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Research / Araştırma Makalesi

Investigate the Push-out Bond Strength of Root Canal Fillings After Calcium Hydroxide Medicament Removal with Ethanol

Kalsiyum Hidroksitin Uzaklaştırılmasında Etanol Kullanımının Kök Kanal Dolgusunun Push-out Bağlantı Dayanımına Etkisinin İncelenmesi

Funda FUNDAOĞLU KÜÇÜKEKENCİ[α]

[α]Ordu Üniversitesi, Diş Hekimliği Fakültesi, Endodonti AD, Ordu, Türkiye

[α]Ordu University, Faculty of Dentistry, Department of Endodontics, Ordu, Türkiye

ABSTRACT

Aim: The present study aims to evaluate the effect of various irrigation solutions used to remove calcium hydroxide [$Ca(OH)_2$], especially ethanol, on the push-out bond strength (PBS) of root canal filling.

Materials And Methods: 50 human incisors were prepared with protaper next X3 files. Root canals were filled with $Ca(OH)_2$. The teeth were kept at 37°C and 100% humidity for one week. The samples were divided into five experimental groups according to the irrigation solution used to remove the $Ca(OH)_2$ (n=10); Group 1: 2.5% NaOCl, Group 2: 6 mL 17% EDTA, Group 3: 6 ml 37% phosphoric acid, Group 4: 6 ml 70% ethanol, Group 5: 6 ml distilled water. After removing the Ca(OH)2, the root canals were filled with AH plus root canal sealer and gutta-percha. PBS test was applied by taking one sample from each tooth from the coronal, middle, and apical thirds. The data were analyzed with a one-way analysis of variance and Tukey's multiple comparison test (α=0.05).

Results: Statistically, the highest bond strength was found in the ethanol group (6.46±0.14 MPa), and there was a statistical difference between all groups ($p<0.05$). The apical PBS was significantly lower than the other thirds in all groups ($p<0.05$).

Conclusion: The high bond value result of the root canal filling after using ethanol as an irrigation solution may positively affect the long-term success of root canal treatment. So, ethanol can be used as an alternative to conventional irrigation solutions to remove $Ca(OH)_2$.

Keywords: Calcium hydroxide, Ethanol, Push-out bond strength

ÖZ

Amaç: Bu çalışmanın amacı, başta etanol olmak üzere, kalsiyum hidroksiti [$Ca(OH)_2$] uzaklaştırmak için kullanilan çeşitli irrigasyon solüsyonlarının kök kanal dolgusunun push-out bağlantı dayanımına etkisinin değerlendirilmesidir.

Gereç ve Yöntemler: 50 adet insan kesici dişi protaper next X3 kanal eğesine kadar genişletildi ve kök kanalları $Ca(OH)_2$ ile dolduruldu ve 37°C ve %100 nemde 1 hafta bekletildi. Örnekler $Ca(OH)_2$ ‘ yi uzaklaştırmak için kullanılan irrigasyon solüsyonuna göre 5 çalışma grubuna ayrıldı (n=10); Grup 1: 6 ml %2.5 NaOCl, Grup 2: 6 ml %17 EDTA, Grup 3: 6 ml %37 fosforik asit, Grup 4: 6 ml %70 etanol, Grup 5: 6 ml distile su. $Ca(OH)_2$ uzaklaştırıldıktan sonra kök kanalları güta perka ve AH plus kanal patı kullanılarak dolduruldu. Her dişten koronal, orta ve apikal üçlüden birer örnek alınarak push-out testi uygulandı. Elde edilen veriler tek yönlü varyans analizi (ANOVA) ve Tukey çoklu karşılaştırma testi ile analiz edildi (α=0.05).

Bulgular: İstatistiksel olarak en yüksek bağlantı değeri etanol kullanılan grupta (6.46 ±0.14 MPa) görülürken tüm gruplar arasında istatiksel olarak anlamlı fark görüldü ($p<0.05$). Tüm gruplarda apikal üçlü bölgesinde ki bağlantı değeri koronal ve orta üçlüden istatistiksel olarak anlamlı olarak düşük tespit edildi ($p<0.05$).

Sonuç: Etanolün irrigasyon solusyonu olarak kullanılması sonrasındaki kök kanal dolgusunun yüksek bağlantı değeri kök kanal tedavisinin başarısını uzun dönemde olumlu etkileyebilir. Bu nedenle, etanol kalsiyum hidroksiti uzaklaştırmak için bilinen irrigasyon solüsyonlarına alternatif olarak kullanılabilir.

Anahtar Kelimeler: Kalsiyum hidroksit, Etanol, Push-out bağlantı dayanımı

INTRODUCTION

Calcium hydroxide [$Ca(OH)_2$] is an intracanal medicament often used in cases where a single-visit root canal treatment is contraindicated.[1] $Ca(OH)_2$ provides additional benefits to irrigation solution in reducing bacterial load inside the root canal.[2] The reason for the widespread use of $Ca(OH)_2$ is that it is a biocompatible material.[3] Unfortunately, the effectiveness of root canal therapy is negatively impacted by the incomplete removal of this medicament from root canals.[4] Because $Ca(OH)_2$ remnants that penetrate the dentinal tubules prevent the sealers from bonding to the root canal dentin and the filling of lateral canals.[5] In addition, $Ca(OH)_2$ is a soluble material; it causes leakage, especially in the apical region.[6] Many irrigation materials and methods are used to remove $Ca(OH)_2$ to counteract these adverse effects.[7,8] Ethylenediaminetetraacetic acid (EDTA) and sodium hypochlorite (NaOCl) are irrigation solutions that are frequently used with or without passive ultrasonic activation for the removal of $Ca(OH)_2$.[9] Researchers reported that phosphoric acid (H_3PO_4) could be used for this purpose due to its organic tissue dissolving properties.[10] De Lima Dias et al.[11] showed that alcoholic solutions such as ethanol might be used to remove $Ca(OH)_2$, and ethanol is more efficient than NaOCl and EDTA. Reducing the quantity of residual $Ca(OH)_2$ improves the penetration of the sealer and increase the bond strength to dentin.[12,13]

The effect of using ethanol to remove $Ca(OH)_2$ on the bond strength of the root canal filling has not been evaluated. Therefore, the objective of the present study was to determine how various $Ca(OH)_2$ removal irrigants, especially ethanol, affected the bonding strength of canal filling. The null hypothesis tested was that the bond strength of the root canal filling would not be affected by the different irrigation solutions used to remove $Ca(OH)_2$.

MATERIALS AND METHODS

The protocol of this study was confirmed by the ethics committee of Ordu University (#2022/78). In this study, fifty human maxillary incisors were extracted for orthodontic, periodontal, or prosthetic reasons were used. Teeth were kept in distilled water until use. Radiographs were taken from each tooth in the mesiodistal and buccolingual direction and evaluated for internal or external

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Sorumlu yazar/Corresponding Author: Funda FUNDAOĞLU KÜÇÜKEKENCİ
E-mail: fundafundaoglu@gmail.com
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resorption, previous root canal treatment, and additional canals. Teeth with additional canals, resorption, or previous endodontic treatment were excluded. Using a diamond separation disc (Sunshine Diamonds, Dr. Hopf GmbH & Co. KG, Langenhagen, Germany), the crowns were separated from the cementoenamel junction to obtain roots that were 12 mm in length. The root canals were prepared up to X3 with protaper next file (Dentsply, Maillefer, Ballaigues, Switzerland) 1 mm shorter than the apical foramen, rinsed with 2.5% NaOCl after each instrumentation, and dried with a paper point. $Ca(OH)_2$ (Kalsin, Spot Diş Deposu Malz. San. Tic. Ltd. Şti, Türkiye) was placed in the canals with a size #30 lentulo spiral (Mani, Utsunomiya Tochigi, Japan). The canal orifices were covered with cotton, restored with Orafil-G (Prevest DenPro Lim. Jammu, India), and kept for one week at 100% humidity and 37°C temperatures.

Irrigations protocol

Temporary restorative material and the $Ca(OH)_2$ were removed using a master apical file and distilled water. According to the irrigation solution used to remove $Ca(OH)_2$, samples were randomly allocated to the following five groups:

Group 1: 6 mL 2.5% NaOCl for 180 seconds

Group 2: 6 mL 17% EDTA for 180 seconds

Group 3: 6 mL 37% H3PO4 for 90 seconds

Group 4: 6 mL 70% ethanol for 180 seconds.[11]

Group 5: 6 mL distilled water (DW; Control) for 180 seconds.

All irrigation solutions were delivered 2 mm short of the working length through a 27G needle (Endo-Eze Irrigator tip, Ultradent Products, Inc., UT, South Jordan) with a nonactivated irrigation method (NAI) for 180 seconds. Only H_3PO_4 was applied for 90 seconds.[10,11] A final irrigation was done with 5 ml of DW and dried with a paper point. The root canals were obturated with gutta-percha cones and epoxy resin-based root canal sealer (AH Plus; Dentsply, Konstanz, Germany) via lateral condensation it was checked with radiographs that the root canals were filled (**Figure 1**). The canal orifices were restored with Orafil G and kept for 48 hours at 100% humidity and 37°C temperatures for the sealer to set completely.

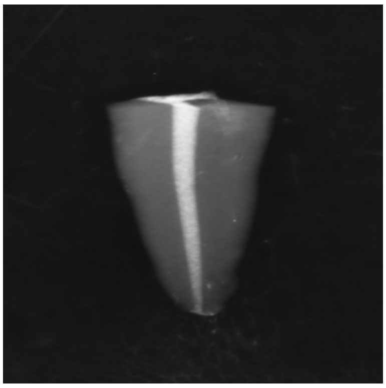

Fig. 1. Radiograph image of the filled root canal with gutta-percha cones and epoxy resin-based root canal sealer.

Push-out bond strength assessment

The roots were vertically embedded in a block of auto-polymerized acrylic resin (Meliodent, Bayer Dental, Leverkusen, Germany) and sectioned into two slices for each third region using a precision cutting machine (Mecatome T180, Presi Metallography, Eybens, France) with water cooling to obtain 1 mm horizontally sections.

A universal testing instrument (Autograph AGS X, Shimadzu Co, Japan.) was used to conduct the Push-out bond strength (PBS) test. One sample was selected from each third region for the PBS test (N=150, n=10). PBS test was applied from apical to coronal with a 1 mm diameter plugger at a rate of 0.5 mm/min until the canal filling was dislocated. The bond failure force recorded in Newtons (N) is the peak force displacing the filling. The N value was converted to megapascals (MPa) for each sample by dividing the N value into the total bonding area (mm^2). The whole bonding area was calculated as $\pi(r1 + r2)\,h$, where h is the thickness of the sample, r1 is the apical radius of the root canal, r2 is the coronal radius of the root canal, and $\pi = 3.14$.

Statistical analysis

According to the Shapiro–Wilk tests of normality, the groups were normally distributed. Statical analysis (SPSS 20.0, SPSS Inc, Chicago, USA) of PBS data was performed using a one-way ANOVA and the Tukey honestly significant difference (HSD) test (α=0.05).

RESULTS

The mean and standard deviation (SD) values of PBS recorded for different groups are presented in **Table 1**. The results showed that the PBS of the ethanol group was significantly greater than all experimental groups (6.46 ±0.14 MPa) ($p<0.05$). The PBS of the other groups was calculated as H3PO4 (4.81 ±0.1 MPa), EDTA (4.43 ±0.17 MPa), NaOCl (3.89 ±0.15 MPa), and DW (2.86 ±0.15 MPa), respectively, and all groups were statistically different from each other ($p<0.05$). The PBS of the apical third was obtained significantly lower than the other third regions in all groups ($p<0.05$) (**Table 1**).

Table 1. Mean ±SD of push-out bond strength values (MPa) in different groups and regions of root canal

	N	NaOCl	EDTA	H_3PO_4	Ethanol	DW
Coronal	10	4.16 ±0.28^a	4.84 ±0.44^a	5.34 ±0.27^a	7.52 ±0.60^a	3.21 ±0.36^a
Middle	10	3.97 ±0.36^a	4.52 ±0.31^a	4.92 ±0.15^b	6.56 ±0.32^b	2.85 ±0.22^b
Apical	10	3.54 ±0.23^b	3.91 ±0.13^b	4.18 ±0.16^c	5.3 ±0.55^c	2.52 ±0.17^c
TOTAL	30	3.89 ±0.15^B	4.43 ±0.17^C	4.81 ±0.1^D	6.46 ±0.14^E	2.86 ±0.15^A

**Tukey HSD comparisons of PBS values (MPa) were presented as superscripts, and significant differences were indicated with different letters (p<0.05). Superscript uppercase letters indicate comparisons of different irrigation solutions; lowercase letters indicate comparisons of the same irrigation solution group in different root regions.*

DISCUSSION

Due to its antimicrobial effect, $Ca(OH)_2$ is frequently used in endodontics.[14] Despite the favorable properties of $Ca(OH)_2$, it must be removed entirely from the canal prior since its residues adversely affect the canal's adhesion.[15,16] However, although different irrigation methods have been tried to remove $Ca(OH)_2$, it is known that no process completely removes $Ca(OH)_2$.[1, 7, 11, 17, 18] In the study examining the residual $Ca(OH)_2$ amount in the root canal with confocal laser microscopy, it has been shown that approximately 55-60% of the root canals are filled with calcium hydroxide residue.[11] Recent studies demonstrated that 70% ethanol did not alter the inorganic content of dentin after calcium hydroxide removal but did increase the surface free energy of root canal dentin, significantly improving the wettability of the root canal sealer [22,34]. Although the effectiveness of ethanol in removing $Ca(OH)_2$ is known, there is no study examining the effect of PBS.[11]

In this study, the effect of $Ca(OH)_2$ removal with ethanol on PBS was investigated. PBS was found to be statistically higher in the ethanol, H_3PO_4, EDTA, and NaOCl groups than distilled water (control) group ($p<0.05$), Therefore, the null hypothesis was rejected. The ethanol group showed the significantly highest bond strength. This situation can be explained by the fact that ethanol is superior to other irrigation solutions in removing $Ca(OH)_2$.[11] Luiz et al. cited the increase in wettability as the reason for this result.[11] Also, Ethanol is an organic solvent that can remove certain oils and glycol-based pastes[35]. The present study was prepared by mixing calcium hydroxide with propylene glycol so that ethanol could be a suitable solvent for this paste. The use of ethanol on dentin promotes drying, inducing a hydrophobic dentin surface, an advantage that allows for the infiltration of resin monomers to wet dentin, increasing resin retention[36]. Due to AH plus root sealer being resin-based, the ethanol group's PBS value may cause a higher in with this way.

The NaOCl group showed significantly lower bond strength (3.89 ±0.15 MPa) than the other groups. This result can be explained by the low efficiency of NaOCl in removing inorganic material.[19] It was previously reported that H_3PO_4 and EDTA are effective on the inorganic structure of dentin.[20] EDTA can increase the adhesion of hydrophobic epoxy resin sealers by reducing the wettability of dentin.[21] 70% ethanol increases the surface energy of dentin without changing the inorganic content, thus increasing the bonding of the sealer using high wettability.[22] Studies show that the application of ethanol on both crown and root dentin increases the bond strength values of adhesives.[37,38] Therefore, it may be an alternative to NaOCl and EDTA, known to cause root weakness.[23] Luiz et al.[11] reported no difference in $Ca(OH)_2$ removal between needle irrigation and passive ultrasonic activation of irrigation solutions used. Therefore, only the NAI method was used in this study since the irrigation solution was evaluated instead of the method. A recent study has shown that placing $Ca(OH)_2$ in the canal and its vehicles are ineffective in penetration.[24] In this study, $Ca(OH)_2$ was placed in the root canal with an aqueous vehicle(propylene glycol) and a lentulo spiral, and the carrier and method were not evaluated.

All groups' apical third PBS values were lower than the coronal and middle third. This situation can be explained because anatomical variations in the apical region make it difficult to remove $Ca(OH)_2$ in this region, with residual $Ca(OH)_2$ reducing the bonding of the canal filling.[25,26,27] In the present study, the adhesion of the sealers to the root canal dentin is evaluated with the PBS test.[28,29] The disadvantage of this method is the deformation of the gutta-percha due to the application of a non-uniform force to the gutta-percha.[30] For this reason, some researchers have evaluated the push-out test using only a sealer.[28,31] Since this evaluation does not simulate clinical practice, canal filling with a conventional epoxy resin-based root canal sealer which is widely used in clinical applications and gutta-percha cone using the cold lateral condensation method were preferred in the present study.[32]

Because ISO, the international standardization organization, does not report the minimum bond strength values required for endodontic sealers, we cannot evaluate the adequacy of the values we have obtained. However, the values in the present study at DW, NaOCl, and EDTA groups were obtained similarly to the previous research.[33]

One of the factors affecting the bond strength of sealers is the smear layer. Gelio et al.[39] suggested that ethanol is not capable to remove the chemical smear layer. Although the effect of the ethanols smear layer removed isn't sufficient, the higher bond strength values in the ethanol group may be related to the fact that it removes $Ca(OH)_2$ more effectively. However, in the presented study, the effect of ethanol on smear removal was not examined. This situation is the limitation of our study. In further more studies, ethanol's effects on the smear layer can be examined.

CONCLUSIONS

According to the results of the present study, the high bond value result of the root canal filling was obtained when ethanol was used to remove $Ca(OH)_2$. However, to achieve better results in effectively removing $Ca(OH)_2$, further studies might be conducted to examine irrigation activation methods to increase the efficiency of ethanol.

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It is declared that during the preparation process of this study, scientific and ethical principles were followed and all the studies benefited are stated in the bibliography.

Benzerlik Taraması / Similarity scan

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ethic.selcukdentaljournal@hotmail.com

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Çıkar Çatışması / Conflict of Interest

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