

ORIGINAL RESEARCH



Impact of Various Irrigating Agents on Root Fracture: An *in vitro* Study

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ABSTRACT

Introduction: Irrigating solutions are used for cleaning and removing dentinal debris, and the other remains from pulpal space during biomechanical preparation. Therefore, we evaluated the impact of various irrigating agents on root fracture at 5-minute time exposure.

Materials and methods: We sectioned 60 permanent maxillary premolars with fully formed root structures transversely maintaining the root length of approximately 14 mm. Five study groups were made comprising ethylenediaminetetraacetic acid (EDTA), cetrimide, citric acid, and so on as various irrigating agents. A universal force test machine was used to calculate the force which was enough to fracture each root. Analysis of variance (ANOVA) test was used to access the level of significance.

Results: About 10% citric acid solution as an irrigating agent showed minimal fracture opposing results, whereas 10% EDTA solution showed the maximum fracture resistance of root portion.

Clinical significance: Selection of suitable EDTA concentration that has minimal adverse effect on the mechanical properties of the tooth is very important for the successful management of tooth fracture.

Conclusion: About 10% EDTA provided the highest fracture resistance, necessitating the use of irrigating solution in root canal therapy (RCT). Further research with higher and different study groups is required to search for more efficient irrigating solution to improve the outcome of RCT.

Keywords: Ethylenediaminetetraacetic acid, Fracture, Irrigating agents.

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INTRODUCTION

One of the common reasons for the failure of root canal therapy (RCT) is the persistence of infection within the apical part of the canals treated with RCT. The complex anatomical shape of the root canal prohibits complete removal of microorganisms by routine instrumentation procedures.¹ Irrigation plays a very crucial role in counteracting this problem. Sodium hypochlorite (NaOCl) is the most frequently used irrigating solution, but it also has certain limitations of causing cytotoxicity, corrosion of instruments, and so on.^{2,3} Another commonly used irrigating agent is ethylenediaminetetraacetic acid (EDTA), which dissolves the inorganic component.⁴ Ethylenediaminetetraacetic acid also provides additional advantages, such as helping in RCT procedures, ease of access for root canal armamentarium, and minimal or reduced corroding activities for instruments. In addition, it is also useful in preparing teeth with calcified canals.⁵ It offers numerous additional positive effects acting as an antibacterial agent because of its effectiveness against viable bacteria. Being chemically stable, its longevity is high.⁵⁻⁷ Citric acid is also additionally added as an irrigating agent because it completely removes the remaining inorganic components of the root canal materials and smear layer. Also, it decalcifies the carious part of root dentin.⁷ Citric acid has been implicated in previous research works on irrigating effects of different solutions in varying concentrations.⁸⁻¹⁰ Because of weakening of tooth structure due to carious process, the risk of root fracture during instrumentation process is increased.^{11,12} This increases the search for irrigating agents, which has

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a positive effect on increasing the fracture resistance of the tooth undergoing or undergone with RCT procedures. Thus, the aim of the study was to access the impact of different irrigating agents on tooth fracture, root portion at 5 minutes time exposure.

MATERIALS AND METHODS

The study group included 60 permanent maxillary premolars whose root structures were fully formed. Immediately after extraction, the teeth were cleaned and stored in normal saline at room temperature (according to the Occupational Safety and Health Administration guidelines). Roots of all the specimens were sectioned transversely by maintaining the length of the root to approximately 14 mm. Visual analysis of all the teeth was done to ensure the absence of tooth structural defects, such as cracks, and this was done with the help of fiberoptic light. A standard root canal procedure was initiated on the specimen starting with measuring of the root canal length, which was kept 1 mm short. Biomechanical preparation was done up to file size no. 15. Sodium hypochlorite with a concentration of approximately 2% was used as an irrigating agent during the biomechanical procedure. The samples were divided into five experimental groups, with 12 teeth each (Table 1).

Universal force testing machine (Fig. 1) was used to calculate the fracture strength by applying fracture test

on the teeth embedded in their apical-most part along their long axis.

Statistical test used for the analysis of the result was one-way analysis of variance (ANOVA) test.

RESULTS

One-way ANOVA: The mean maximum compressive load of control group was 612.91 ± 8.26 , 10% EDTA was 540.08 ± 9.82 , 17% EDTA was 375.83 ± 31.11 , Largal Ultra was 461.08 ± 2704 , and citric acid was 326.83 ± 13.36 . By using one-way ANOVA, a statistically significant variation was found in the maximum compressive load in five groups ($F=400.52$, $p=0.000$).

The fracture resistance values (N) are presented in Table 2 as mean and standard deviation. Statistically significant differences were detected among the groups by using one-way ANOVA ($p<0.05$). The highest mean fracture resistance was obtained from the group treated with 10% EDTA for 5 minutes. This is about twice more than the weakest mean fracture resistance, which was obtained from the 10% citric acid 5 minute group. In addition, the fracture resistance of root canal dentin irrigated with 17% EDTA for 5 minutes was statistically lower compared with positive control (saline water).

DISCUSSION

During RCT, instrumentation can create a smear layer containing microorganisms, their by-products creating obstacles in the treatment procedure by blocking the dentinal tubules.^{13,14} Therefore, complete removal of this smear layer causes penetration of root canal filling materials and medicaments into the dentinal tubules.^{13,15} The main process that helps to remove this smear layer and other dentinal debris is irrigation.¹⁶ Various irrigating solutions may cause structural change in the dentin, thereby altering its solubility and permeability characteristics, and helping in RCT procedure.¹⁷ Hence, we estimated the effect of root fracture strength of different irrigating solutions. Our results showed that the group containing normal saline had the highest fracture resistance compared with other groups. Among all other study groups, the group containing 10% EDTA had the maximum fracture resistance strength ($n=540.08$), whereas the group

Table 1: List of groups

Sl. no	Groups	Number of samples	Placement technique
1	I	12	10 mL irrigation with saline
2	II	12	10 mL of 10% EDTA
3	III	12	10 mL of 15% EDTA + cetrimide 0.75%
4	IV	12	10 mL of 17% EDTA
5	V	12	10 mL of citric acid 10.5% + cetrimide 0.2% + 1% doxycycline hyclate + polypropylene glycol

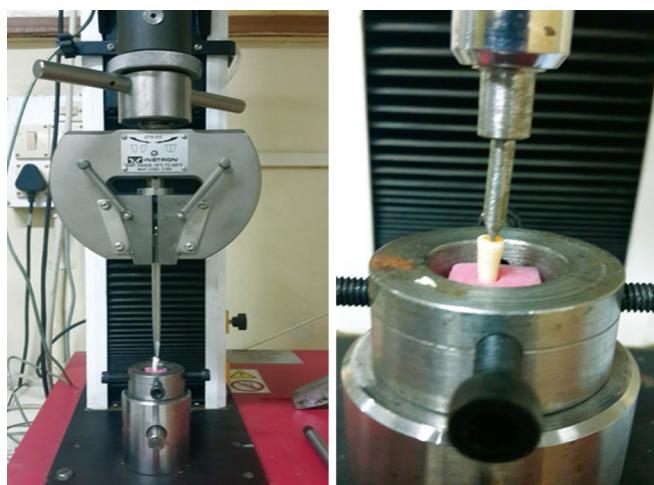
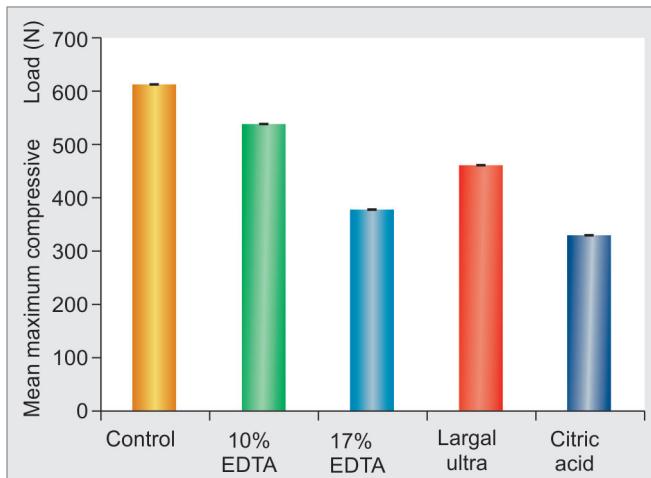


Fig. 1: Samples mounted on universal testing machine

Table 2: Fracture strength in all the groups

Groups	Maximum compressive load (N)	Maximum compressive strain (%)	Maximum compressive stress (MPa)
I	605.59	12.85	16.60
II	542.51	33.95	14.87
III	394.06	17.85	10.80
IV	324.50	13.50	8.90
V	480.95	13.10	13.18



Graph 1: Comparison of maximum compressive Load (N) of control group with four groups

containing citric acid had the minimal fracture resistance strength ($n=326.83$) (Graph 1). Cruz-Filho et al¹⁸ also reported that EDTA solutions at varying concentrations significantly reduce the dentin hardness compared with distilled water.

In a research carried by Zehnder et al,¹⁹ results showed that citric acid has a lower surface energy than 17% EDTA, thus explaining the cause of low bond strength on its use as a final irrigant. Apart from different irrigating solutions being used to decrease the chances of root fracture, it has also been hypothesized that different techniques of condensing the root canal filling material also affect the fracture resistance of the root portion. Based on their findings, researchers postulated that the lateral condensation technique creates stresses in the root during obturation, which can create subsequent fracture. Even though the lateral condensing technique should not directly create root fracture, sufficient amount of elasticity is present in the dentin to permit separation without complete vertical root fracture.²⁰

In a research carried by Pawlicka²¹ in 1982 on the hardness of the dentin portion of the root, results showed alteration in hardness due to the effect of chelators by approximately 20 HV. No difference in the change could be found between the different varieties of chelators used. Shaktidar et al²² compared the root reinforcing abilities of resilon/epiphany in endodontically treated teeth irrigated with different solutions *in vitro* and found that the teeth irrigated with 17% EDTA and 5.25% NaOCl followed by 17% EDTA showed significantly greater resistance to fracture than the groups irrigated with 5.25% NaOCl and 2% chlorhexidine. For complete cleaning of the root canal system, the irrigating solution that can dissolve both the organic component and the inorganic material is required. In addition, NaOCl is active only against the organic part; addition of EDTA can effectively dissolve

the inorganic material, including the complete removal of the smear layer. Arslan et al²³ while evaluating the effect of citric acid irrigation on root fracture in different concentrations found that citric acid used in 50% conc. showed the highest fracture resistance compared with its various concentrations. Therefore, the type of irrigating solution does affect the root fracture resistance and the outcome of RCT procedure.

CONCLUSION

From this study, it can be concluded that among the irrigants tested, 10% EDTA provided the highest fracture resistance compared with other irrigants as well as EDTA in other concentrations. Therefore, irrigating solution must be used during biomechanical preparation of root canal to reduce the chances of root fracture. Further research with higher and different study groups is required to search for more efficient irrigating solution to improve the outcome of RCT.

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