiliydi.

Introduction

Internal root resorption (IRR) is an inflammatory process that starts within the pulp space presenting destruction of dentin and possible invasion of the cementum in teeth with pulpitis and pulp necrosis (1). Due to the limitations of chemomechanical debridement of IRR cavities, irrigation and medication becomes a critical step. Sodium hypochlorite (NaOCl) and different chelators are used to eliminate bacteria, biofilm, necrotic and granulation tissues from IRR cavities.

To increase the effect of disinfection, calcium hydroxide (CH) has been used as an interappointment dressing (2). However, CH medicament applied to the root canal should be eliminated from the canal walls before the permanent obturation procedures are performed (3).

EDDY (VDW, Munich, Germany) features a size-25, 4% taper, sterile, non-cutting flexible polyamide tip driven with a sonic-powered irrigation activation device at lower frequencies. According to the manufacturer, it is claimed that it creates a three-dimensional movement that triggers "cavitation" and "acoustic streaming". Till date, there is limited information with regard to its CH removal capacity (4).

Rispisonic (RS, Micro-Mega, Besançon, France) files which are used within the sonic handpiece (SONIC AIR® MM 1500, Micro-Mega, France) have a non-uniform taper that increases with file size. Because they are barbed, it is necessary to perform continuous small repositioning movements to prevent the file from being inadvertently bound to the canal walls and damage the completed canal preparation during agitation. The operating frequencies of sonic instruments are lower than ultrasonic instruments and produce smaller shear stress while they have higher amplitude and tip movement (5,6).

There is limited research investigating the competency of EDDY and RS tips on the elimination

of CH from artificial IRR cavities. The purpose of this *in vitro* study is to assess how effective EDDY and RS are in the elimination of CH from artificial IRR cavities compared with syringe irrigation (SI), manual dynamic irrigation (MDI), passive ultrasonic irrigation (PUI) and CanalBrush (CB) protocols. The null hypothesis was that the choice of the irrigation technique has no effect on the amount of CH eliminated from IRR cavities.

Materials and Methods

The present study was approved by the Ethics Committee of the Bolu Abant İzzet Baysal University (decision number: 2019/204, date: 07.11.2019) and signed informed consent/assent was obtained from all patients.

A priori power analysis was performed to calculate the adequate number of samples to be included in the study. An effect size of 0.40 was added to a power b=93% and a=5% input into an F-test family for analysis of variance. The power analysis showed that a total of 120 specimens (20 for 6 test groups) were required. Eight specimens were selected per positive and negative groups. A total size of 128 samples was required for this study.

One hundred and twenty-eight extracted-intact permanent maxillary incisor teeth were selected. The teeth have a single root and a similar size/shape measured from the cemento-enamel junction to the root apex. Two radiographs of each root were taken from mesio-distal and bucco-lingual directions to verify the presence of a single-rooted canal without calcifications, resorption or previous root canal treatment with the canal curvature limitation taken as <10° (7). The criteria for exclusion were fractures/cracks/carries on the tooth surface and immature root apices. All teeth were decoronated with the help of a high-speed bur under copious water spray to standardize root lengths as 15 mm. Conventional

endodontic access cavities were prepared using diamond fissure burs with a high-speed hand piece under water cooling. The working length of canals was measured by placing a size-15 K-file (Dentsply Maillefer, Ballaigues, Switzerland) into the root canal until the tip of the file was visible at the apical terminus under stereomicroscope and shortening 1.0 mm from this point. To obtain teeth with similar canal size, only teeth whose working length could be reached passively with a size 20 K-file without exceeding the apical foramen were used. All canals were enlarged with rotary nickel-titanium instruments up to X4 (size 40) (ProTaper Next, Dentsply Maillefer, Switzerland) with a crown down sequence at working length. During root canal preparation, 2 mL 5% NaOCl, delivered with a 30-gauge needle, was used between each file change. After the chemomechanical preparation was completed, the roots were inserted in Eppendorf vials filled with impression material. Afterwards, the roots were extracted from the completely set impression material and two longitudinal grooves were created on lingual and buccal surfaces of the root using a water-cooled diamond disc. The roots were longitudinally split in a bucco-lingual direction using a small chisel and hammer. Both root halves were examined under a stereomicroscope to confirm that the halves could be reassembled without gaps.

A simulated resorption cavity (1.6 mm diameter and 0.8 mm deep) was prepared in the middle third of each half of the specimens at a distance of 5 mm above the anatomic apex, using a round diamond bur (Diotech, Coltène/Whaledent AG, Altstätten, Switzerland). The photographs were taken using a stereomicroscope (Olympus SZX10, Tokyo, Japan) equipped with a digital camera (Olympus DP73, Tokyo, Japan) at 20× magnification to confirm the cavity dimensions.

The cavities and root canal walls were flushed with 5 mL 17% EDTA for 1 minute (min) followed by 5 mL 5% NaOCl with a duration of 1 min duration and agitated with a toothbrush to eliminate debris. Five mL of distilled water and paper points were used for the final irrigation and to dry canal, respectively. The 120 roots were randomly allocated into six experimental groups (n=20). Eight specimens were used as negative (n=4) and positive (n=4) controls. The CH paste was not inserted in the samples of the negative control group.

CH powder (Promida, Eskişehir, Turkey) was prepared with distilled water at a liquid/powder ratio of 1.5:1. The prepared CH paste was placed into the main root canal and the cavities using paper points under observation through a stereomicroscope. The root halves were reassembled with wax, avoiding applying the wax to the main canal and cavities throughout the process. Nonetheless, each of the apices were sealed with wax in order to guarantee a closed system. Two radiographs were taken to verify that the cavities were fully filled with CH. The orifices of the root canals were restored with temporary filling material. The specimens were remounted into the Eppendorf vials and kept in 37 °C for 14 days at 100% humidity.

Four of the remaining 124 roots were used as positive controls and no irrigation procedures were performed on them.

After the coronal access was opened, an X4 file (Dentsply Maillefer, Switzerland) and 1 mL 5% NaOCl were used to create a pathway up to the working length for instruments and irrigation needles.

SI; The root canals were flushed with 5 mL 5% NaOCl for 1 min, followed by 5 mL of 17% EDTA for 1 min using a 30-gauge endodontic needle (Canal Clean, South Korea). The needle was placed 1 mm short of the working length and the flow rate of irrigants was set as 0.08 mL/s.

MDI; canals were irrigated with 2.5 mL 5% NaOCl followed by manually performed in-and-out motions up to 7-8 mm of the working length using a well-fitted ProTaper Next X4 (Dentsply Maillefer) gutta-percha cone at an approximate rate of 100 strokes per min for 30 seconds. This procedure was repeated 2 times followed by irrigation with 5 mL 17% EDTA activated by a new ProTaper Next X4 gutta-percha cone for 1 min at the same rate.

PUI; Canals were irrigated with 2.5 mL 5% NaOCl thereafter an ultrasonic tip with a size-25, %2 taper (Irrisafe, Satelec Acteongroup, France) was inserted up to 1 mm of the working length. The tip inserted to the handpiece of a Satelec P5 Newtron XS (Acteon Group, Merignac, France) ultrasonic system was activated at a power setting of 9 for 30 seconds without contacting or locking the wall. This procedure was repeated 2 times, followed by irrigation with 5 mL 17% EDTA for 1 min at the same rate, employing the same activation method. Each tip was used for 4 roots and then replaced with a new one.

EDDY; The irrigation cycles were executed in the same manner as the PUI group with the exception that an EDDY (VDW, Munich, Germany) with a size-25, %4 taper tip, 28 mm length, mounted on a sonic handpiece (SonicMax, Endo-Perio Sonic Handpiece, Maximum Dental Inc, Japan) set at maximum speed was used.

CB; Irrigation was performed under the same technique as the PUI group with the exception that a medium size CB (Coltene/Whaledent GmbHCo. KG, Langenau, Germany) set at 600 rpm was used adopting a gentle in-and-out motion.

RS; Irrigation was performed under the same technique as the PUI group with the exception of a size 3 RS file tip (Micro-Mega, Besançon, France), 22 mm length with a size-25, %2 taper, mounted on a SONIC AIR® MM 1500 sonic handpiece (Micro-Mega, France) set at maximum speed.

During the activation process, in cases where the level of irrigants in the canal decreased, a drop solution was added. A total volume of 5 mL 5% NaOCl and 5 mL 17% EDTA was used for each sample. Finally, canals were flushed with 5 mL of distilled water to eliminate further solution action. A total of 15 mL irrigant was used for each specimen.

Digital images of simulated IRR cavities were photographed at 20× magnification using a stereomicroscope. Two calibrated endodontists independently scored the coded images.

The following scores were used: 0: empty cavity, 1: less than 50% of the cavity is covered with CH, 2: CH covered more than 50% of the cavity, and 3: the cavity is fully covered with CH (Figure 1).

Calibration was conducted by twice scoring a total of 100 reference images at an interval of 48 h by two observers. The results were discussed by both investigators. If any disagreement occurred, a consensus was reached through discussion.

Statistical Analysis

All photographs were evaluated by the calibrated examiners 1 week later and intraobserver and interobserver reproducibility were measured using the weighted coefficient kappa. According to the Shapiro-Wilks test, the data was not distributed normally; therefore non-parametric tests were performed. The scoring results of CH remnants were analyzed by means of Kruskal-Wallis and the Mann-Whitney U tests. The significance level was set at 0.05.

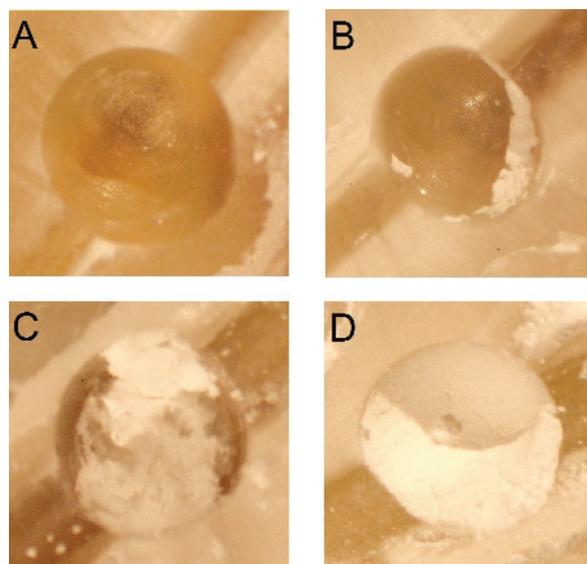


Figure 1. Score system for evaluation of remnants of CH in the artificial cavity. (A) Score 0; empty cavity (B) Score 1; less than 50% of the cavity is covered with CH (C) Score 2; CH covered more than 50% of the cavity (D) Score 3; the cavity is fully covered with CH

CH: Calcium hydroxide

All analyses were performed using SPSS 20.0 software (SPSS Inc., Chicago, IL, USA).

Results

The Cohen Kappa value was 0.889 for two examiners, indicating good agreement and intraindividual reproducibility was found to be 94% and 92%, respectively. Table 1 shows the median and interquartile ranges of all tested groups. Each of the negative control specimens had a result score of 0 while all the positive control specimens showed a result score of 3. There was a significant difference among the positive and negative control groups and all the investigated groups ($p < 0.05$). None of the tested methods were able to create cavities free of CH. PUI left significantly less CH remnants in comparison to all tested groups ($p < 0.05$) but was found to be similar to the EDDY ($p > 0.05$). SI removed significantly less CH than the other activation protocols ($p < 0.05$). RS and CB eliminated significantly more CH than MDI ($p < 0.05$); however, no significant differences were found between these two groups ($p > 0.05$). MDI was significantly more efficient than SI but less successful compared with the other tested groups ($p < 0.05$).

Discussion

The purpose of this study was to investigate the efficacy of different irrigation devices and compare them with the irrigation of ethylenediaminetetraacetic acid (EDTA) and NaOCl in the elimination of CH from artificial IRR cavities. The main outcome of this study was that PUI and EDDY were more effective than RS, CB and MDI in the elimination of CH. The null hypothesis that the choice of the irrigation technique would have no effect on the amount of CH eliminated from IRR cavities was rejected.

In previous studies, it was reported that removal of medicaments before the completion of the root canal filling, strengthens the bond between dentin and sealer by creating sealer tags in the dentinal tubules and it also results in a good seal (3,8). CH provides a physical barrier that prevents the development of microorganisms and reinfection. However, in agreement with the findings of this study, it is seen in the literature that CH could not completely be eliminated from the root canal recesses with any of the methods and irrigation solutions being used currently (4,9-13).

EDDY tips have been recently introduced as sonic irrigation activation tips which are made of polyamide driven at a frequency of 6000 Hz by an air-driven handpiece. The EDDY was tested in the present study for its superior ability to remove CH from artificial IRR cavities, as reported in a recent study (14). In another study, it was reported that PUI and EDDY have similar CH medicament removal capacity from artificial IRR cavities when the cavities were created by bur (4). In this study, EDDY eliminated CH fully in 47.5% of the IRR cavities, whereas PUI eliminated CH fully in 60% of the cavities. The CH removal percentages of the other investigated irrigants were 32.5%, 17.5%, 0% and 0% for RS, CB, MDI, and SI, respectively. However, no significant difference was found between EDDY and PUI (Table 1). This may be due to the fact that although EDDY is used with frequencies below 30,000 Hz, it has a flexible tip made of polyamide which can freely swing inside the root canal and create a cavitation effect.

PUI is the most popular method in activating the irrigant for the removal of debris and bacteria (15-17). Cavitation and acoustic streaming of the irrigant by means of ultrasonic wave have a critical role in the

Table 1. The scoring results of the simulated IRR cavities

Groups	Median	IQR	Minimum	Maximum
SI	2.0 ^A	1.0	1.0	3.0
MDI	2.0 ^B	1.0	1.0	3.0
PUI	0.0 ^C	1.0	0.0	1.0
EDDY	1.0 ^C	1.0	0.0	2.0
CB	1.0 ^D	1.0	0.0	3.0
RS	1.0 ^D	2.0	0.0	2.0

SI: Syringe irrigation, MDI: Manual dynamic irrigation, PUI: Passive ultrasonic irrigation, CB: CanalBrush, RS: Rispisonic, IQR: Interquartile range, IRR: Internal root resorption. Values with different superscript letters were statistically different at $p < 0.05$ (Kruskal-Wallis and Mann-Whitney U tests)

effectiveness of PUI. This feature has enabled PUI to be superior to sonic activation as stated in many studies (9,10,18). In the present study, PUI was found to be superior to other tested methods, which was consistent with previous studies (11,13), while it performed similarly to EDDY (Table 1). In a previous study, it has been shown that PUI with EDTA and NaOCl was superior to CB and SI in the elimination of CH from simulated IRR cavities (10). Although these results are in line with those of Topçuoğlu et al. (18), the results showed that PUI was not able to completely remove CH from artificial IRR cavities.

CB features a polypropylene brush with high flexibility for endodontic use. The manufacturer suggests that it helps cleaning by activating the irrigation solutions and directing the irrigation solution to the canal irregularities that cannot be touched by instruments. Contrary to our results, in the limited number of studies (10,18), CB removed a similar amount of CH from resorption cavities compared to SI. This discrepancy may be attributable to the differences in the irrigation protocol in which irrigants were refreshed every 30 seconds. However, CB was less effective than PUI in clearing resorption cavities. This is in accordance with the findings of previous studies (10,18). The researchers found CB to be effective in cleaning the main canal however, further examinations showed that it tends to fill the canal irregularities with CH remnants (10,18,19). In a recent study, it has been shown that CB removed less CH from the main canal compared to EDDY and RS (20).

The SONIC AIR[®] MM 1,500 handpiece which is hooked directly to the dental unit with a RS file was

originally developed for the purpose of shaping the root canals (5). However, in many studies, it was used to activate the irrigants. The investigators found that the efficacy of RS in the removal of debris was superior to SI while it was comparable to PUI (21). However, to date, no data are available in the literature with regard to its effectiveness on the removal of CH. In this study, RS removed significantly less CH compared with PUI and EDDY.

The effect of NaOCl alone or the combined use of EDTA and NaOCl in the elimination of medicaments from root canals was investigated in previous studies. Some previous studies reported that the addition of chelators to NaOCl did not enhance the removal of CH compared with NaOCl irrigation (22). However, other studies reported that NaOCl showed the least favorable results of CH removal when used without a combination containing a chelating agent (8,23). In another study, PUI with NaOCl was found more effective on the elimination of CH than SI with NaOCl and PUI with water (24). However, EDTA is considered to be superior to NaOCl in the elimination of CH and smear layer (23). In the present study, the canals were flushed with 2.5 mL EDTA followed by NaOCl to resemble an actual clinical application cycle.

In previous studies, artificial standardized grooves or cavities were used to investigate the effectiveness of different irrigation protocols or solutions in the elimination of intracanal medicaments (9-11,13-15,18,22,24). The use of standardized cavities provides a standardization in the size and location of cavities as well as the amount of medicament used. This allows a good agreement between the intraobserver and interobserver. However, the artificial cavities created by a bur do not represent the complexity and irregularities of resorption cavities or isthmuses. In addition to this, evaluation of only visible CH remnants overlooking the residues in the dentinal tubules are the limitations of the presented study (4,22).

Conclusion

The activation of irrigants has improved the elimination of CH from simulated IRR cavities. Among the investigated activation regimens, PUI and EDDY were more effective than CB, MDI, RS in CH removal. However, none of the tested methods were able to create cavities free of CH.

Ethics

Ethics Committee Approval: The present study was approved by the Ethics Committee of the Bolu Abant İzzet Baysal University (decision number: 2019/204, date: 07.11.2019).

Informed Consent: Informed consent/assent was obtained from all patients.

Peer-review: Externally and internally peer-reviewed.

Authorship Contributions

Concept: H.G., İ.Ö., Design: H.G., İ.Ö., Data Collection or Processing: H.G., İ.Ö., S.T.İ., Analysis or Interpretation: H.G., İ.Ö., S.T.İ., Literature Search: H.G., İ.Ö., S.T.İ., Writing: H.G., İ.Ö.

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