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Comparative Evaluation of the Effect of Three Root Canal Irrigation on the Fracture Resistance of Endodontically Treated Roots –An In Vitro Study

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Abstract

The main aim of instrumentation in endodontic treatment is the mechanical debridement of the root canal this creates a space for antimicrobial agents which leads to the success of the treatment.[1]

It is considered as an important phase in removing the remnants of tissue. Irrigation is followed by which expels pulpal tissue remnants and dentinal shavings and makes the root canal system clean[2]. There are various agents used as irrigants chemical, herbal and in combinations.

A multitude of irrigation solutions with antiseptic and tissue dissolving properties are used during the procedure. A favorable protocol to prevent infection of the root canal and improve the outcome of endodontic treatment is to use irrigation solutions with antimicrobial property. A layer consisting of dentin debris, necrotic pulp during instrumentation is termed as smear layer.[3]

This smear layer can harbor bacteria offering protection to biofilms adhering to root canal walls. It's presence or absence to be beneficial is still controversy though. It is advisable to remove it by chemical irrigants. Various irrigants such as NaOCl, EDTA, Saline, Citric acid, Phytic acid been introduced which have the property of removing smear layer .[1]

Among them sodium hypochlorite and EDTA are the most commonly used currently. Many irrigants like citric acid, phytic acid been introduced which have process the smear layer removing ability.

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. Among which vertical root fracture is more common. It has been found from studies that the irrigating

solution have an effect on the fracture resistance of endodontically treated teeth.[4]

Citric Acid

Citric acid has been used at 5 to 50% concentration.The most effective one is the concentration with 10%. Citric acid which can chelate and remove the smear layer and inorganic particles. It was emphasized that the exposure time of dentin to citric acid increased surface roughness which might be beneficial because of the micromechanical bonding of endodontic sealers to root canal irregularities.[5]

EDTA (Ethylenediaminetetraacetic acid)

EDTA is commonly used at a concentration of 17% that can chelate and remove the smear and inorganic particles. Study reported that samples in which the smear layer was removed exhibited higher resistance to fracture which might the attributed to mineralizing potential of 17% EDTA and its ability to remove the inorganic components of the smear layer changing the surface energy thereby helping the sealer to flow into the dentinal tubules more easily to improve adhesion.[6]

PHYTIC

ACID (known as inositol hexakisphosphate,IP6)

Phytic acid (IP6, inositol hexakisphosphate), is a major storage form of phosphorus in plant seeds and bran that contributes in a variety of cellular function. It has got multiple negative charges, making it an effective chelator of multivalent cations such as calcium (Ca2+), magnesium, and iron. It has also got the cariostatic and antiplaque effect.[7]

Phytic acid has got the ability to remove smear layer and was proved to be less cytotoxic and more biocompatible as compared to EDTA.[8]

This invitro study was taken to compare and evaluate the effect of phytic acid, citric acid and EDTA irrigation on the fracture resistance of endodontically treated root.

Materials and Methods

Tooth Selection and Specimen Preparation

Thirty extracted single rooted mandibular 1st premolar teeth were collected and cleaned as per OSHA Guideline. The procedure for preparation and obturation was standardized for all groups and performed by a single operator to minimize experimental variables.

The study samples were decoronated apical to the cement enamel junction to standardize the canal length to 15 mm measured from the tip of the root to the cement-enamel junction with a diamond disc under water coolant mounted on a straight micro motor handpiece. The prepared teeth were stored in normal saline solution until use.The canal patency was determined by passively placing a no. 8 size k-file in narrow canals and10 k-file in medium sized root canals until the tip of the file was visible at the apical foramen.Working lengths were established by subtracting 1mm from the measurement obtained when a size 10 file was placed into the canal until its tip was visible at the apex namely working length of 14mm.Initial negotiation of root canal space was performed using a size 15 manual K-file used in a watch-winding motion to assure the presence of a glide path. The samples were prepared up to file size 30/0.06 taper using Protaper Universal (Dentsply Maillefer) Ni-Ti rotary instruments at a rotation of 300 r.p.m

FIGURE 1

The 30 samples were randomly divided into 3 groups accordingly to the irrigating solution

Group 1-1% phytic acid solution

Group 2-10% citric acid solution

Group 3-17% EDTA solution

1% of PHYTIC ACID solution was prepared by adding 2ml of 50% of PHYTIC ACID.

Figure 2

In Group 1-the irrigation was done with the 1% PHYTIC ACID using 30 gauge side vented needle and allowed to stay for 1 minute in the canal and then 5ml NaOCl for 2mintues followed by a rinse of with the distilled H_2O.

The same procedure of irrigation done with 10% CITRIC ACID in Group 2 and 17% EDTA in Group 3

The sample root canals were dried with paper points and later obturated using gutta-percha cone with the AH Plus sealer using cold lateral compaction technique.The apical 5 mm of roots was embedded along the long axis in self-curing acrylic blocks, with 9 mm of each root exposed.

Fracture Test

All the samples were mounted vertically in acrylic resin exposing the 9 mm of the coronal part. Then the sample was subjected to fracture test using universal testing machine to root fracture assessment. 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

Result

PHYTIC ACID (GROUP 1)	CITRIC ACID (GROUP 2)	EDTA (GROUP 3)
578.21 N	912.35 N	1856.08 N
357.34 N	771.16 N	2095.36 N
333.47 N	1602.70 N	1959.32 N
418.91 N	830.77 N	917.32 N
391.63 N	763.12 N	818.35 N
402.18 N	805.51 N	861.23 N
629.73 N	548.97 N	986.14 N
356.26 N	995.63 N	1267.60 N
895.47 N	854.11 N	909.74 N
1160.97 N	934.71 N	1153.18 N

Table 1: Frature Resistance Load

**N=Newton

Instrument Details:Universal Testing Machine : Fine Testing Machine

Model: TFUC-1000

Test Speed : 1mm/min

Multiple comparison of mean differences between groups revealed that Group 3 showed significantly highest mean fracture resistance as compared to Group 1 and Group 2

Hence, we can state that 17% EDTA demonstrated significantly highest fracture (1282.43 N) resistance followed by 10% Citric acid (901.90 N) and least with 1% Phytic acid (552.42 N)

Statistical Analysis

Comparison of mean Fracture Resistance (in Newton) between 3 groups using Kruskal Wallis Test						
Groups	N	Mean	SD	Min	Max	P-Value
Group 1	10	552.42	275.96	333.5	1161.0	0.001*
Group 2	10	901.90	274.60	549.0	1602.7	
Group 3	10	1282.43	496.41	818.4	2095.4	

Table 2 : The values obtained were analyzed using Kruskal Wallis Test

Graphical Representation

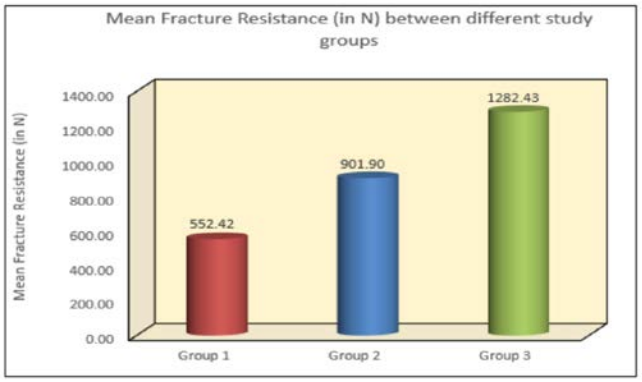

Table 3: Graphical representation of fracture resistance between different study

Discussion

During root canal treatment,the instrumentation can create a smear layer consists of microorganisms, their by-products.This creates hindrance the complete opening of the dentinal tubules. [9,10]

Therefore, complete removal of this smear layer causes penetration of root canal filling materials and medicaments into the dentinal tubules.[9,11] The main process that helps to remove this smear layer and other dentinal debris is irrigation.[12,13]

Shaping during instrumentation of the root canal, preparation for rehabilitation with intraradicular Pinus and loss of moisture caused by the absence of pulp tissue are factors that modify the mechanical integrity of endodontically treated teeth and consequently reduce the root fracture resistance.[14] In this context, it was observed that the deleterious effects caused by irrigation solutions include dentin dehydration[15] and altered dentin microhardness[16], flexural strength and modulus of elasticity[17] as well as the erosion of dentin tissue [18,19,20] and the oxidation of organic components [21]. Although studies demonstrate the effect of irrigating solutions on the mechanical properties of root dentin, in the clinical scope, the results are extrapolated because of the greater susceptibility to fracture of treated teeth and by interfering with tooth longevity [22,17]

Irrigation solutions promote changes in the morphology and physical and chemical composition of dentin .[18] Therefore, for endodontic treatment, the search for the ideal irrigation regime aims to maintain the integrity of the mechanical properties of dentin tissue while promoting tissue dissolution and antimicrobial activity.[23]

In this study the irrigants used were phytic acid,citric acid and EDTA for its inherent property of removal of smear layer.

In a research carried by Zehnder et al[13] 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[24]

In this study Group 3 irrigated with 17% EDTA had the maximum fracture resistance strength followed by 10% of citric acid and 1% of phytic acid.

GROUP 3 17% EDTA has the highest root fracture resistance (1282.43)

EDTA is a chelating agent and therefore capable of removing the smear layer.

Relying on EDTA alone with activity against the inorganic matter only, however, results in incomplete removal of the smear layer. Complete cleaning of the root canal system requires the use of irrigants that dissolve organic and inorganic material. As hypochlorite is active only against the former, EDTA can effectively dissolve inorganic material, including hydroxyapatite to complete

the removal of the smear layer and dentin debris[25] which exhibited higher resistance to fracture .

In addition, EDTA has low surface tension, facilitating its flow into the dentinal tubules. Removal of the smear layer changed the surface energy, helping the sealer flow into the dentinal tubules more easily to improve adhesion,similar study been conducted by Yassen GH.[6]

It has been reported that endodontic irrigation is capable of causing alterations in the chemical composition of dentin,and this effect can increase by extended application time and concentration of irrigating solutions.These changes in the chemical property of dentin arise because of the changes in the inorganic and the organic phases of the dentin.In turn,the microhardness ,permeability and solubility characteristics of dentin changes,and this might also adversely affect the fracture resistance of teeth.[26,27,28]

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.[29] Arslan et al[30] 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 Root canal procedure.

In present study Phytic Acid GROUP 1 showed lowest root fracture resistance (552.42) due to decreased dentin microhardness affect causes by 1% phytic acid of Ph 1.3.Similar found study conducted by Nikhil et al[31] evaluated in his study that phytic acid has the ability to reduce the dentin microhardness which was lesser than EDTA.

EDTA and citric acid increased surface roughness, which might be beneficial because of the micromechanical bonding of endodontic sealers to root canal irregularities.[32]

Conclusion

With the limitation of the study it may be concluded that

-Among the irrigants tested, 17% EDTA provided the highest fracture resistance compared with other irrigants.

-Phytic acid proved to be less cytotoxic and more biocompatible as compared to EDTA.

Furthermore, studies are required to throw information about chelating agents used as irrigation which cause less cytotoxic and more resistant to fracture.

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