Journal of Research in Medical and Dental Science
Volume 5, Issue 5, Page No: 108-114

Available Online at: www.jrmds.in
eISSN No. 2347-2367: pISSN No. 2347-2545

Influence of Root Canal Irrigants on Fracture Resistance of Teeth: A Narrative Review

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DOI: 10.24896/jrmds.20175517

ABSTRACT

Various single and combined irrigation solutions and protocols are used during endodontic treatment. There is no review available on the effect of root canal irrigation solutions on root and crown fracture resistance. This review evaluates the effect of root canal irrigation solutions on bonding and root and crown fracture. The MEDLINE-PubMed and SCOPUS databases were searched for appropriate papers addressing the effects of irrigation solutions on crown and root fracture resistance and bond strength. Databases were searched from 2005 to 2014. The search was performed using a variety of keywords, including root fracture resistance, crown fracture resistance, resistance, bonding, and canal irrigants. Using multiple key words and different strategies, 119 publications were initially screened. The abstracts of these 119 publications were scanned for relevance, and 45 full-text articles were selected. Based on the review of all the relevant papers, it can be concluded that root canal irrigation solutions can affect the fracture resistance of the crown and root.

Key words: Root Canal Irrigants, Fracture Resistance, Review

HOW TO CITE THIS ARTICLE: Maryam Khoroushi, Fatemeh Tavakol, Navid Mojtahedi, Sanaz Ziaei, Hamid Mosleh, Influence of Root Canal Irrigants on Fracture Resistance of Teeth: A narrative Review, J Res Med Dent Sci, 2017, 5 (5): 108-114, DOI: 10.24896/jrmds.20175517

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Received: 15/10/2016
Accepted: 20/03/2017

INTRODUCTION

The principal aim of root canal instrumentation is the mechanical debridement of the root canal system in order to create a space for antimicrobial agents [1]. Mechanical debridement of the root canal is considered an important step to remove tissue and should always be supplemented by irrigation to expel pulpal tissue remnants and dentinal shavings from the root canal system. In this context, chemical debridement is an important adjunct to ensure complete removal of necrotic tissue and debris [2]. A multitude of irrigation solutions with antiseptic and tissue-dissolving properties are used during root canal treatment. A favorable protocol to prevent reinfection of the root canal and improve the outcome of endodontic treatment is to use irrigation solutions with long-standing antimicrobial activity [3]. On the other hand, a smear layer is left on instrumented root canal walls, consisting of inorganic and organic materials such as dentin chips and pulp tissue remnants. The smear layer can harbor bacteria, offering protection to biofilms adhering to root canal walls. Furthermore, it interferes with adaptation of currently used root canal sealers to dentin walls, promoting micro leakage; therefore, it is advisable to remove it by chemical irrigants[1].

Root canal therapy should result in a fluid-tight obturation and coronal restoration. Irrigation

solutions have different physical/mechanical, chemical, biological and microbiological effects.

MATERIAL AND METHODS

The MEDLINE-PubMed and SCOPUS databases were searched for papers addressing the aims of the present study. Databases were searched from2005 to 2014 using different keywords, including fracture, resistance, root canal, canal irrigants, root and crown. Different strategies (connecting different key words with 'or', 'nor', and 'and', as well as truncating the stems of words) were used during the search. A manual search of the references in papers identified additional relevant articles on the topic. In vivo and invitro investigations related to the topic were included in this review. Only papers published in English were included.

RESULTS

The electronic and manual searches brought up 119 potential papers for inclusion in this review. The abstracts of these 119 articles were checked for relevance, yielding 45 relevant full-text articles, which were read in detail. Thirty papers evaluated the effects of various intra canal irrigation solutions on root and crown fracture resistance and bonding; 29 of the 45 reported the effects of different irrigation protocols on bonding; and 14 of the 45 reported the effect of different irrigation techniques on root fracture resistance.

Using 'intra canal irrigants' as a key word, substances such as sodium hypochlorite (NaOCl), chlorhexidine gluconate (also called chlorhexidine digluconate or simply chlorhexidine, CHX), 17% EDTA, citric acid and ethanol were the most commonly used irrigation solutions during root canal and post space preparation.

NaOCl

Sodium hypochlorite is the most commonly used root canal irrigation solution in endodontics, with 0.5–5.25% concentrations[4]. The advantages of NaOCl include antimicrobial activity, dissolution of the pulp tissue remnants, lubrication during mechanical instrumentation, availability and low cost, which are the fundamental requirements for root canal irrigation solutions [5-7].

Cecchin *et al* [8] evaluated the effect of NaOCl and EDTA on the microtensile bond strength of a self-etching adhesive system. The use of 1% NaOCl alone increased the bond strength compared to the other protocols. The combination of 1% NaOCl and 17% EDTA resulted in bond strengths comparable to that of untreated dentin [8]. Based on the results of one study 5.25% NaOCl reduced the elastic modulus and flexural strength of dentin. Irrigation of the root canals of single-rooted premolars with 5.25% NaOCl altered their strain properties in the absence of enamel [9].

In another study different irrigation regimens did not significantly change the microshear bond strengths of bonding systems, except NaOCl, which significantly decreased the micro shear bond strength of Adper Single Bond 2.Bonding-irrigated specimens with the Adper Single Bond 2 without prior etching resulted in significantly decreased values[10]. Renovato et al. [11] evaluate the effect of Ca(OH)2 and root canal irrigants on fiber post bond strengths to root canal dentin. EDTA and SH decreased the bond strength in the immediate (middle and apical thirds) and 21-day (middle third) groups. A significant decrease in bond strength was recorded in groups undergoing irrigation with SH and tested at 6 months (cervical and middle thirds) [11].

In one study the root canals in 90 single-rooted teeth, instrumented using a rotary Ni-Ti system, were assessed in relation to the effect of root dentin conditioning on sealing ability and push-out bond strength of an epoxy resin root canal sealer. The maximum push-out bond strength was recorded in the coronal third, with the lowest in the apical root third ($P<0.05$). Final irrigation with a decalcifying agent decreased the microleakage and increased the push-out bond strength significantly, in contrast to the protocol using NaOCl as the final rinse ($P<0.05$), in which the effect of the decalcifying agent was neutralized. CHX exerted no effects on the outcomes. There was a strong correlation between fluid transport and push-out bond strength (P= -0.83)[12]. One study was designed to assess adhesion of Epiphany self-etch sealer to dentin exposed to intra canal irrigation solutions. NaOCl decreased the bond strength of Epiphany SE sealer to dentin; however, Na-Ascr reversed this negative effect of NaOCl. CHX had no effect on the bond strength [13]. De-Deus *et al*., [14] used a soft chelating irrigation protocol that improved the bonding quality of Resilon/Epiphany root filling materials NaOCl + 18% HEPB. Samples exposed to EDTA and MTAD exhibited intermediate bond strength. The

lowest bond strength values were recorded in NaOCl-treated samples, with the highest in the HEBP-treated samples [14].
In a study by Muniz *et al*., [15] the effect of 5.25% NaOCl was evaluated as an irrigant and root canal sealers on post retention in different dentin regions. The minimum resistance to dislodgment was recorded in the cervical region, mainly in groups in which distilled water was used as an irrigation solution [15].

EDTA
EDTA is commonly used at a concentration of 17%, can chelate and remove the smear layer and inorganic particles.

One study reported that samples in which the smear layer was removed exhibited higher resistance to fracture, which might be attributed to the demineralizing potential of 17% EDTA and its ability to remove the inorganic components of the smear layer. 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 [16]. One study reported that the apparent aggressiveness of EDTA, in the presence of NaOCl, in eroding the canal wall can be attributed to the prolonged use of NaOCl. The associated decrease in dentin flexural strength is clinically relevant when thin pulp chamber dentin is immersed in NaOCl for a long time during root canal instrumentation. This might make endodontically treated teeth more susceptible to vertical fractures [17].

Uzunoglu *et al*., [18] evaluated the effect of EDTA on root fracture at different concentrations and exposure durations. The highest mean fracture resistance was obtained in the group treated with 5% EDTA for 10 minutes. In one study complete elimination of the smear layer with the application of EDTA decreased the fracture resistance of tooth roots restored with epoxy fiber posts [19].

An in vitro study evaluates the bond strength of a self-etch adhesive system to dentin treated with NaOCl, CHX and EDTA, using microtensile testing. It was concluded that use of 2% CHX, followed by 17% EDTA, increased the bond strength of the self-etch adhesive system to dentin, compared with the results of other groups[20]. Another study evaluated the effect of exposing intra radicular dentin to irrigation solutions (11.5% poly acrylic acid for 30 seconds, 17% EDTA for 60 seconds, or 5% NaOCl for 60 seconds) on the retention of glass-fiber posts luted with self-adhesive resin cement. The results showed that use of EDTA before application of self-etch adhesive resin cements might interfere with retention of fiber posts[21]. Ballal *et al*., [22] evaluated the effect of 7% maleic acid and 17% EDTA on the shear bond strength of RealSeal SE sealer to root canal dentin. Twenty incisor teeth were split into coronal, middle and apical thirds and treated in the following manner: Group 1: 5 mL of saline solution for 1 minute; Group 2: 2.5% NaOCl (5 mL/min), followed by 79% maleic acid (5 mL/min); Group 3: 2.5% NaOCl (5 mL/min), followed by 17% EDTA (5 mL/min). The sealer was applied to the root dentin and the samples underwent a bond strength test. There were no significant differences in bond strength between maleic acid and 17% EDTA in the coronal and middle thirds. However, in the apical third, 7% maleic acid resulted in higher bond strength. The least bond strength was observed with the saline solution. Bond strength was maximum in the apical third for both 7% maleic acid and 17% EDTA. Neelakantan *et al*., [23] reported that the continuous chelation irrigation technique improved the adhesion of epoxy resin-based root canal sealer to root dentin after the root canals were instrumented with a rotary Ni-Ti system. The use of a strong chelator as the final rinse further increased bond strengths (G4, $P<0.05$). In one study the results showed significantly higher apical microleakage in teeth in which the smear layer was not removed [24]. Thompson *et al*., [25] evaluated the inhibition of endogenous dentin matrix metallo proteinases by EDTA;17% EDTA significantly inhibited endogenous MMP activity in human dentin in 1–2 minutes, which might minimize the hybrid layer degradation after resin bonding procedures in the root canal space[25]. In another study was indicated the effect of intracanal irrigation solutions on the bond strength of epoxy resin-based and methacrylate-based resin sealers to root canal walls. Except for 1% NaOCl, removal of the smear layer with the other irrigants increased the bond strength of AH-Plus to intracanal dentin [26]. In a study by Gopikrishna *et al*., [27] on the effect of MTAD in comparison with EDTA as the final rinse on the shear bond strength of three endodontic sealers to dentin, AH plus exhibited the highest bond strength when EDTA was employed as the final rinse ($P<0.05$). MTAD as the final rinse resulted in significantly lower bond strengths with AH Plus

and Apexit compared to the control group [27]. Shokouhinejad et al. applied different irrigation protocols to evaluate the push-out bond strength of Resilon/Epiphany self-etch and gutta-percha/AH26). Irrigation with 5.25% NaOCl + EDTA proved a better conditioner before the application of gutta-percha/AH26. Irrigation with 5.25% NaOCl + EDTA or 1.3% NaOCl + MTAD did not affect the bond strength of Resilon/Epiphany SE [28].

Ballal *et al.,* evaluated the post-obturation apical seal after intra canal irrigation with maleic acid and EDTA. Maleic acid resulted in the least apical leakage, with the saline solution resulting in maximum leakage [29].

In a study by Yurdagüven *et al.,* the effect of root canal irrigants on the microtensile bond strength of dentin adhesives was evaluated. The microtensile bond strength of the MTAD + Clearfil SE group decreased significantly compared to those of the distilled water + Clearfil SE Bond group and the NaOCl, EDTA + Clearfil SE Bond group[30]. Another study evaluated the long-term influence of the smear layer on the apical sealing ability of MTA. It was concluded that MTA exhibited less apical microleakagein the presence of the smear layer [31].

Citric acid

Citric acid being used at 5–50% concentrations; however, the most effective concentration is 10%. Citric acid, similar to EDTA, can chelate and remove the smear layer and inorganic particles.

One study showed that citric acid has the less effect on micro hardness compared to EDTA. However, it was emphasized that the exposure time of dentin to citric acid should be kept to a minimum. On the other hand, the erosion of dentinal tubules compromises the dentin structure. One study compared the effects of EDTA and citric acid on root dentin roughness, demonstrating that compared with EDTA, citric acid increased surface roughness, which might be beneficial because of the micromechanical bonding of endodontic sealers to root canal irregularities [32]. Arsalan showed that use of citric acid is safe in terms of fracture resistance in endodontically treated teeth [33].

CHX

In endodontics, CHX has been studied as an irrigant and intracanal medication, both in vivo and in vitro [34].In vitro, CHX is at least as effective as or even better than Ca(OH)2as an antimicrobial agent.

de Assis *et al*., reported that root canal irrigation with CHX significantly increased the bond strength to root dentin, indicating that adsorption of CHX by dentin might assist the resin penetrate into dentinal tubules, which accounts for the high bond strength achieved. However, further studies are necessary in this respect [35].

A study showed that a final rinse with CHX improves the wetting of AH Plus and Real Seal SE sealers on dentin surfaces [35]. Furthermore, Hashem *et al.,* reported that 2% CHX as the final rinse after 17% EDTA improved the bond strength of Active-GP [36].

One study showed that different irrigation protocols had different effects on the bond strength of resin sealers to dentin. In the gutta-percha/AH Plus groups, a combination of NaOCl and phosphoric acid or a combination of CHX and EDTA resulted in higher bond strength. In Resilon/Real Seal SE groups, a combination of CHX and phosphoric acid resulted in more favorable results. Use of CHX as a final rinse had no detrimental effects on the bond strength [37]. One study evaluated the influence of 2% CHX and 2.5% NaOCl on the resin sealer–dentin interface bond strength of AH Plus/gutta-percha and Epiphany/Resilon, indicating that NaOCl had a deleterious effect on AH Plus/gutta-percha bond strength, with CHX increasing the bond strength[38]. In one study the adhesion of Real Seal to human root dentin treated with different solutions was evaluated. No significant differences were noted between the irrigation protocols in the same root canal portion [39].

Cecchin *et al*., evaluated the effect of CHX and ethanol on the bond strength and durability of fiber posts bonded to root dentin using a total-etch adhesive system. The use of CHX pretreatment preserved the bond strength of the fiber post relined with composite resin to root dentin for 12 months. Application of EtOH and CHX, followed by EtOH, did not preserve the bond strength of the Scotchbond Multi-Purposetotal-etch adhesive system [40].

Pelegrine *et al*., evaluated the effect of chemical irrigants on the tensile bond strength of an adhesive system used to cement glass fiber posts to root dentin. The results showed that different

irrigation protocols had noeffect on the tensile bond strength of the intra radicular glass fiber posts to dentin [41].

Guneser *et al*., evaluated the effect of various root canal irrigation solutions on the push-out bond strength of Bio dentine in comparison with contemporary root perforation repair materials. The push-out bond strengths of Dyract AP, amalgam, IRM, and Biodentine were not significantly affected by immersion in NaOCl, CHX and saline solutions; however, MTA lost bond strength after being exposed to CHX [42]

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Ethanol

A 2011 study showed that drying with ethanol after etching of the post space did not increase the bond strength of fiber posts. One study investigated the effects of pretreatment with 2% CHX in a gel base and 100% EtOH on the bond strength between fiber posts relined with composite resin and root dentin under cyclic loading. The results showed that CHX and/or ethanol pretreatment preserved the bond strength of the fiber post after cyclic loading. Considering the lack of conclusive results on the effect of ethanol, further studies are recommended on its effect on fiber post bond strengths [43].

CONCLUSIONS

Based on studies that investigated the effects of irrigation protocols on teeth, it can be concluded that various irrigation protocols can affect different properties of tooth dentin such as micro hardness and dentin roughness. It can also affect the bond strength of fiber post and adhesive system, which can affect fracture resistance in teeth.

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