

Effect of Different Irrigation Solutions on the Fracture Resistance of Endodontically Teeth

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Abstract

Objective: The aim of this study was to assess the effect of three root canal irrigation solutions on the fracture resistance of endodontically treated teeth with three root canal obturation materials.

Materials and Methods: A total of 90 teeth with single straight root canals were randomly divided into three equal groups (n = 30) according to the irrigation solution (citric acid, chlorhexidine, and MTAD 2%). Each group was subdivided into three subgroups (n = 10) according to the root canal obturation materials (Gutta-percha with AH plus or MM-seal, Resilon with Epiphany SE). The crowns of the teeth were removed at the cemento-enamel junction with a diamond disc under water coolant. For each group, the root canals were prepared using step-back technique and one of the tested irrigation solutions. For each subgroup, the roots were obturated with lateral condensation technique using one of the used obturation materials and subjected to the strength test. Statistical analysis was performed using Kruskal-Wallis. The level of significance was set at (P = 0.05).

Result: Resilon with Epiphany SE with citric acid irrigation showed the highest fracture resistance (629.97 N), while Gutta-percha with AH plus with chlorhexidine irrigation showed the lowest fracture resistance (507.085 N).

Conclusions: The results of this study suggest that use of citric acid is safe in terms of fracture resistance.

Keywords: Irrigation; Fracture Resistance; Gutta Percha; Citric Acid; Chlorhexidine

Introduction

Endodontic therapy seeks the elimination of bacteria and its products from the root canal. Intracanal medications to disinfect the root canal system have been advocated to increase the success of the treatment [1]. Studies have suggested NaOCl and chlorhexidine as irrigation solutions [2-4]. However, MTAD is a recently developed irrigating solution that consists of tetracycline, acetic acid and detergent [5]. It has antimicrobial effect and appears to be effective for removing smear layer along the entire length of the prepared root canal [5,6]. It is able to remove both organic and inorganic debris [7].

Citric acid, a chelating agent, reacts with metals to form a non-ionic soluble chelate [8]. It has been applied on root surfaces altered by periodontal diseases. Also, it has been proposed as conditioning agent for dental hard tissues [9]. It has good chemical stability [10], and shows anti-microbial effects against the facultative and obligatory anaerobes [8]. Use of citric acid was suggested as root canal irrigating

solution as it has the ability to remove the inorganic component of smear layer and decalcifying dentin. When compared with phosphoric acid, polyacrylic acid or lactic acid, it is more effective in smear layer removal [11]. It has been with different concentrations ranged from 1% to 50% [12-14].

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 are predisposing factors that may ultimately lead to root fracture of endodontically treated teeth [15,16]. Another factor that may play a role in root fracture of endodontically treated teeth is the irrigation solution [17].

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 (30s) [18]. It has been reported that citric acid is more biocompatible and suitable for clinical use than EDTA [19]. There is a perception that the root canal irrigants would weaken the tooth structure predisposing it to fracture [17]. 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.

Aim of the Study

The aim of this study was to assess the effect of three root canal irrigation solutions on the fracture resistance of three root canal obturation materials: gutta-percha/AH plus or MM-seal and Resilon/Epiphany SE.

Materials and Methods

Ninety 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.

The canal lengths were visually established by placing a size 15 K file (Kerr, Romulus, MI, USA) into each root canal until the tip of the file was visible at the tip of the apical foramen. The working length was established 1 mm short of the apex. The canal systems were instrumented to the working length with a size 45 K file by using a step-back technique and irrigated with either 2% citric acid (Wizard, Rehber Chemistry, Istanbul, Turkey), 2% chlorhexidine (Klorhex, Drogosan, Ankara, Turkey), or MTAD (Dentsply, Washington, USA) solutions. Finally, the root canals were flushed with 5 ml of 17% EDTA (Canal +, Septodont, France) for 1 minute and 2 ml of saline solution and then dried with paper points. After the preparations of the root canals, specimens were divided randomly into 3 groups as shown in table 1.

Irrigation solution	Root canal obturation materials		
	Gutta-percha/AH plus	Gutta-percha/MM-seal	Resilon/Epiphany SE
2% citric acid	Group 1 (G1)	Group 4 (G4)	Group 7 (G7)
2% chlorhexidine	Group 2 (G2)	Group 5 (G5)	Group 8 (G8)
2% MTAD	Group 3 (G3)	Group 6 (G6)	Group 9 (G9)

Table 1: Specimen grouping of root canal obturation materials with irrigation solution.

Roots were filled using the lateral condensation technique with gutta-percha/AH plus sealer® (Dentsply DeTrey, Kontanz, Germany), gutta-percha/MM-seal (Dentsply DeTrey, Kontanz, Germany) and Resilon/Epiphany SE (Resilon Research LLC, Madison, CT, USA; Epiphany sealer - Pentron Clinical Technologies, Wallingford, CT, USA). For the Epiphany SE, light curing was applied for 40 seconds with a standard light-curing unit (Hilux, Ledmax-550, Benlioglu, Turkey), according to the manufacturer’s instructions.

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. 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).

Results and Discussion

The mean and standard deviations of the fracture resistance data for tested groups are shown in table 2 and figure 1. The results showed that the highest fracture resistance was observed in group 7 (629.97), while the least fracture resistance was recorded for group 3 (507.085). Increases or reductions in fracture resistance values were not statistically significant when compared all groups (P = 0.394).

Irrigation solution	Fracture resistance (N)			P-value
	Gutta-percha/AH plus	Gutta-percha/MM-seal	Resilon/Epiphany SE	
	Mean ± S.D	Mean ± S.D	Mean ± S.D	
2% citric acid	591.555 ± 128.816 (G1)	548.34 ± 90.01 (G4)	629.97 ± 192.27 (G7)	0.394
2% chlorhexidine	553.066 ± 68.97 (G2)	509.47 ± 67.31 (G5)	627.86 ± 204.28 (G8)	
2% MTAD	507.085 (G3)	531.76 ± 207.7 (G6)	611.58± 136.74 (G9)	

Table 2: Mean and standard deviations of the fracture resistance of all tested groups

*: Significant at P ≤ 0.05.

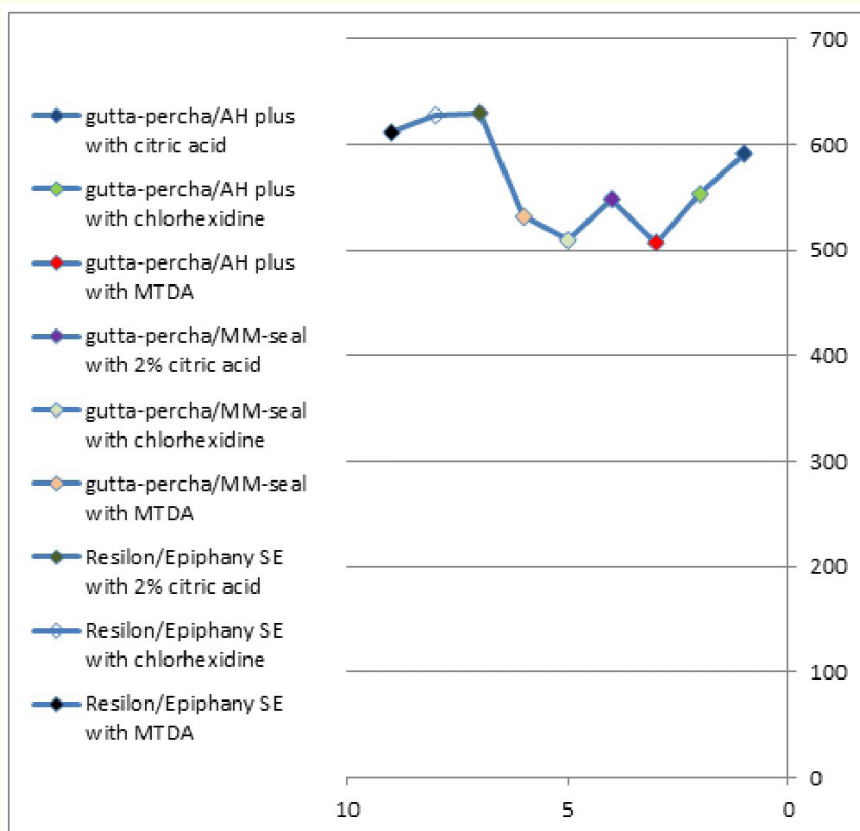


Figure 1: Line of fracture resistance of all tested groups.

Endodontic treatment employs an aseptic technique during which the infected root canal is disinfected using a combination of mechanical and chemical procedures. A chemomechanical approach to disinfection of root canals has been adopted in modern endodontics [20].

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 [21]. 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 weaken the root dentin. The chlorhexidine use as an endodontic irrigant [23]. Compared to CHX groups, the NaOCl and MTAD solutions seem to create a more favorable surface for the root canal filling materials to achieve a better apical seal. On the contrary, this outcome may be attributed to the fact that the CHX solutions do not have the ability to dissolve organic tissues from the root canal system.

As previously mentioned, an ideal root canal filling material should be able to reinforce and strengthen a weakened root structure against fracture in addition to sealing the canal [24].

The results of the present study demonstrated that root canal obturated with Resilon resulted in higher resistance to fracture when compared with the roots obturated with a gutta percha. Resilon/Epiphany system provides a new obturation material for endodontic treatment. This system creates a chemical bond with root canal structure that is maintained over time; therefore, representing a better option than gutta-percha [25-27]. Resilon is a synthetic polymer, and thus, resin sealer attaches to it as well as to bonding agent or primer. Furthermore, primer penetrates easily into dentinal tubules. In so doing, a monoblock is formed (consisting of Resilon core material, resin sealer, bonding agent/primer and dentin) [28,29].

Although gutta percha has been the standard obturating material used in root canal treatment, but it does not reinforce endodontically treated roots owing to its inability to achieve an impervious seal along the dentinal walls of the root canal as stated by Aptekar, *et al.* [25] Gutta percha does not show increased resistance to internally generated stresses in root canal because it does not chemically bond to the dentin wall i.e. does not form the monoblock system. Mandibular incisors are generally the smallest teeth in the adult dentition, with relatively small thicknesses of enamel and dentin [30]. The roots of these teeth are more prone to fracture because root cross-sections are usually ovoid in shape [31]. In the present study, mandibular incisors were used for evaluating the effect of citric acid on the fracture resistance because of their weak structure.

Conclusion

Within the limitations of this study, it could be concluded that the use of citric acid did not significantly changed the fracture resistance of endodontically treated roots. This property of citric acid could provide benefit in root canal treatment.

Conflict of Interest

The authors declare there is no conflict of interest.

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