The Effect of Various Solvents on Dentinal Crack Formation During Endodontic Retreatment

Farklı Çözücülerin Kök Kanal Yenilenmesi Sırasında Dentinde Çatlak Oluşumuna Etkisi

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Received \ Geliş tarihi : 10.10.2018
Accepted \ Kabul tarihi : 24.10.2018
Online published : 12.03.2019
Elektronik yayın tarihi

Cite this article as:
Bu makaleye yapılacak atıf:
Kırıcı D, Karataş E, Kol E, Arslan H. The effect of various solvents on dentinal crack formation during endodontic retreatment. Akd Med J 2019; 5(2):296-300.

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DOI: 10.17954/amj.2019.1623

ABSTRACT

Objective: The aim of this study was to compare the effect of chloroform, eucalyptol oil and orange oil on dentinal crack formation during retreatment.

Material and Methods: Sixty extracted mandibular premolar teeth were used. Twelve teeth were left unprepared as a negative control group, and 48 teeth were prepared using the ProTaper Universal (PTU) up to a size of F3. Before the filling of the root canals, 12 roots were allocated as a positive control group. Root canals were filled. Retreatment was performed using the ProTaper Retreatment system. In three different groups, chloroform, eucalyptol oil, and orange oil were used during the retreatment procedure.

Results: Regarding the different sections (3, 6, and 9 mm) there was a significant difference between the experimental groups at the 9 mm level ($P < 0.05$).

Conclusion: Chloroform and negative control groups were associated with less dentinal crack formation than the positive control group at 9 mm level.

Key Words: Dentinal crack, Chloroform, Eucalyptol oil, Gutta percha polvent, Orange oil

ÖZ

Amaç: Bu çalışmanın amacı kloroform, ökaliptol yağı ve portakal yağının kök kanal yenilenmesi sırasında dentinde oluşan çatlak üzerindeki etkilerinin karşılaştırılmasıdır.

Gereç ve Yöntemler: 60 adet çekilmiş alt küçük azı dişi kullanıldı.12 diş şekillendirme yapılmadan negatif kontrol grubu olarak ayrıldı. 48 diş Protaper Universal ile F3'e kadar genişletildi. Kök kanalları doldurulmadan önce 12 kök pozitif kontrol grubu olarak ayrıldı. Kök kanalları dolduruldu. Protaper Retreatment seti kullanılarak kök kanal tedavileri yenilendi. Kloroform, ökaliptol yağı ve portakal yağı 3 farklı grupta kök kanal tedavisinin yenilenmesi sırasında kullanıldı.

Bulgular: Farklı kesitlere göre (3, 6 ve 9 mm) değerlendirildiğinde 9 mm'lik kesitte istatistiksel olarak anlamlı farklılık vardı.

Sonuç: Kloroform ve negatif kontrol grubunda 9 mm'lik kesitlerde pozitif kontrol grubuna göre daha az dentin çatlağı tespit edildi.

Anahtar Sözcükler: Dentin çatlağı, Kloroform, Ökaliptol yağı, Güta perka çözücü, Portakal yağı

INTRODUCTION

A complete or incomplete fracture that is initiated from the root at any levels, usually directed facio-lingually, is defined as a vertical root fracture (1). The root canals generate stress and they are transmitted through the root to the surface where they may well surmount the bonds holding the dentine together (2). If the tensile stress in the canal wall exceeds the ultimate tensile strength of dentine, fractures develop (3). Very little research literature has reported

such root fracture during root canal treatment; therefore, vertical root fracture is the end result of the propagation of a crack (4).

Non-surgical retreatment aims to remove the filling material thoroughly to get back access to the apical foramen and facilitate sufficient cleaning and shaping of the root canal system before refilling (5). Several techniques can be used for gutta percha removal such as the use of stainless steel hand files, nickel-titanium (NiTi) rotary instruments, heat-bearing instruments and ultrasound (6). A study has also suggested that the use of a solvent is to facilitate the removal of gutta percha by softening it (7). Some studies have used the following as solvents: orange oil, eucalyptol, xylol, chloroform, Endosolve E (Septodont, Paris, France), Endosolv R (Septodont), halothane and rectified turpentine (8, 9).

Chloroform has been proven to be effective if it is used with gutta percha (10); yet, it has carcinogenic potential (11) and the search for alternative solvents continues (12). Given that the essential oils including eucalyptol, orange oil, and turpentine oil are harmless and useful for dissolution of root canal filling materials, the research literature has indicated that they can be used in retreatment (13, 14). In a study, Karatas et al. reported that chloroform resulted in more canal transportation than eucalyptol and orange oil throughout endodontic retreatment (15). However, there is no study evaluating the effect of solvents on dentinal crack formation during endodontic retreatment. In this sense, this study aims to bridge the research gap by investigating whether three gutta percha solvents (chloroform, eucalyptol oil and orange oil) have an impact on dentinal crack formation during the removal of root canal materials. The null hypothesis states that there is no significant crack formation difference between the groups.

MATERIALS and METHODS

A total of 60 extracted human single-rooted mandibular premolar teeth were used in this study. The teeth were selected based on the following criteria: a) a single root canal; no visible root caries; cracks or fractures; no signs of internal or external resorption; b) no signs of calcification and c) a fully formed apex and a curvature of <5, according to Schneider (16). The teeth were radiographed from both the buccolingual and mesiodistal directions to check for the existence of a single canal. All the roots were examined to see if there were any pre-existing external defects or cracks, using a stereomicroscope (Novex, Arnhem, The Netherlands) with 12 × magnification. Teeth with such defects were excluded and replaced by similar teeth before carrying out the study. Next, the soft tissue remnants were removed from the outer surface of the root. Diamond burrs were used to prepare endodontic access cavities (Diatech; Coltene Whaledent, Altstätten, Switzerland) and a high-speed handpiece under water cooling. Following preparation of the access cavity, the canal patency was established using a #10 K-file (Dentsply Maillefer, Ballaigues Switzerland). Canals that were patent with an ISO size greater than 15 were discarded and only fresh teeth were included in the study. Finally, 12 teeth were eliminated and a total of 60 teeth were used in this study. To guarantee standardization and to obtain a reference point, the buccal point edge of each tooth was flattened, using a high-speed burr. As a result, the lengths of all teeth were standardized to 14 mm. A #10 K-file was inserted into the canal until the file tip was observed at the apical foramen. After subtracting 1 mm from this measurement, the working length (WL) was determined. The eliminated 12 teeth were left unprepared as a negative control group. The roots in all the other groups were prepared using the ProTaper Universal system (Dentsply Maillefer, Ballaigues Switzerland) until an F3 size. The canals were irrigated with 3 ml of 5.25% sodium hypochlorite (NaOCl) between each file using a syringe with a 29 gauge double-side port NaviTip irrigation needle (Ultradent, South Jordan, UT). The canals were then rinsed with 5 ml of 17% ethylenediaminetetraacetic acid (EDTA) for 1 min and then rinsed with 5 ml of distilled water. Sterile paper points were used to dry the root canals. Before the roots were filled, 12 roots were allocated as a positive control group.

Root Canal Obturation

The gutta percha and AH Plus sealer (Dentsply, Konstanz, Germany) was used to fill the remaining 36 roots based on the cold lateral compaction technique. Next, a lentulo spiral filler was used placed the AH Plus sealer into the root canal. A 0.02/30 master gutta percha cone (Dentsply Maillefer, Konstanz, Germany) with good tug-back was coated with sealer and then gently placed into the canal till the working length was reached. Using a size 25 finger spreader and accessory cones, lateral condensation was applied. For the purpose of controlling finish filling, Mesiodistal and buccolingual radiographs were taken. The coronal 1 mm of the filling material was removed, and the spaces were filled with a temporary filling material (Cavit; 3M ESPE, Seefeld, Germany). The teeth were kept at 37 °C and 100% humidity for two weeks to permit the sealers to set.

Experimental Groups and Retreatment Procedures

The coronal parts of the root canal fillings (nearly 4 mm) were removed with a Gates-Glidden drill (Mani Inc.) to make a reservoir for the solvent. Retreatment of all the root canals was performed using the ProTaper Retreatment (PTR) system with continuous rotation. Root fillings were removed with the implementation the D1, D2 and D3

retreatment instruments at 2-Ncm torque and a speed of 500 rpm with continuous rotation. The files were used with a brushing movement against the canal walls in a crown-down course until the WL was reached. The D1 file was used in the cervical third, the D2 file in the middle third and the D3 file through the entire WL. Finally, the apical preparation was performed with the ProTaper Universal System with an F4 size. Three groups were formed according to the solvent used (chloroform, orange oil and eucalyptol) during retreatment procedures. Three supplementary drops of the solvent were required in order to reach the working length. A total of 0.5 ml of solvent was used for each sample to soften the gutta percha.

Initially, using a low-speed saw under water cooling, the roots were horizontally sectioned at 3, 6, and 9 mm level from the apex. Next, a stereomicroscope at 25× magnification was used to view the slices. Finally, the samples were shot with a camera (Nikon Coolpix 4500; Nikon Tokyo, Japan) to find out the presence of dentinal cracks. The cracks were defined as microcracks or fractures in root dentin. No crack was defined as root dentin devoid of craze lines, microcracks in the root canal dentin. The chi-square test was performed to compare the appearances of cracked roots in the experimental groups. SPSS/PC version 16 (SPSS Inc, Chicago, IL) was used with a significance level of $p<0.05$.

RESULTS

The results are shown in Table I. Dentinal crack formation was observed in all groups. However, there was no statistically significant difference between the groups in terms of dentinal crack formation ($P>0.05$).

Regarding the different sections (3, 6, and 9 mm) there was a significant difference between the experimental groups at the 9-mm level ($P<0.05$). The positive control group was associated with more dentinal cracks than the negative and chloroform groups in the coronal section ($P<0.05$). There was no significant difference between the negative control, chloroform, orange oil, and eucalyptol groups at the 9 mm level in terms of crack formation ($P>0.05$). At the 6 mm and 3 mm levels, there was no significant difference between the groups in terms of dentinal crack formation ($P >0.05$).

DISCUSSION

This present study investigated the impact of three gutta percha solvents (e.g. chloroform, eucalyptol oil, and orange oil) on the incidence of dentinal defects created during root canal retreatment preparation. Briefly, the results showed that there were dentinal cracks in all groups. The previous research has shown a clear correlation between root canal preparation and the initiation and/or propagation of dentinal microcracks (17-19). However De-Deus et al. stated that root canal preparation with rotary NiTi file systems did not induce the formation of new dentinal microcracks (20). Further, De-Deus et al. reported that there were dentinal cracks before the preparation of roots, evaluating the views with a microcomputer both before and after the preparation of the roots (20). Similarly, in this present study, dentinal cracks were observed in the negative control group. However, there were fewer dentinal cracks in the negative control group than the positive control group in which the root canals were retreated without solvent ($p<0.05$). Barreto et al. emphasize that the design of the instrument might contribute to the potential to promote dentinal defects (21). Similarly, Bier et al. stated that an increased file taper could lead to the formation of dentinal cracks as a result of the increased stress on the canal walls (22). Moreover, Karatas et al. reported that movement kinematics had a significant effect on the amount of dentinal crack (23). On the other hand, De-Deus et al. found that there was no link between the variations in the instrument's design and crack formation even when the canals were prepared up to size 40 (24).

Rotstein et al. examined the impact of chloroform, xylene and halothane upon the enamel and the dentin microhardness of human teeth (25). They reported that

Table I: Absolute number and percentage of cracks at different sections.

	3 mm	6 mm	9 mm	Total cracks per group
Eucalyptol	0/0%	3/25%	4/33%^{ab}	7/19%
Chloroform	0/0%	4/33%	3/25%^{a}	7/14%
Orange oil	0/0%	4/33%	5/42%^{ab}	9/25%
Positive Control	0/0%	4/33%	8/67%^{b}	12/33%
Negative Control	0/0%	2/17%	3/25%^{a}	5/19%
***P* value**	**1.0**	**0.859**	**0.041**	**0.343**

Values with the same letters were not statistically different at P = 0.05.
Note that more than one crack per section was possible.

chloroform, xylene, and halothane might generate a significant softening influence on both enamel and dentin. Similarly, Erdemir et al. have investigated the effect of chloroform and halothane on the mineral contents of human root dentin (26). They reported that chloroform led to an increase in magnesium level of the root canal dentin. Further, it was found that gutta percha solvents had an impact on the mineral content of root dentin.

According to the result of the present study, the chloroform group was associated with less dentinal crack formation than the positive control group. It can be speculated that chloroform might have decreased the dentinal microhardness of the root canals and resulted in less stress concentration on dentinal walls during root canal preparation. The softening effect of chloroform on dentin may explain less crack formation in the chloroform group.

According to the result of the present study, there was no significant difference among the orange oil, eucalyptol and positive control groups. Dogan et al. reported that neither eucalyptol nor orange oil was capable of altering the histochemical composition of cut root dentin surfaces (27). This similar features of orange oil and eucalyptol may explain our study's results.

CONCLUSION

The results showed that dentinal crack formation was observed in all groups. Chloroform and negative control groups were associated with less dentinal crack formation than the positive control group at the 9 mm level. There was no significant difference among the negative control, chloroform, eucalyptol and orange oil groups.

Compliance with Ethical Standards

Conflict of Interest: Author Ozsu Kırıcı declares that she has no conflict of interest. Author Karatas declares that he has no conflict of interest. Author Arslan declares that he has no conflict of interest.

Funding: The work was supported by the Department of Endodontics, Faculty of Dentistry, Akdeniz University, Turkey and Department of Endodontics, Faculty of Dentistry, Ataturk University, Erzurum, Turkey

Ethical Approval: This article does not contain any studies with human participants or animals performed by any of the authors.

Informed consent: For this type of this study, formal consent is not required.

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