

Comparative Evaluation Of Effect Of Irrigants On The Mechanical Properties Of Dentin – An In-Vitro Study

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ABSTRACT

Aim: The present study aimed to evaluate the effect of irritants: sodium hypochlorite (NaOCl), Ethylene diamine tetra acetic acid (EDTA), chlorhexidine (CHX) and chitosan nanoparticles (CNP) on the modulus of elasticity and flexural strength of radicular dentin. The null hypothesis was that there will not be any difference among the tested irrigants.

Materials and methods: Seventy-five dentine bars were prepared from orthodontically extracted premolars and stored in deionized water. The samples were divided into 5 experimental groups (n= 15 per group): Group 1 - 2.5% NaOCl, Group 2 - 17% EDTA, Group 3 - 2% CHX, Group 4 - 0.2% CNP, Group 5 - Saline (Control). The samples were immersed in 24 well tissue culture plates containing one of the solutions for 30 minutes and rinsed with deionised water. They were then subjected to three-point bending test. The samples were placed on the Instron universal testing machine and loaded with a cross-head speed of 1 mm/min until fracture occurred. The modulus of elasticity and flexural strength were calculated accordingly. The values were statistically analysed using one-way analysis of variance (ANOVA) and Fisher's test for pairwise comparison.

Results: Statistically significant difference in the reduction of modulus of elasticity and flexural strength was observed only with 17% EDTA (P > 0.05). All the other experimental groups showed no statistically significant difference compared to the control. Hence the null hypothesis was partially accepted.

Conclusion: When compared to the other irrigating solutions tested, EDTA exhibited significant reduction in the modulus of elasticity and flexural strength of radicular dentin.

KEYWORDS: Irrigants, Sodium hypochlorite, EDTA, Chlorhexidine, Chitosan nanoparticles.

INTRODUCTION

Endodontic treatment involves removal of infected or necrotic pulp followed by irrigation to remove the debris, microbes and the smear layer [1]. The smear layer removal is important because of its components, both organic and inorganic can interfere with complete disinfection, adaptation of root canal sealer to root canal wall and interfere with bonding of resin cement to dentin when fiber posts are used [1,2]. Commonly used irrigants include saline, sodium hypochlorite (NaOCl), ethylene diamine tetra acetic acid (EDTA) and chlorhexidine (CHX)⁽¹⁾. Recently various nanoparticles have been tested successfully as irrigants due to its antimicrobial and chelating property [3]. It is well known that a single irrigant cannot exhibit all properties expected of an irrigant. Therefore, there is a constant research to establish an irrigant exhibiting as many optimal properties to reduce the inventory in a clinic. It is imperative such irrigants do not affect the mechanical properties of the dentin as a decrease in mechanical properties can result in root fracture leading to failure of endodontic treatment.

Though NaOCl has excellent antimicrobial and tissue dissolution property, it causes ultrastructural degradation of collagen as it dissolves organic components of dentin [4,5]. EDTA has been used to remove the inorganic component of smear layer although it does not possess antimicrobial property. Dissolution of inorganic components are also known to reduce the mechanical properties of dentin [6,7]. Though CHX is good antimicrobial agent it does not possess smear layer removal property [3]. Chlorhexidine is known to an effective antimicrobial irrigant [3,8]. Chitosan nanoparticle (CNP) is capable of removing smear layer due to its chelating property [3]. With common irrigants having an effect on dentin components it is important to study the effect of different irrigants on the mechanical properties of dentin.

Therefore, the aim of this study is to evaluate the effect of various common irrigants such as NaOCl, EDTA and to compare it with chitosan nanoparticle on the modulus of elasticity and flexural strength of dentin. The null hypothesis was that there will not be any difference among the tested irrigants.

MATERIALS AND METHODS:

A total of 75 dentine bars were prepared from orthodontically extracted premolar and stored in deionized water. Rectangular bars measured 1mm x 1mm x 6mm in dimension. They were finished using silicon carbide abrasive papers up to 2500 grit. The dentin bars were evaluated under 24 X magnification to rule out any pre-existing cracks that may interfere with the results.

The dentin bars were divided into five groups namely

Group I - 2.5% NaOCl

Group II - 17% EDTA

Group III- 2% CHX

Group IV -0.2% CNP

Group V - Saline (control)

The dentin bars (n=15 per group) were immersed in 24 well tissue culture plates containing one of the solutions for 30 minutes. The solutions in the respective wells were replenished with fresh solution after every three minutes thereby simulating the clinical condition of continuous irrigation. The dentin bars were then removed from the respective solutions and rinsed with deionised water to remove the remnants of the irrigants which may have a continued effect on the specimen. The bars were then evaluated for three-point flexural bending test.

Dehydration of dentin bars was prevented during the loading by continuously moistening with deionised water. The bars were placed parallel on the Instron Universal Testing machine and loaded with a cross-head speed of 1 mm/min until fracture occurred. The modulus of elasticity and flexural strength were calculated using the values recorded.

RESULTS:

Table-1 shows the modulus of elasticity and flexural strength values for all the experimental groups. The values were analysed using one-way analysis of variance (ANOVA) and Fisher’s test was used to determine pairwise comparisons. The P-values are shown in the Table-1. Statistically significant difference in the reduction of modulus of elasticity and flexural strength was observed only with 17% EDTA (P> 0.05). Whereas all the other irrigants showed no significant difference compared to the control.

Table-1 - Modulus of elasticity and flexural strength of dentin after exposure of different irrigating solutions.

Irrigant	Modulus of elasticity	P-value	Flexural strength	P-value
NaOCl	8.787	0.26	164.315	0.26
EDTA	4.437	0.001*	110.428	0.001*
CHX	9.067	0.43	171.629	0.43
CNP	8.927	0.31	164.944	0.38

Saline	9.246	-	173.312	-
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*- indicates statistically significant difference with control group

DISCUSSION

Endodontic treatment is generally believed to cause weakening of tooth structure. Though various reasons have been cited, a reduction in tooth structure during endodontic treatment and dentin dehydration are considered to be the most important causes for the brittleness compared to a vital tooth [9]. Though the conditions of this in-vitro study may differ from the clinical scenario, we have tried to simulate using the common concentration and the usual time taken for chemo-mechanical preparation. The root fracture resistance to root can be negatively affected by reduction in elastic modulus and flexural strength. Therefore, it is important to assess these qualities to predict the resistance of root the fracture after chemo-mechanical preparation.

The current study has shown that none of the irrigants evaluated cause a decrease in mechanical properties of dentin except EDTA. Hence the null hypothesis was partially accepted. The result of this study in respect to NaOCl does not concur with some of the previous studies. Previous studies have reported that there is no significant reduction in the modulus of elasticity of dentin and neither the flexural strength of dentine on exposure to NaOCl [10, 11]. But it does not concur with some other studies [12]. Their study showed that exposure to 3–9% NaOCl had resulted in a significant reduction in modulus of elasticity of dentin. The mechanism of depletion in dentine and resultant weakening effect of NaOCl is due to degradation of organic portion of dentin. Despite the degradation of collagen, it was not sufficient to significantly reduce mechanical properties. A higher concentration or a longer time could have a weakening effect on dentin. Other studies have shown a decrease in micro hardness, but was not evaluated in this study as flexural strength and modulus of elasticity also play a major role in root fracture [6,13].

Our study has shown EDTA is able to decrease the mechanical properties significantly. This concurs with previous studies [6-14]. The chelating property of EDTA removes calcified portion of dentin causing softening of dentin [6,15]. This results in reduction in mechanical properties of dentin. But the duration of exposure of dentin to EDTA in this study was for 30 minutes. If EDTA is used only as final irrigant, the duration of exposure would be much less and therefore the deleterious effect would not be seen⁽¹⁶⁾. Calt and Serper in their study had recommended an exposure of not more than 1 minute to preserve the integrity of dentin⁽¹⁶⁾. Therefore, it would be prudent to use EDTA only as final irrigant and not to irrigate the root canal for more than 1 minute even during the final irrigation.

CHX has not shown to cause any decrease in flexural strength and modulus of elasticity in our study. This in accordance with previous studies which established that the mechanical properties were not significantly affected by CHX [11, 17]. Though CHX is an excellent antimicrobial agent it has shown to be ineffective in removing the smear layer as it has poor tissue dissolving property and very little effect on the organic portion of the dentin [18]. But this property of poor ability of CHX to remove the smear layer has also resulted in its decreased ability to affect the mechanical properties of the dentin.

The effects of CNP had also been similar to CHX in our study. It did not cause any significant decrease in mechanical properties. These results indicated that chitosan has a weak chelating property that demineralises dentin to a lesser extent when compared to irrigants such as EDTA [14]. Moreover, covalent interaction of CNP to dentinal collagen could strengthen the dentin by attracting calcium. This reverses the weakening caused during smear layer removal by precipitating calcium released to precipitate back on dentin [19].

This study shows that all solutions tested in this study are safe as irrigant with regard to altering the modulus of elasticity and flexural strength except EDTA. Even EDTA could be a safe irrigant if the duration of contact of EDTA to dentin wall is reduced unlike 30 minutes as used in this study. CNP has shown to be a very effective among irrigants as it shown to have antimicrobial and smear layer removal properties in previous studies in addition to maintaining the mechanical properties of dentin as shown in this study.

CONCLUSION:

Within the limitations of this study it can be concluded that only EDTA has shown to reduce the modulus of elasticity and flexural strength of dentin.

SOURCE OF FUNDING : Nil

ETHICAL CLEARANCE : Not required for an in vitro research manuscript

CONFLICT OF INTEREST : Nil

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