A comparative evaluation of the effect of 8% and 17% ethylenediaminetetraacetic acid exposure for 1 min and 10 min on the fracture resistance of endodontically treated roots: An in vitro study

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Abstract

Objective: The objective of this study was to evaluate the effect of 8% and 17% ethylenediaminetetraacetic acid (EDTA) exposure for 1 min and 10 min on the fracture resistance of endodontically treated roots.

Methodology: Sixty human single-rooted teeth were decoronated and divided into six groups (n = 10). Canal preparation was carried out except in negative control group, using the ProTaper rotary file system. Final irrigation was performed using distilled water, 17% EDTA for 1 min and 10 min, 8% EDTA for 1 min and 10 min. Thereafter, roots were obturated with ProTaper F3 Gutta-percha points and AH Plus sealer using a single-cone technique. The specimens were loaded vertically at 1 mm/min crosshead speed until vertical root fracture occurred. Results were evaluated statistically with one-way analysis of variance and post hoc Tukey test.

Results: Analysis of results showed that the unprepared roots showed the highest fracture resistance and roots irrigated with 17% EDTA for 10 min showed the lowest fracture resistance. The mean fracture resistance of unprepared roots, roots irrigated with 8% EDTA for 10 min and 17% EDTA for 1 min was significantly higher than roots irrigated with 8% EDTA for 1 min, 17% EDTA for 10 min and distilled water.

Conclusion: From a clinical viewpoint, if EDTA has to be used, it is safer to use higher concentration for a shorter application time or a low concentration with a longer application time. Prolonged use of high concentrations of EDTA might increase the risk of root fracture.

Keywords: Ethylenediaminetetraacetic acid; final irrigation; fracture resistance

INTRODUCTION

The success of root canal treatment depends on proper technique and the quality of instrumentation, irrigation, disinfection, and three-dimensional obturation of the root canal system. Mechanical instrumentation of the root canal either using hand or rotary instruments produces a layer of debris on the root canal walls called the smear layer. This amorphous irregular layer contains both organic and inorganic components like vital or necrotic pulp tissue, odontoblastic process, microorganisms, and dentin chips. It is generally recommended that this smear layer be removed, as it harbors bacteria, covers the prepared canal.
walls, occludes the orifices of the dentinal tubules and limits effective action of irrigants and intracanal medicaments.\(^6\)

Several methods have been recommended for removal of smear layer such as ultrasonic instruments, lasers, and chelating agents such as ethylenediaminetetraacetic acid (EDTA), citric acid, phosphoric acid, polyacrylic acid, and lactic acid.\(^4\) EDTA is the most commonly used chelating agent.\(^4\) It demineralizes the inorganic components of smear layer via calcium chelation.\(^7\) EDTA reacts with calcium ions in hydroxyapatite crystals and removes them from the dentin by forming stable water soluble complexes.\(^8\)

However, this process can cause changes in the microstructure of the dentin and calcium to phosphorus ratio.\(^5,9,10\) Change in mineral content ratio may alter the original proportion of organic and inorganic components of the dentin.\(^5\) This can result in a reduction of modulus of elasticity and flexure strength and can have a deleterious effect on the microhardness and the fracture resistance of teeth.\(^1,11\)

Hence, the present study was undertaken to evaluate the effect of 8% and 17% EDTA exposure for 1 min and 10 min on the fracture resistance of endodontically treated roots.

**MATERIALS AND METHODS**

**Sample selection**

Sixty human single-rooted teeth extracted for periodontal or orthodontic purpose were employed in the study. Teeth were stored in normal saline until further preparation.

**Teeth preparation**

The crown of each tooth was sectioned perpendicular to the long axis of the root below the cementoenamel junction using a diamond disc (Horico, Germany) under a water coolant so that the length of root was adjusted to 13 mm. The working length of each root was determined by inserting #10 K-file (Mani, Japan) until it just exited the apical foramen and then 1 mm was subtracted from the obtained length.

**Canal preparation technique**

The root canals were prepared with the ProTaper (Dentsply, Maillefer, Switzerland) rotary file system till size F3 according to manufacturer’s instructions in a crown down manner. During biomechanical preparation, the canals were irrigated with 2 ml of 1% sodium hypochlorite solution after each instrument change. This procedure was followed by irrigation with saline solution.

**Final irrigation**

The final irrigating solutions were delivered through 27-gauge needles within 2 mm of the working length.

Specimens were divided into following groups according to the final irrigation procedure:

- **Group I:** No biomechanical preparation and no obturation
- **Group II:** 10 ml of distilled water for 10 min
- **Group III:** 10 ml of 17% EDTA for 1 min followed by 10 ml of 1% NaOCl for 1 min
- **Group IV:** 10 ml of 8% EDTA for 1 min followed by 10 ml of 1% NaOCl for 1 min
- **Group V:** 10 ml of 17% EDTA for 10 min followed by 10 ml of 1% NaOCl for 1 min
- **Group VI:** 10 ml of 8% EDTA for 10 min followed by 10 ml of 1% NaOCl for 1 min

**Obturation**

Roots were obturated with ProTaper F3 Gutta-percha points, and AH Plus (Dentsply DeTrey, Konstanz, Germany) root canal sealer using a single-cone technique. Excess coronal Gutta-percha was removed with a ball burnisher 1 mm below canal opening and sealed with Coltrosol F. Specimens were stored in an incubator at 37°C and 100% humidity for 7 days to allow the sealer to set completely.

**Fracture resistance testing**

Specimens from all groups were prepared for test assembly. The apical 5 mm of roots were embedded along the long axis in self-curing acrylic blocks with 8 mm of each root exposed. Fracture resistance of the specimen was tested using a Universal Testing Machine (Lloyd, LR50K, UK). A custom made stainless steel loading indenter with a round tip (r = 2 mm) was used to deliver force directed along the long axis of the tooth. The load increased at the rate of 1 mm/min until fracture occurred. The fracture was evidenced by an audible crack and/or a sudden drop in load as seen on the graph. The force necessary to fracture each root was recorded in Newtons (N). The peak load to fracture the samples was recorded.

**Statistical analyses**

The data were then analyzed statistically using one-way analysis of variance and post hoc Tukey test.

**RESULTS**

Statistically significant results were obtained. The mean fracture resistance and standard deviation for all groups were computed. The descriptive statistics are summarized in Table 1.

Highest mean fracture resistance was recorded in the unprepared roots group, i.e., Group I (829.43 N) and the lowest mean fracture resistance was recorded in 17% EDTA 10 min group, i.e., Group V (495.46 N). The difference in mean fracture resistance between the groups was found to be statistically significant (\(P < 0.001\)).
Pair-wise comparisons [Table 2] showed that the mean fracture resistance of unprepared roots and roots irrigated with 17% EDTA for 1 min and 8% EDTA for 10 min (i.e., Groups I, III, and VI) were significantly higher than the roots irrigated with distilled water, 8% EDTA for 1 min and 17% EDTA for 10 min (i.e., Groups II, IV, and V, respectively).

However, no statistically significant differences were found in the mean fracture resistance of Groups I, III, and VI that is the unprepared roots and roots irrigated with 17% EDTA for 1 min and 8% EDTA for 10 min ($P > 0.05$).

At the same time, no statistically significant differences were found among Groups II, IV, and V that is when the roots irrigated with distilled water, 8% EDTA for 1 min and 17% EDTA for 10 min ($P > 0.05$).

**DISCUSSION**

Current concepts of chemomechanical preparation suggest that chelating agents should be applied on instrumented root canal surfaces to remove the inorganic components of the smear layer.$^{[1,2]}$ EDTA is widely used as a chelating agent during endodontic treatments. Studies have shown that 17% EDTA is more efficient in smear layer removal than other decalcifying agents.$^{[3]}$ For removal of both organic and inorganic components of the smear layer, it is generally recommended to use EDTA followed by NaOCl.$^{[4,12]}$

Single-rooted teeth with similar dimensions were used in the study to standardize the experimental teeth. Length differences were compensated for by decoronating the teeth to a standardized root length of 13 mm.

Biomechanical preparation was performed with ProTaper rotary files in a crown down manner as this technique allows for adequate cleaning and penetration of irrigant to the apical third of the root canal. One percent sodium hypochlorite was selected for its antimicrobial and tissue dissolving property. Furthermore, at this low concentration, it has minimal effect on the mechanical properties of dentin.$^{[7]}$ Single cone technique of obturation was used in the study as it excluded both the wedging forces of the spreaders during lateral compaction and the excessive dentin removal required to facilitate the plunger’s insertion during vertical compaction.$^{[13]}$

A custom made stainless steel fixture with circular tip of radius 2 mm was used to apply a compressive force in a vertical direction at the rate of 1 mm/min. Studies have reported that applying the force vertically to the long axis of the tooth transmits the force uniformly.$^{[11]}$ Therefore, in the present study, a single load to fracture was applied vertically to evaluate the fracture resistance of endodontically treated roots.

EDTA has been used at various concentrations and exposure times in root canal treatment. Hülsmann et al.$^{[14]}$ reported that the optimum working time for EDTA is 10 min. In contrast, Meryon et al.$^{[15]}$ reported that the smear layer was completely removed with 10% EDTA for 1 min, resulting in increased tubular orifice size. Perez and Rouqueyr-Pourcel$^{[16]}$ reported that 3 min 8% EDTA irrigation was as effective as 1 min 15% EDTA irrigation without producing erosive lesions. Hence, in this study, we have used 8% and 17% EDTA with an exposure time of 1 min and 10 min.

Analyses of results showed that unprepared roots (Group I) showed the highest fracture resistance while the roots that were irrigated with 17% EDTA for 10 min (Group V) showed the lowest resistance to fracture. Among the test groups, the roots irrigated with 8% EDTA for 10 min (Group VI) demonstrated highest fracture resistance followed by those irrigated with 17% EDTA for 1 min (Group III), 8% EDTA for 10 min (Group IV), and lastly those irrigated with 17% EDTA for 10 min (Group V).

These results are in accordance with a study by Uzunoglu et al.$^{[11]}$ who reported that the roots irrigated with 5% EDTA for 10 min had fracture resistance two times that of 17% EDTA for 10 min, 17% EDTA for 1 min had fracture resistance similar to that of untreated teeth and 17% EDTA for 10 min had least fracture resistance.

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**Table 1: Mean fracture resistance among groups**

| Group | n* | Mean | SD** | Minimum | Maximum | F     | P      |
|-------|----|------|------|---------|---------|-------|--------|
| I     | 10 | 829.43 | 170.147 | 639.9  | 1155.0 | 11.275 | <0.001 |
| II    | 10 | 526.40 | 101.441 | 425.8  | 789.6  | 506.9  | 1112.0 |
| III   | 10 | 740.03 | 222.568 | 506.9  | 1112.0 | 506.9  | 1112.0 |
| IV    | 10 | 555.14 | 108.232 | 426.3  | 753.3  | 426.3  | 753.3  |
| V     | 10 | 495.46 | 68.866  | 393.2  | 589.9  | 393.2  | 589.9  |
| VI    | 10 | 806.93 | 120.209 | 678.3  | 1000.0 | 678.3  | 1000.0 |

*Sample size, **SD: Standard deviation

**Table 2: Post hoc Turkey test for pair-wise comparison among groups**

| Comparison between | Mean difference | P     |
|--------------------|-----------------|-------|
| Group I            |                 |       |
| Group II           | 303.03          | <0.001|
| Group III          | 89.40           | 0.718 |
| Group IV           | 274.79          | 0.001 |
| Group V            | 333.97          | <0.001|
| Group VI           | 22.50           | 0.999 |
| Group II           |                 |       |
| Group III          | -213.63         | 0.016 |
| Group IV           | -28.74          | 0.997 |
| Group V            | 30.94           | 0.996 |
| Group VI           | -280.53         | 0.001 |
| Group III          |                 |       |
| Group IV           | 184.89          | 0.054 |
| Group V            | 244.57          | 0.004 |
| Group VI           | -66.90          | 0.895 |
| Group IV           |                 |       |
| Group V            | 59.68           | 0.933 |
| Group VI           | -251.79         | 0.003 |
| Group VI           | -311.47         | <0.001|
De-Deus et al. indicated that 3 min application of 17% EDTA decreased dentin microhardness more than its 1 min application. Similarly, Cruz-Filho et al. also observed decrease in microhardness after irrigation with 15% EDTA for 5 min. EDTA’s ability to dissolve the intertubular and peritubular dentin can result in a decrease in both microhardness and fracture resistance. Hence, we compared the results of our study to microhardness studies and found them to be in accordance.

From the results of our study, it was also observed that the mean force required to fracture roots irrigated with 8% EDTA for 10 min (Group VI) was in the same range as that required to fracture unprepared roots (Group I) (P > 0.05). This could be because EDTA removed smear layer effectively without an erosive effect and not compromising the physical and mechanical properties of the tooth significantly. Furthermore, optimum smear layer removal enhanced the sealing ability and bond strength of resin-based root canal sealers to dentin and thereby probably increasing the fracture resistance.

A 10-min irrigation of 17% EDTA resulted in the lowest fracture resistance values. A possible explanation for this is that long-term exposure of 17% EDTA can result in dissolution of peritubular and intertubular dentin, resulting in decreased modulus of elasticity and flexure strength. This in turn will reduce the microhardness and resistance to fracture.

The present experiment emphasizes the deleterious effects that can be seen on the root canal dentin by the long-term exposure to 17% EDTA. Consequently, the results obtained from the present study support the hypothesis that prolonged use of higher concentrations of EDTA might increase the risk for root fracture.

Overall, the results of our study suggest that extensive use of 17% EDTA jeopardizes the integrity of the tooth by weakening the root making it more susceptible to vertical root fracture. On the other hand, using lower concentration of EDTA with longer application time and higher concentration of EDTA with shorter application time can minimize the adverse effects. Therefore, we can conclude that the concentration and application time of EDTA has a major role to play in the fracture resistance of roots.

CONCLUSION

The following conclusions can be drawn from this study:

1. The fracture resistance of roots irrigated with 8% EDTA for 10 min was similar to that of intact roots
2. Roots irrigated with 17% EDTA for 1 min had slightly lower fracture resistance than unprepared roots
3. Irrigation with 17% EDTA for 10 min resulted in lowest fracture resistance when compared to other groups
4. Based on the results of our study, it can be recommended that when EDTA is used at a higher concentration, a shorter exposure time is safer and when it is used at a lower concentration, a longer exposure time is preferred to reduce the root fracture susceptibility.

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Conflicts of interest
There are no conflicts of interest.

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