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Original Article

Effect of citric acid irrigation on the fracture resistance of endodontically treated roots

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ABSTRACT

Objective: The aim of this study was to evaluate the effect of citric acid irrigation on root fracture in different concentrations and at various time exposures on root fracture. **Materials and Methods:** Forty-eight human mandibular incisors with similar dimensions were selected. The specimens were decoronated, then divided into 6 groups as follows: A group without instrumentation and filling (G1) and the 5 other groups with canal preparation and irrigation of distilled water (G2), 10% citric acid for 1 min (G3), 50% citric acid for 1 min (G4), 10% citric acid for 10 min (G5), and 50% citric acid for 10 min (G6). In the experimental groups, the canals were obturated and subjected to the strength test. Statistical analysis was performed using Kruskal-Wallis test ($P = 0.05$). **Results:** G6 showed the highest fracture resistance (629.97 N), and G3 showed the lowest fracture resistance (507.76 N). However, there was no statistically significant difference among the groups. **Conclusions:** The results of this study suggest that use of citric acid is safe in terms of fracture resistance.

Key words: Citric acid, endodontics, fracture resistance, root canal

INTRODUCTION

Chemomechanical preparation of the root canal system is one of the most important steps in root canal treatment.[1] During chemomechanical preparation, cutting dentin by using hand or rotary instruments results in producing considerable quantities of debris and smear layer.[2] Smear layer is composed of organic and inorganic components like vital or necrotic pulp tissue, micro-organisms, saliva, blood cells, and tooth structure.[3]

Irrigation solutions are used for removal of smear layer and also for different purposes like lubrication, removal of debris, and anti-bacterial effects. Among them, sodium hypochlorite (NaOCl) is widely used in root canal treatment and has some advantages like capacity of dissolving organic tissue and anti-microbial properties.[1,2] Due to the fact that NaOCl has an influence upon only organic components of smear layer, it should be used with demineralizing agents, which can remove the inorganic component of smear layer.[3,4]

Ethylenediaminetetraacetic acid (EDTA) was frequently used for removing inorganic component of smear layer.[1] EDTA aids root canal preparation, provides lubrication for root canal instruments, provides less corrosion when used with stainless steel instruments, can used in detection of calcified canal orifices, provides

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less mercury oscillation in amalgamate restoration, and increases bonding strength of adhesive materials to root canal dentin walls.[5-7] Despite of its advantages, Koulaouzidou *et al*.[8] demonstrated that it has severe cytotoxic effects. Segura *et al*.[9] also reported that it results in decalcification in periapical tissues when it is extruded. Another limitation of EDTA is that it can inhibit the bacterial growth, but lower concentrations of EDTA solution has no or a reduced effect.[5,10]

Citric acid, a chelating agent, reacts with metals to form a non-ionic soluble chelate.[11] It has been applied on root surfaces altered by periodontal diseases. Also, it has been proposed for conditioning agent for dental hard tissues.[12] It has good chemical stability,[13] shows anti-microbial effects against the facultative and obligative anaerobes.[11] Use of citric acid was suggested as root canal irrigating solution because of its properties like the removing capacity of the inorganic component of smear layer and decalcification capacity of dentin. When compared with phosphoric acid, polyacrylic acid or lactic acid, it is more effective in smear layer removal.[14] This acidic solution was used in previous studies with different concentrations ranged from 1% to 50%.[15-17]

Vertical root fracture is one of the most serious complications of the root canal treatment. Loss of tissue during instrumentation and pressure during filling process may play an important role in the predisposition of endodontically treated teeth to root fracture.[18,19] Besides, irrigation solutions have an effect on the fracture resistance of endodontically treated teeth.[20] Citric acid is well-established solution in root canal treatments like EDTA. It is as effective as EDTA in removing smear layer. Moreover citric acid solutions could be more effective than EDTA at short periods (30 s).[21] It has been reported that citric acid is more biocompatible and suitable for clinical use than EDTA.[22] There is a perception that the root canal irrigants would weaken the tooth structure predisposing it to fracture.[20] Previously, it was not published whether citric acid has an influence on root fracture resistance or not. There is no data in the literature about the effect of citric acid on the fracture resistance of endodontically treated roots. The aim of this study was to evaluate the effect of citric acid on root fracture concerning different concentrations and different time exposures. The null hypothesis was that the use of citric acid with different concentrations at different time periods would not affect the resistance of the root to fracture.

MATERIALS AND METHODS

The protocol of this study was approved by Research Ethics Committee of Izmir Katip Celebi University (2012.12.3/83). Forty-eight single-rooted, non-carious human mandibular incisors with the similar dimension were used for this study. The teeth were stored in 4°C distilled water until usage. For evaluating the anatomical structures of the teeth, buccolingual and mesiodistal radiographs were provided. Soft tissues and calculus were removed mechanically from the root surfaces with a periodontal scaler. The teeth with internal or external resorption, two or more root canal, and calcifications were discarded. The teeth were examined under a stereomicroscope to discard specimens with cracks and craze lines. To standardize the dimensions of the roots, measurements were performed for each specimen mesiodistally and buccolingually at the 13 mm coronal from the apex using an electronic digital caliper. The specimens presenting a difference of 20% from the mean dimension were discarded. The mean of the buccolingual and mesiodistal root dimensions were 6.98 ± 1.39 mm and 4.81 ± 0.96 mm, respectively. The crowns were separated with a diamond disc under water coolant to obtain a standardized root length of 13 mm.

Before the cleaning and shaping, 8 teeth were chosen randomly as non-instrumented group. A size #10 stainless steel K-file (Dentsply Maillefer, Ballaigues, Switzerland) was inserted into the canal until the file was just visible, and then the length measurement was done. Working lengths were set by deducting 1 mm from these lengths. Root canal shaping procedures were performed with Protaper Universal rotary files (Dentsply Maillefer, Ballaigues, Switzerland). Apical part was prepared to size #30 (F3) in all the specimens. Root canals were irrigated with 2 ml 5% NaOCl (ImidentMedEndosolve-HP, Konya, Turkey) after changing each of the instruments. Thirty-one gauge side port tip irrigators (Ultradent, Utah, USA) were placed at a distance of 1 mm from the working length, and then the tips were moved backwards and forwards.

After the preparations of the root canals, 48 specimens were divided randomly into 6 groups of 8 teeth each.

Group 1 (Negative Control Group): In this group, the specimens were not instrumented

Group 2 (Positive Control Group): The specimens were prepared and irrigated with 15 mL distilled water.

In the experimental groups, the canals were prepared and irrigated with one of the following solutions, then with 5 mL 5% NaOCl for 120 s followed by final rinse with 5 mL distilled water.

Group 3: 1 min with 5 mL 10% citric acid (pH = 1.8)
Group 4: 1 min with 5 mL 50% citric acid (pH = 1.6)
Group 5: 10 min with 5 mL 10% citric acid
Group 6: 10 min with 5 mL 50% citric acid.

The specimens were dried with paper points and filled with gutta-percha and AH Plus sealer® (Dentsply DeTrey, Kontanz, Germany) using cold lateral compaction technique. The root surfaces were covered with 0.3-mm-thick wax 8 mm below the coronal margin to simulate the biologic width. The specimens were then embedded in auto polymerizing acrylic resin surrounded by a cylindrical-shaped plastic mold, with the long axis of the tooth parallel to that of the cylinder. After the first signs of polymerization, the teeth were removed from the resin blocks, and the wax on the root surfaces was removed using a hand instrument. Light-body silicone-based impression material was injected into the resin base, and the teeth were re-inserted into the resin base. Thus, the standardized silicone layer that simulated the periodontal ligament was created.

All the roots were mounted vertically in Copper rings, which were filled with acrylic resin (Imicryl, Konya, Turkey) with exposing the 8 mm of the coronal part. A universal testing machine (Instron Corp., Canton, USA) was used for the strength test. The upper plate included a steel spherical tip with a diameter of 4 mm. The tip contacted a slowly increasing vertical force (1 mm/1 min) until fracture occurred. When the fracture occurred, the force was recorded in Newtons [Figure 1]. Statistical analysis was carried out using Kruskal–Wallis at 95% confidence interval ($P = 0.05$). All statistical analyses were performed using the SPSS software (SPSS Inc., Chicago, USA).

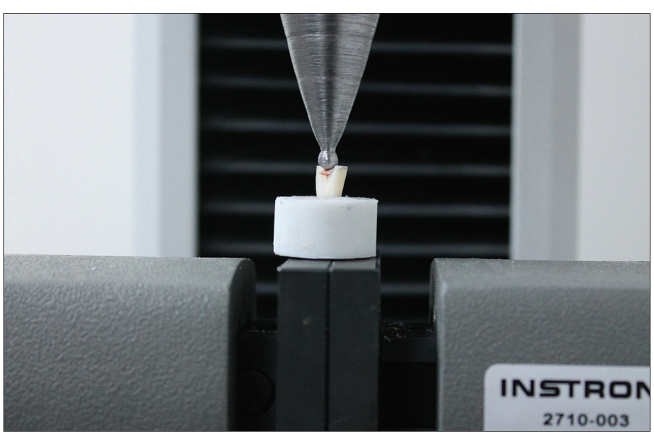

Figure 1: Shows specimen when the fracture occurred

RESULTS

The mean and standard deviations of the fracture resistance data for control groups (G1, G2) and citric acid-treated groups (G3, G4, G5, G6) are shown in Figure 2 and were as follows, respectively; 548.34 ± 90.01, 509.47 ± 67.31, 507.76 ± 207.7, 551.97 ± 180.87, 629.97 ± 192.27, and 627.86 ± 204.28. Increases or reductions in fracture resistance values were not statistically significant for citric acid-treated groups when compared with control groups ($P = 0.382$) [Figure 2].

DISCUSSION

The null hypothesis was that the use of citric acid concentrations at different time periods would not affect the risk for root fracture because the exposure of citric acid to the dentin could be detrimental for peritubular dentin. But, this study showed that the irrigation of root canals with citric acid irrigation did not weaken the endodontically treated root. The erosion of dentinal tubules is a factor, which could lead to weakness of dentinal structure.[23] Scelza *et al*.[22] evaluated the effect of citric acid and the other chelating agents on smear layer removal. They demonstrated that citric acid did not cause dentinal erosion, and so, it was mentioned that citric acid could not weaken the root dentin. In this study, it has been demonstrated that citric acid does not weakened the root dentin.

The increased adhesion between root canal sealers and root dentin could be an important factor to provide strengthened tooth.[24] Because of gutta-percha does not directly bond to dentin surface, a sealer should be used.[24] Because of its good adhesion capability to dentin and gutta-percha, AH Plus was used in this study.[25] Fisher *et al*.[25] used sealers for evaluating their bond strength to the smear-free root dentin and found that AH Plus sealer had significantly higher bond strength compared with the others. Eldeniz *et al*.[26] evaluated the effect of EDTA and citric acid solutions on root dentin roughness. They indicated that compared with EDTA, citric acid increased surface roughness. This could be beneficial because of micromechanical bonding of endodontic sealers to the root canal irregularities. In the present study, however, there was not statistically significant difference; increased fracture resistance was observed in some of the groups treated with citric acid.

The change in microhardness could be a relevant factor in fracture resistance.[27] De-Deus *et al*.[28] revealed that

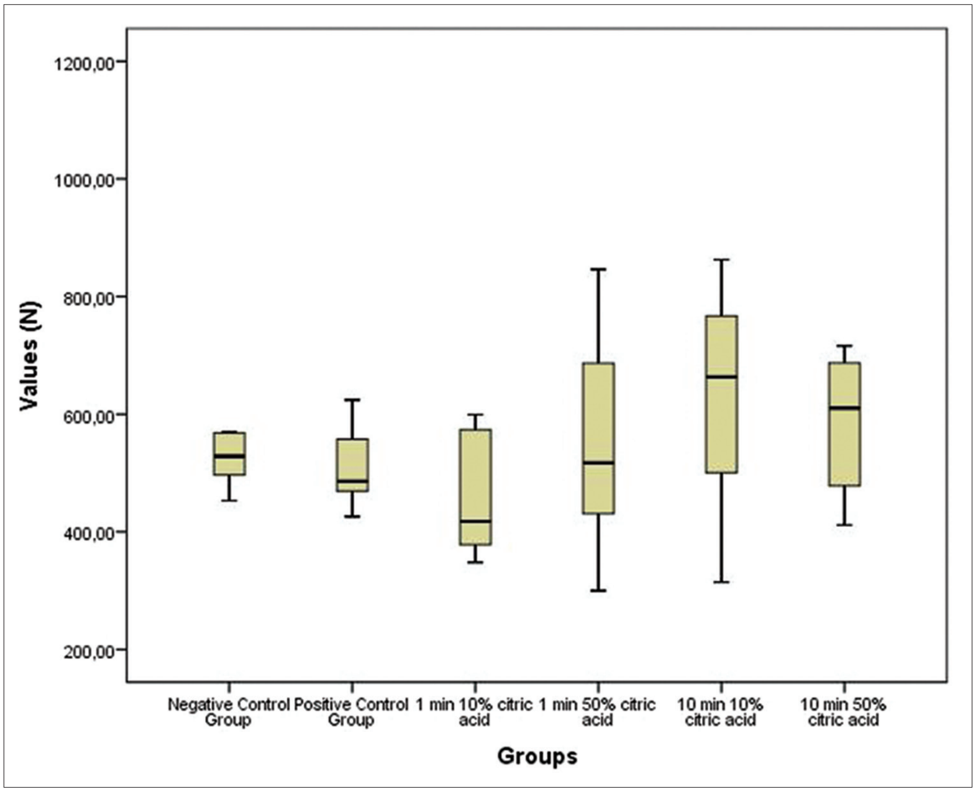

Figure 2: Graph showing the median values according to the groups. There were not statistically significant differences among the groups

citric acid have the least effect on microhardness when compared with EDTA and EDTAC. However, it was negotiated that the exposure time of citric acid to dentin should be limited.[13] If citric acid roughens the dentin effectively and a sealer is used, which has high bond strength to dentin, the fracture resistance of root might not change.

In this study, the controllable factors like diameter and the length of the specimens were standardized as much as possible. However, the standard deviations within the groups were rather high. But, in the previous studies, this is not unusual because of the variations in the strength and hardness of the teeth (inherent weakness), and remaining dentin thickness.[29-31] In the present study, the specimens were measured mesiodistally and buccolingually at the same height (13 mm coronal from the apex), and the specimens presenting a difference of 20% from the mean dimension were discarded. This method was well-established in the literature.[20,30]

Topcuoglu *et al*.[30] evaluated the effect of different filling techniques on the fracture resistance of endodontically treated teeth. They demonstrated that non-instrumented group had higher fracture resistance than prepared and filled group. Karapınar *et al*.[32] evaluated the effect of different canal fillings systems on the fracture resistance. They observed that negative control group (non-instrumented) had higher fracture resistance than positive control group. Unlike in this study, as it was stated in the results, there was no significant difference between the groups, and it was different with the mentioned studies.

Mandibular incisors are generally the smallest teeth in the adult dentition, with relatively small thicknesses of enamel and dentin.[33] The roots of these teeth are more prone to fracture because root cross-sections are usually ovoid in shape.[34] In the present study, mandibular incisors were used for evaluating the effect of citric acid on the fracture resistance because of their weak structure.

We aimed to study the effect of changes in concentration and time period of citric acid on the fracture resistance. Therefore, we used this solution in very high concentration (50%) and at long exposure time (10 min). This experimental protocol is not clinically applicable and was designed for only investigating its effect.

CONCLUSIONS

The null hypothesis was accepted. Within the limitations of this study, it could be concluded that the use of citric acid concentrations at different time periods did not significantly changed the fracture resistance of endodontically treated roots. This property of citric acid could provide benefit in root canal treatment.

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