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EVALUATING THE EFFECTS OF VARIOUS IRRIGATION SOLUTIONS ON THE FRACTURE STRENGTH OF ENDODONTICALLY TREATED TEETH

KÖK KANAL TEDAVİSİ YAPILMIŞ DİŞLERDE FARKLI İRRİGASYON SOLÜSYONLARININ KIRILMA DAYANIMLARI ÜZERİNE ETKİSİNİN İNCELENMESİ

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ABSTRACT

Objective: Various irrigation solutions can affect the root canal sealer to bind dentine and not remove microorganisms from the root canal system completely. This study's objective is to investigate the efficiency of fracture strength of various irrigation solution protocols.

Material and Methods: The study involves 60 single-rooted teeth. The working lengths were determined, and ProTaper Next (PTN; Dentsply-Sirona) files (X5 50.06) were used to prepare the root canal shaping. The teeth were then randomly divided into three (n=20) groups according to the different irrigation solutions: ethylene diamine tetra acetic acid (EDTA), Irritrol, and chlorhexidine (CHX). A fracture strength test was performed with the fracture value being recorded in Newtons (N). Data were statistically analyzed with the Kruskall-Wallis test ($p<0.05$).

Results: The EDTA group showed higher bond strength values than the CHX or Irritrol groups. No significant difference was found between EDTA and CHX ($p>0.05$). When using Irritrol as the final irrigation solution, fracture values were significantly lower compared to when CHX and EDTA were used ($p<0.05$).

Conclusion: EDTA and CHX have similar effects on fracture strength.

Keywords: Fracture strength, irrigation solutions, Irritrol, resin-based sealers

ÖZ

Amaç: Farklı irrigasyon solüsyonlarının kök kanal patının dentine bağlanma gücünü olumsuz etkileyebildiğini ve mikroorganizmaların kök kanal sisteminden tamamen uzaklaştırılamadığı görülmüştür. Bu çalışmanın amacı, farklı irrigasyon solüsyonlarının kullanılmasının dişlerin kırılma dayanımları üzerindeki etkisinin değerlendirilmesidir.

Gereç ve Yöntem: Çalışmaya 60 adet çürüksüz, tek köklü mandibular premolar diş dahil edildi. Çalışma boyları belirlendi ve kök kanal şekillendirilmesi üretici firmanın talimatlarına göre ProTaper Next (PTN; Dentsply-Sirona) X5 50.06 apikal genişlik elde edilinceye kadar prepare edildi. Ardından, dişler kullanılan irrigasyon solüsyonlarına (Etilendiamin tetraasetik asit (EDTA), Irritrol, Klorheksidin (CHX)) göre rastgele 3 (n=20) gruba ayrıldı. Kırılma dayanım testi uygulandı ve bu kırılma değeri Newton (N) cinsinden kaydedildi. Gruplarda normal dağılım göstermemiştir. Çalışmamızda, Non-Parametrik test olan Kruskall-Wallis ve Mann Whitney U testleri uygulanmıştır.

Bulgular: Etilendiamin tetraasetik asit grubu CHX ve Irritrol gruplarına göre daha fazla kırılma dayanımı göstermiştir. Etilendiamin tetraasetik asit ve CHX grupları arasında anlamlı bir farklılık bulunmamıştır ($p>0,05$). Irritrol ise diğer gruplara göre anlamlı derecede daha düşük kırılma dayanımı göstermiştir ($p<0,05$).

Sonuç: EDTA ve CHX'nin irrigasyon solüsyonu olarak kullanıldıktan sonra kök kanal patına ve gütaperkanın adhezyonuna benzer etkide bulundukları görülmüştür.

Anahtar Kelimeler: Irritrol, irrigasyon solüsyonu, kırılma dayanımı, resin içerikli kök kanal patları

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INTRODUCTION

The removal of bacteria from the root canal system using appropriate instrumentation, medications, and irrigation solutions is crucial for good root canal therapy (1). Chemomechanical preparation of root canals is very important for providing disinfection (2). However, mechanical preparation of the root canal results in the production of a smear layer of 1-2 µm thickness that includes necrotic debris, bacteria, and bacterial byproducts. This smear layer clogs the dentinal tubules and is responsible for the establishment of bacterial growth (3). It also prevents irrigation solutions, medicaments, and canal sealers from penetrating the dentinal tubules (4, 5). Ethylenediaminetetraacetic acid solutions (EDTA), which are chelating agents, and sodium hypochlorite (NaOCl) are often used to remove the smear layer. Different antimicrobial agents can be used as irrigation solutions. Chlorhexidine (CHX) can be preferred as the final irrigation solution in root canal treatment due to its low toxicity and extended-release antimicrobial agent. As a final irrigation solution, Irritrol Two-In-One with EDTA and CHX was just introduced. The manufacturer claims that it causes a small amount of demineralization in dentin and provides effectiveness by removing the smear layer less aggressively than conventional irrigation solutions (6).

Recent studies have shown that using various irrigation solutions may adversely affect how the root canal sealer binds to the dentine and may incompletely remove microorganisms from the root canal system (7).

The present study aims to evaluate the fracture strength of the bond between the root canal filling and root canal wall after using EDTA, Irritrol, and CHX. The study's null hypothesis is that no significant difference will occur between any of the three groups.

MATERIALS and METHODS

Upon obtaining permission from the Ankara Yıldırım Beyazıt University Ethics Committee, this investigation began involving 60 caries-free single-root mandibular premolar teeth. Periodontal curettes were used to remove debris and soft tissue remnants from the root surfaces. Teeth were examined under a stereomicroscope at x20 magnification for the existence of fractures and cracks. Teeth with cracks, fractures, defects, or an open apex were not included in the study. All teeth were examined with radiographs taken at buccolingual and mesiodistal angles. Teeth with calcification, resorption, curved canals, or multiple canals were replaced with new teeth that met the eligible criteria. All teeth were selected to have buccolingual diameters of 4-6 mm and mesiodistal diameters of 2-4 mm. Until testing, the teeth were maintained in a 0.9% saline solution. After removing the crowns of teeth, the root lengths were standardized at 13±1 mm (8). Working lengths were determined using an electronic apex locater (Propex Mini; Dentsply, Sirona, Ballaigues, Switzerland). Root canal shaping was prepared with ProTaper Next (PTN) using an endomotor (X-Smart Plus, Dentsply-Sirona) until an apical width of 50.06 was obtained.

Experimental groups

The teeth were randomly divided into three (*n*=20) groups based on the different irrigation solutions to be used (i.e., EDTA, Irritrol, CHX). The apex of the teeth was coated with wax to prevent the irrigation solutions from extruding the apex.

EDTA-Saline Group: The root canals were irrigated with 2 mL of 5.25% NaOCl following each file change. All samples were irrigated with 5 mL of a 17% EDTA solution for 1 minute to eliminate the smear layer. Samples were then irrigated with 5 mL of saline.

EDTA-CHX Group: The root canals were irrigated with 2 mL of 5.25% NaOCl following each file change, and then all samples were irrigated for 1 minute with 5 mL of 17% EDTA solution to remove the smear layer. Next, the samples were irrigated with 5 mL of saline and lastly with 5 mL of 2% CHX.

Irritrol Group: The root canals were irrigated with 2 mL of 5.25% NaOCl following each file change. Samples were then irrigated with 5 mL of saline, followed by 5mL of Irritrol. Afterward, all root canals were dried with ProTaper Next X5 paper points.

Root canals were filled with the single cone technique using ProTaper Next X5 (PTN) gutta-percha and AH Plus (Dentsply-Sirona), a resin-containing root canal sealer. Afterward, the samples were kept in a 100% humidity environment at 37°C for 7 days in order to cure the root canal sealer.

The specimens were embedded in acrylic blocks with their 2 mm coronal part exposed (9). The samples were stored in a humid environment with the help of a wet towel stop to prevent dehydration until the fracture test was applied. The fracture strength values were determined using an electromechanical servo universal testing machine (Besmak Ltd., Ankara, Türkiye). The study was carried out with reference to the experimental conditions of the previous study (10). The sudden decrease in the graph value displayed on the computer screen connected to the test device against the applied load was determined as the force value at the moment of fracture (Figure 1). This fracture value was recorded in Newtons (N).

Statistical analysis

The obtained data were analyzed using the program IBM SPSS 21 (IBM SPSS Corp., Armonk, NY, USA). The Kolmogorow-Smirnow test was applied to determine whether the obtained data were normally distributed. The Kruskal-Wallis test, a non-parametric test, was then applied. The Mann-Whitney U test was used to determine whether differences between groups exists.

This study was approved by the Ankara Yıldırım Beyazıt University (AYBU) Health Science Ethics Committee (Approval No. 2022-1231 dated December 8, 2022).

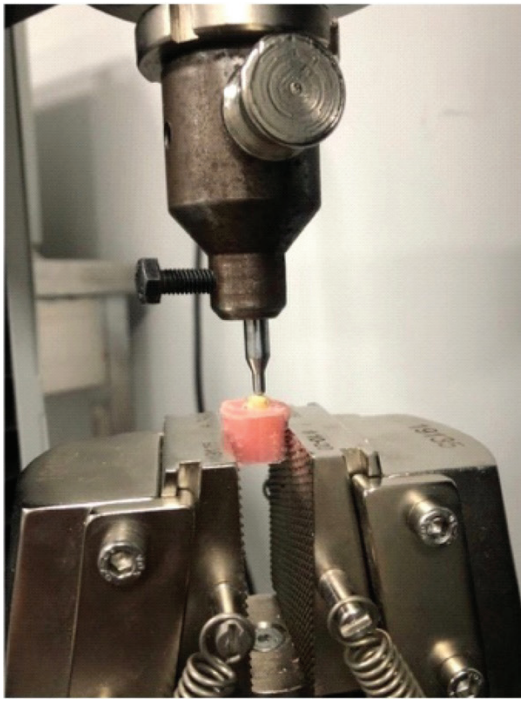

Figure 1: Applying the fracture strength test

RESULTS

Table 1 shows the median and standard deviation values for the fracture strengths. While the EDTA group showed higher fracture strength values than the CHX and Irritrol groups, no significant difference was observed between the EDTA and CHX groups (p>0.121). When using Irritrol as the final irrigation solution, fracture strength values were significantly lower than the CHX (p<0.012) and EDTA values (p<0.000).

Table 1: Fracture Strength Values (N) of the Experimental Groups

Irrigation solutions	Median	Min	Max	SD	P value
EDTA	353.36^{X}	240.57	450.88	59.14	
CHX	327.66^{X}	116.14	431.44	88.44	0.001
Irritrol	197.87^{Y}	128.67	452.77	101.38	

Different superscript letters indicate statistically significant differences between groups. P<0.05, $^{x\text{-}y\text{-}z}$: Columns, EDTA: Ethylenediaminetetraacetic acid; CHX: Chlorhexidine

DISCUSSION

The aim of the treatment has been to provide a three-dimensional obturation that completely covers the dentin canals, accessory canals, and lateral canals, as well as the coronal and apical sections in the root canal system (11). The use of a canal sealer is important in terms of providing a connection between the gutta-percha and canal walls and for filling the canal spaces where gutta-percha cannot be reached. During root canal preparation, a smear layer forms that adversely affects the adhesion of the sealer to the radicular dentin and dentinal tubules (12). This study has used AH-Plus root canal sealer due to its epoxy resin content and stronger bond compared to other sealers (1). This bond has been observed to occur by binding to the amino groups in dentinal collagen (13). Additionally, different irrigation solutions can affect the adhesion of the sealer, which in turn affects the collagen structure, the wettability of the dentin, and root fracture resistance (14, 15).

Fracture strength is the maximum stress that a dental structure or material can withstand before breaking and is considered the best measure of tooth strength (16). This study completed the root canal fillings with the single cone technique to eliminate the effect the root canal filling technique has on the fracture strength values. EDTA showed higher values than the other groups, so the null hypothesis of this study has been rejected. While EDTA showed numerically higher fracture strength values than CHX, no statistically significant difference was found between them. Stelzer et al. showed CHX to have no impact on bond strength in either of the gutta-percha/AH Plus root canals when comparing EDTA and NaOCl as an irrigation solution (17). The current study supports these findings. The reason why the fracture strength value of Irritrol was significantly lower than the other groups in this study may have been due to the interaction of EDTA and CHXs in the solution and the production of some white precipitate (18). This white precipitate may have blocked the dentinal tubules or prevented the sealer from penetrating the tubules, thus resulting in less adhesion. All specimens in the present study included mandibular premolar teeth and were grouped according to similarity of dimensions. The specimens were standardized to 13 mm, and the root canals were enlarged with the same instruments and techniques. However, the strength of the roots could still be affected by uncontrollable physiological variations, such as the unknown age of the patient and dentin thickness (19, 20). An increase in the mineral content (inorganic part) of hard tissues occurs with age, as well as a decrease in collagen content (organic part). Fracture strength and elasticity depend on the amount of collagen in the hard tissue (21). Furthermore, the mechanical properties of obturated roots may vary based on the amount of dentine remaining around the root canal after the different irrigation techniques. As such. these could be limitations for this study.

Küçük et al. examined the dentin tubular penetration activities of Irritol, CHX, and QMIX, with Irritrol showing similar effects to CHX (18). Other studies have reported Irritrol and CHX to have similar dentin tubule penetration effects when performing the final irrigation with PIPS (22). Another study reported Irritrol, EDTA, and QMIX to provide similar root canal sealer adhesion (23). The current study found binding the root canal sealer to the dentin tubule to be highly influenced by Irritrol. The fracture strength value is thought to be lower in the Irritrol group compare to the other groups due to the unknown amount of EDTA in the Irritrol solution.

The need exists for comprehensive studies to evaluate the solutions' effectiveness at removing the smear layer after using

irrigation activation techniques, as well as their interactions with root canal sealers and their differing contents.

CONCLUSION

Under the experimental terms of the current in vitro study, the fracture strength of Irritrol, which is combined with EDTA and CHX, has been shown to have a significantly lower fracture strength value than the other two groups.

Ethics Committee Approval: This study was approved by Ankara Yıldırım Beyazıt University (AYBU) Health Science Ethics Committee (Approval No. 2022-1231 dated December 8, 2022).

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