10.21608/ADJC.2023.209833.1306 Advanced Dental Journal
Volume 5 (2023) | Issue 3| Pages 651-658

Original Article

Influence Of Sodium Hypochlorite Used in Combination With EDTA Versus Sodium Hypochlorite Mixed With Etidronate Irrigants On Coronal Fracture Resistance Of Endodontically Treated Bleached Teeth -A Comparative In-Vitro Study

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Submitted: 8-5-2023
Accepted: 7-9-2023

Abstract

Aim: The study aimed to examine the influence of NaOCl used in combination with EDTA as irrigant versus NaOCl mixed with Etidronate as irrigant on the coronal fracture resistance of endodontically-treated bleached teeth

Subjects and methods: Twenty-four sound mandibular premolars were chosen and randomly split into two groups: control group (n= 12), NaOCl was used in combination with EDTA; in the experimental group (n=12) NaOCl mixed with etidronate was used. After obturation, internal and external bleaching were performed, and then Composite resin was used to restore teeth. The specimens were tested utilizing compressive loading by a universal testing machine.

Results: Results showed that the coronal fracture resistance of the experimental group recorded a significantly higher value in comparison to the control group. Comparing the two groups revealed a statistically significant difference.There was no significant difference in the two group's modes of failure. In the intervention group, 2 samples (16.7%) showed a favorable fracture, and 10 samples showed an unfavorable fracture (83.3%). .

Conclusion: Sodium hypochlorite mixed with Etidronate has higher coronal fracture resistance than sodium hypochlorite used in combination with EDTA in endodontically treated bleached teeth

Keywords: etidronate, root canal irrigation, coronal fracture resistance, bleaching.

I. INTRODUCTION

The success of endodontic treatment depends on how well the root canal system is cleaned and instrumented for debridement with irrigation followed by sealing the endodontic cavity. Chemical substances are essential to disinfect, remove and dissolve organic content. they can also alter the chemical composition and mechanical characteristics of dentin by altering the proportion of minerals [1]. This decreases the possibility of the tooth resisting the functional loads and the tooth becomes less resistant to fracture [2].

One of the main drawbacks of endodontic treatment is the weakening of the tooth structure. It becomes more susceptible to fracture than sound vital teeth due to many reasons including dehydration and loss of tooth structure [3,4] .

NaOCl is the most commonly used irrigant in endodontic practice. Its proteolytic activity on the tissues is what distinguishes it, but it diminishes the moisture content of the dentin**,** which is the main factor contributing to the brittleness of a pulpless tooth [5]. It only has an impact on the organic parts of the smear layer.

Ethylene diamine tetra acetic acid (EDTA) is a chelating agent, when used with NaOCl, it enhances the efficiency of smear layer removal by chelating calcium ions impact on the organic parts of the smear layer [6]**.**

Etidronate, is a biocompatible chelating agent. Its use mixed with NaOCl has been suggested as a substitute irrigation protocol to remove the smear layer. The previous research indicates that mixing 5% NaOCl with 18% etidronate prevents the direct impact on dentin collagen fibers, resulting in a greater dentinal tubular opening than NaOCl combined with EDTA [7,8] .

Another problem that faces endodontically-treated teeth is the loss of esthetic appearance due to discoloration either from hemosiderin pigmentation of the tooth structure or due to the remnants of materials for filling a root canal [9]**.**

Dental bleaching results in changes in the enamel and dentin mechanical characteristics. These include decreased microhardness of dentin and enamel.

To our knowledge, there is no previous clinical study that assessed the coronal fracture resistance of endodontically-treated teeth when used a mixture of etidronate with NaOCl as an irrigant in endodontic procedures then bleaching was done.

Therefore, the aim was to determine the effect of NaOCl when mixed with etidronate as an irrigant versus sodium hypochlorite combined with EDTA on the coronal teeth fracture resistance of endodontically- treated bleached single-rooted premolars.

The null hypothesis was that there is no difference between the control and intervention groups.

II. SUBJECTS AND METHODS

Trial design:

The ethics committee (EC) of Cairo University's Faculty of Dentistry reviewed and approved this comparative in vitro study. The approval number was (7-3-21). Random sequence was generated by using a random sequence generator program. The study was registered at www.nature.com (NP-P210002).

Sample size:

The sample size was calculated using data from a previous study by (Khoroushi *et al.*, 2018) [10] **.** It was found that for the primary outcome (coronal fracture resistance) 12 teeth per group was appropriate sample size for the study with total sample size 24 teeth (2 groups). The power is 80% and α error probability =0.05. Sample size was calculated using the (PS software).

Sample selection:

Twenty-four, human, freshly-extracted, intact, straight, single-rooted single-canalled mandibular premolar, were collected after extraction due to orthodontic or periodontal problems. Teeth were radiographically examined to verify the existence of just one canal as well as absence of calcifications, resorption, or any other anomalies by using digital radiography. Teeth were visually examined under dental operating microscope at magnification of X16 in order to select teeth with no caries or cracks. For 30 minutes, teeth were immersed in 5.25% NaOCl to facilitate the removal of periodontal tissue and debris, then stored in purified distilled water until use.

Root Canal Preparation:

A standardized access cavity was prepared using high-speed diamond round bur and Endo-Z bur. The residual radicular pulp tissue was extirpated. After checking the root canal patency, working length was determined by K file size # 15**.** All roots were prepared by M Pro rotary files (Meta Biomed Co.Ltd,Korea,China) in the sequence of first one orifice opener #18/ 0.04 (torque 3 N.cm) then file #20 /0.04(torque 1.5 N.cm) then file #25/0.06 (torque 1.5 N.cm) up to #35 /0.04 (torque 1.5 N.cm). All files were used with a speed of 450 rpm. Irrigation and recapitulation after each rotary file were done according to groups for the control group the root canal irrigation used was 2.5% NaOCl ; 5ml between each file with flow rate 1ml /60 sec , followed by distilled water irrigation 5ml, 1ml/ 60 sec , then irrigation with 17% ethylene diamine tetra acetic acid (EDTA 5ml, 1ml /60 sec) after each file. While for the intervention group the root canal irrigation used was 2.5% NaOCl,10ml mixed with etidronate capsule 18% hydroxyethylidene bisphosphonate (HEBP), until complete dissolution, 5ml between each file with flow rate 1ml/60 sec.

Root canal filling:

The root canal filling was done by using lateral condensation technique using gutta-percha #35 /0.04 as master cone. Then the excess of the filling material was cut off using a hot instrument. After the removal of excess filling material, a hot instrument was used to remove 3mm of gutta percha below the orifice of the canal.

A barrier made of light cure resin-modified glass ionomer was used over the root canal filling material. The teeth were fixed in two different metal trays using brown compound material to separate each group and to resemble the patient mouth (fig1).

Figure 1: Tooth fixation during bleaching session

The bleaching agent was 40% hydrogen peroxide (Ultradent Products Inc, South Jordan, UT, USA) . The opalescence Xtra Boost bleaching gel was applied directly to each sample's buccal surface and pulp chamber. A 0.5-1mm thick layer was applied to the buccal surface of each sample to get a homogeneous result. After 45 minutes, the samples were washed with an air-water spray after the gel was removed. The bleaching procedure was repeated three times in one week. The bleaching material was removed, and the tooth surfaces were washed with distilled water after each session. All samples were kept in artificial saliva at 37°C to resemble the body temperature using an incubator[10] .

Final restoration and bonding procedures were delayed for two weeks, as proposed by most of the literature [11,12] to overcome the adverse effects of bleaching on bonding to the tooth structure.

Embedding of specimens :

To stabilizing each root specimen in a vertical direction (fig 2), a special cylindrical mold having around 2cm length and 2cm internal diameter was formed. The root of each tooth was immersed in it to the level of 1mm below the cementoenamel junction. Excess acrylic resin was rapidly removed with a clean wax carver and the complete assembly was left for complete chemical curing.

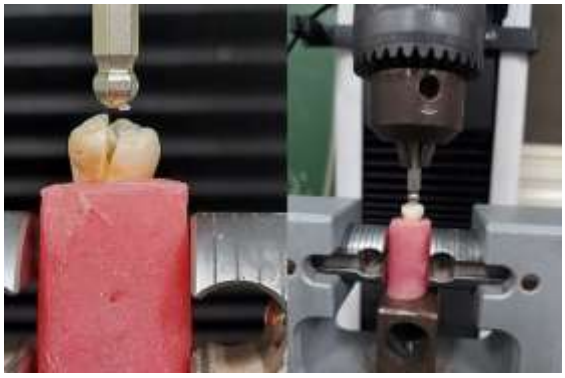

Figure 2: Fracture resistance test

Fracture resistance test:

Finally, the universal testing machine (Instron, canton, MA,USA) was used to perform a fracture resistance test on the specimens. Axial compression mode of force was applied at a crosshead speed of 1.0 mm/min up to specimen failure. The force required for failure (Newton) was recorded by machine software BlueHill universal Instron England.

The mode of failure was assessed according to the level of fracture, favorable fracture which means that the fracture line was above the cementoenamel junction, and the tooth could be restorable, unfavorable fracture which means that the fracture has occurred below the cementoenamel junction, and the tooth became non-restorable.

Randomization

Sequence generation:

The random sequence was obtained by a random sequence generator software system in two equal columns on the website (https:///:www.random.org), Where the samples (n=24) was divided at random into two equal groups (n=12). To prevent the selection bias, the allocated sequence was protected and concealed until assignment using sequentially number on opaque sealed containers in which the teeth were placed. The co-supervisor handled the random allocation sequence and allocation concealment. while the technical procedures of the research method were carried out by the investigator.

Blinding:

The trial was a double-blind study, with both the outcome assessor and the statistician blinded during the outcome evaluation process.

Statistical analysis:

Continuous data were presented as mean, standard deviation, median, range, and 95% confidence interval. Continuous data were tested for normality using Shapiro - Wilk and Kolmogrov Smirnov tests. Independent *t*-test was used for between group comparison.

Categorical data were presented as frequencies and percentages. Fisher's exact test was used for between group comparison.

The level of significance for all tests was set at $p < 0.05$.

Statistical analysis was performed using SPSS software (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.)

III. RESULTS

A total of 24 single root premolars with single canal fulfilled the inclusion criteria and were included in the study. Teeth were divided into two groups of 12 teeth each. All teeth were included in the analysis.

Comparing the two groups revealed a statistically significant difference. (p=0.018). The experimental group recorded a significantly higher value in coronal fracture resistance in comparison to the control group. Additionally, there was no significant difference in the two groups' modes of failure. (p = 1.0). In the intervention group, 2 samples (16.7%) showed a favorable fracture, and 10 samples showed an unfavorable fracture (83.3%). Within the control group, the same results were shown.

Table 1: Descriptive statistics, 95% confidence interval, and the result of independent t-test for comparison of coronal fracture resistance between the two groups.

	Intervention group	Control group	*P* - Value
Mean (SD)	874.2 (351.0)	580.2 (163.4)	
Median (Range)	765.3 (506.1 - 1608.3)	523.1 (395.3 - 873.7)	0.018*
95% CI	(651.2 - 1097.3)	(476.4 - 684.1)	

**Significant at p<0.05*

Table 2: Frequencies, percentages, and Fisher's exact test results for comparing the mode of fracture between the intervention and control groups.

	Intervention		Control		
	Frequency	**Percentage**	**Frequency**	**Percentage**	***P*-Val**
Favorable	2	16.7%	2	16.7%	1.0
Unfavorable	10	83.3%	10	83.3%	

IV. DISCUSSION

This in vitro investigation aimed to compare the effects of sodium hypochlorite combined with etidronate versus sodium hypochlorite combined with EDTA on the coronal fracture resistance of bleached teeth that had undergone endodontic treatment.

NaOCl has the unique ability to clean and disinfect the root canal while dissolving organic tissues even in untouched root canal areas, so it is considered as the preferred endodontic irrigant [13] therefore, it is used in conjunction with other chelating substances to eliminate the inorganic component [14].

Ethylenediaminetetraacetic acid (EDTA) has the power to dissolve calcifications and inorganic tissues. It was highly recommended as a final rinse with 17% concentration for one minute for smear layer removal prior to obturation [15,16] . However, many studies evaluated the tooth fracture resistance after irrigating with EDTA solution and they found that EDTA/ NaOCl combination decreased the fracture resistance of the endodontically- treated tooth also, a high EDTA concentration may raise the chance of root fracture [17,18].

When comparing the use of etidronate and sodium hypochlorite mixture versus final flush with neutral Ph of ETDA, they found that group of etidronate mixed with NaOCl reduced the calcium chelation by half to two-thirds, it appeared to be sufficient to remove the smear layer and this combination did not affect the antimicrobial ability of NaOCl [19].

The addition of etidronic acid to sodium hypochlorite could enhance the irrigant's antibacterial effectiveness while preserving the advantages of continuous chelation [20] . That's why in the present study, we decide to evaluate the effect of etidronate on fracture resistance.

In this investigation, light cure resin-modified glass ionomer was placed over the gutta percha filling to act as a barrier before bleaching to avoid external cervical root resorption which may be caused by internal bleaching according to (Attin *et al.*, 2003)[21]**.** With the excessive use of bleaching agents' adverse effects will increase such as change in properties of the tooth structure like fracture resistance, microhardness and external cervical root resorption.

The period elapsing between the application of bleaching agents and the start of the bonding and final restoration procedures was seven days in bonding to enamel while restorations in dentin should be delayed for 14 days to overcome the adverse effects of bleaching on bonding according to(Barbosa et al , 2008; Kılınç Hİ et al,2016)[11,12] .

In this study, the results showed that the coronal fracture resistance of the intervention group (dual rinse) recorded a significantly higher value, in comparison to the control (EDTA) group. This difference was statistically significant. Additionally, there was no significant difference between the two groups in terms of the mode of failure.

Since etidronate (HEDP) was a less effective chelating agent than EDTA, it was suggested that it be combined with NaOCl and used as a complete root canal irrigation solution. because it decreases the erosion of dentin. It was performed as a single step rather than three steps of NaOCl, distilled water, and EDTA [22].

In the obturation step when used etidronate mixed with NaOCL as an irrigant, it had a better sealer penetrating ability than used NaOCl combined with ETDA, which increases the tooth fracture resistance [18].

The results of this study coincide with two recent studies suggested the superiority of etidronate over other irrigations solution as EDTA, NaOCl and chlorhexidine when comparing the tooth fracture resistance [23,24]

Whereas the other two studies showed no significant difference between etidronate and EDTA[25,26] . The first one was conducted by (Gonzalez et al.2020)[25] this might be related to various concentrations of etidronate 9% was used and the limited contact time between tooth structure and the irrigant solution, which was only 1min contact time. The second study conducted by (Wright et al. 2021) [26] could be related to differences in concentration, where it used 7.7% of etidronate, which was roughly half the EDTA 17% concentration .

These results showed disagreements with the study conducted by (Lantigua Domínguez *et al.*, 2018)[27], which concluded that 5% NaOCl mixed with 18% HEBP had a lower fracture resistance than the NaOCl combined with EDTA as a final rinse. This could be due to the fact that in this study using EDTA irrigant as a final irrigant only, while using 5% NaOCl mixed with 18% HEBP during the full preparation and instrumentation procedure.

In the present study there was no significant different in the term of mode of failure between the control and intervention group about 2 samples in each group showed favorable fracture, which means that the fracture line was above the cementoenamel junction of the tooth, so it can be restored again. While 10 samples showed unfavorable fracture, which means that the tooth become non restorable.

The mode of fracture was classified according to a study conducted by (Khoroushi et al., 2018)[10] according the position of the fractures line, as follows: a- more than 1 mm above the cemento enamel junction is considered favourable fractures, b- fracture line less than 1 mm coronal to the cementoenamel junction is considered unfavourable fractures and the result showed that the minimum rate of favourable fracture was observed in group of NaOCl when it was used alone .This could be due to difference in the comparison groups, as it compared chlorhexidine, NaOCl alone, NaOCl + CHX, NaOCl +EDTA, and the last group was NaOCl +EDTA+ CHX.

V. CONCLUSION

Within the limitations of this in-vitro investigation, it could be concluded that application of HEBP (etidronate) mixed with NaOCl, when used as an irrigants, leads to a higher coronal fracture resistance in endodontically- treated and bleached teeth than the EDTA combined with NaOCl, so it is recommended as an irrigant.

Conflict of Interest:

The authors declare no conflict of interest.

Funding:

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Ethics:

This study protocol was approved by the ethical committee of the faculty of dentistry-

Cairo university on: (30\3\2021) approval number (7-3-21).

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