Original Article

Influence of Various Irrigation Protocols on Resistance to Vertical Root Fracture in Root Canal Treated Teeth

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Received 9 September 2020 and Accepted 6 November 2020

Abstract

Introduction: This study compared influence of various irrigation protocols on vertical root fracture resistance of root canal treated teeth. **Methods:** Forty-eight extracted mandibular premolars were included in the study. The root canals of teeth were instrumented and specimens were allocated into 4 (n = 12) groups according to the irrigation solutions: Group 1: 5% EDTA, 2.5% NaOCl and DW; Group 2: 5% EDTA, 2.5% NaOCl, DW and 2% CHX; Group 3: 5% EDTA, 2.5% NaOCl and 5% $Na_2S_2O_3$; Group 4: 5% EDTA, 2.5% NaOCl, 5% $Na_2S_2O_3$ and 2% CHX. Root canals were filled and a load in a vertical direction was applied a week later to specimens. The data were analysed using two-way ANOVA test ($P < 0.05$). **Results:** Interaction between using DW or $Na_2S_2O_3$ and using or not using CHX had a significant effect on fracture resistance to vertical forces ($P < 0.001$). Irrigation with $Na_2S_2O_3$ improves fracture resistance to vertical forces when compared to irrigation with DW ($P < 0.001$). Irrigation with CHX did not affect fracture resistance to vertical forces ($P = 0.759$). **Conclusion:** The irrigation solutions statistically affect resistance of root canal treated teeth to vertical fracture forces.

Keywords: Irrigation, Final Irrigation, Sodium Thiosulfate, Fracture Resistance

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Doğanay Yıldız E, Fidan ME, Dinçer B. Influence of Various Irrigation Protocols on Resistance to Vertical Root Fracture in Root Canal Treated Teeth. J Dent Mater Tech. 2021; 10(1): 28-33.

Introduction

The main goal of a root canal treatment is to remove bacteria from root canal system and provide a coronal and apical seal. Chemomechanical cleaning of root canals includes chemically active irrigation in addition to mechanical cleansing of canals (1). Mechanical debridement is important for this purpose; however, it alone is insufficient to provide disinfection of root canals (2, 3). Irrigation with chemical solutions is required in order to kill and remove more microorganisms from root canals (3). Until today, different irrigation solutions have been proposed for this purpose, but sodium hypochlorite (NaOCl) is still the gold standard irrigation for root canal treatment (4).

Using chemical solutions during root canal treatment may change physical and mechanical properties of dentine (5-8). Previous studies have shown that microhardness (9, 10), flexural strength (6), elasticity (11, 12), erosion (13) and fracture resistance of roots (8, 14, 15) might be negatively affected using irrigation solutions. It was shown that sequential use of irrigations during endodontic treatment might cause chemical interactions between them affecting root dentin (16).

Application of NaOCl decreases microhardness, elastic modulus and flexural strength of dentine (12). Irrigation with NaOCl, as an oxidizing agent, can degrade collagen and leave an oxygen-rich layer on surface of dentine (17, 18). The residual-free oxygen radicals can diffuse into dentine inhibiting bonding and decreasing bond strength of adhesive to root dentine. This oxygen-rich layer might also prevent penetration of root canal sealers into inter-tubular dentine and dentinal tubules (19-21). An antioxidant or reducing agent (e.g. sodium thiosulfate ($Na_2S_2O_3$) and sodium ascorbate) may restore decreased bond strength of dentine (17, 18). Since $Na_2S_2O_3$ is a potent antioxidant, it can neutralize oxidants and provide formation of a stable product (17). Many studies using $Na_2S_2O_3$ as a neutralizing agent for NaOCl have been published in microbiology field (22, 23).

This study aimed to compare influence of various irrigation protocols on resistance of root canal treated teeth to vertical forces. The null hypothesis was that there would be no significant difference among groups in regards to fracture resistance values.

Materials and Methods

Forty-eight extracted single straight rooted mandibular premolars were selected for this study. Crowns of teeth were removed and a standardized length (13±1) was obtained.

Dimensions of teeth (mesiodistal and buccolingual) were measured and recorded using an electronic calliper. Teeth were randomly allocated into four groups (n=12). A #15 K-file (Dentsply Sirona, Ballaigues, Switzerland) was inserted into the root canal under operating microscope. The length of the root was measured when tip of the instrument was seen at the apex. Working length was defined as 1 mm shorter of this length. Root canals were enlarged using ProTaper Universal system (Dentsply Sirona) up to F4 according to the manufacturer's instructions. After using each file, 1 mL 2.5% sodium hypochlorite (NaOCl) (Werax; Spot Dis Deposu AS, Izmir, Turkey) was used to irrigate with a side-vented irrigation needle (30-G; CK Dental Ind.Co.Ltd, Korea).

The irrigation solution as the final procedure of experimental groups was as follow:

Group 1: 5% ethylenediaminetetraaceticacid (EDTA), 2.5% NaOCl and distilled water (DW)

Group 2: 5% EDTA, 2.5% NaOCl, DW and 2% chlorhexidine (CHX)

Group 3: 5% EDTA, 2.5% NaOCl and 5% $Na_2S_2O_3$

Group 4: 5% EDTA, 2.5% NaOCl, 5% $Na_2S_2O_3$ and 2% CHX.

EDTA and NaOCl were used in order to dissolve organic and inorganic contents of smear layer, respectively. DW and $Na_2S_2O_3$ was used in order to remove oxygen-rich layer formed due to NaOCl use. CHX was used to change surface energy and wetting angle.

During final irrigation procedure, 5 ml of each solution was used. The irrigation needle was bended at a length corresponding to 1 mm short of working length and inserted into the canal until the bending. After completion of irrigation protocols, root canals were dried, and obturated with gutta-percha and sealer (2seal; VDW, Munchen, Germany) using lateral condensation technique. All teeth were kept at 37 ℃ in 100% humidity for one week to allow root canal sealer set.

The specimens were mounted vertically on custom made acrylic blocks exposing 3 mm of coronal part, while the rest was embedded in resin (Imicryl, Konya, Turkey). A cone-shaped rod was mounted on a Universal test machine (Esetron, Ankara, Turkey) directly over specimens (Figure 1). A load in a vertical direction at 1 mm/min speed was performed. Applied force was recorded (in Newtons) when fracture occurred.

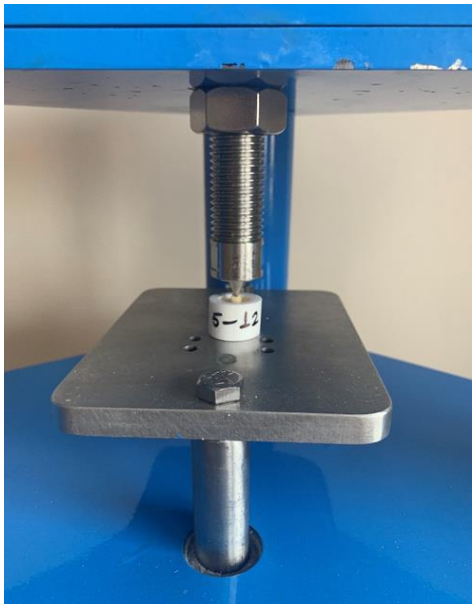

Figure 1. Fracture strength test apparatus.

Statistical Analysis

The statistical analyses were performed using SPSS 15.0 (IBM SPSS Inc, Chicago, IL) software. The statistical

significance level was set at 5%. Komolgov-Smirnov and two-factor analysis of variance (ANOVA) tests were used to analyse data.

Results

ANOVA test was performed to ensure that groups were similar in terms of mesiodistal and buccolingual dimensions. According to ANOVA, mesiodistal and buccolingual dimensions of teeth were similar (P = 0.440 for mesiodistal and P = 0.165 for buccolingual dimensions).

The fracture strength values (mean, standard deviations, minimum and maximum) were presented in Table I.

Table I. Mean ± standard deviation (SD), minimum and maximum fracture resistance values (N).

Groups	Mean ± SD	Minimum	Maximum
Group 1	268.61 ±36.9	178	307.4
Group 2	302.37 ± 17.67	277.4	329.4
Group 3	348.11 ± 19.01	319.7	372
Group 4	308.69 ± 44.81	222	398.8

According to Komolgov-Smirnov test, data distribution was normal and homogeneous. According to ANOVA, interaction between usage of DW or $Na_2S_2O_3$ and using or not using CHX had a significant effect on fracture resistance to vertical forces ($P < 0.001$, $F = 15.896$). When DW was used as solution for NaOCl removal, using CHX enhanced fracture resistance values. However, when $Na_2S_2O_3$ was used as solution for NaOCl removal, using CHX decreased the fracture resistance values. The type of solution used for NaOCl removal (DW or $Na_2S_2O_3$) showed statistically significant difference. Irrigation with $Na_2S_2O_3$ improved fracture resistance to the vertical forces when compared to irrigation with DW ($P < 0.001$, $F = 21.858$). Irrigation with CHX did not affect the fracture resistance to the vertical forces ($P = 0.759$, $F = 0.095$).

Discussion

In the present study, the influence of various irrigation protocols on resistance of root canal treated teeth to vertical fracture forces were assessed. The null hypothesis was that there would be no significant difference among groups with regard to fracture resistance to vertical forces. According to statistical analysis, significant differences among groups were found. Therefore, the null hypothesis was not accepted.

NaOCl is the most preferred irrigation solution in endodontics. However, it is known that the use of NaOCl causes dentine bond strength reduction. This feature of NaOCl could be related to forming a less receptive bonding surface (24). Irrigation with NaOCl can leave an oxygen-rich layer on surface of dentine, and this layer decrease bond strength of root canal sealer to root dentin (19-21). $Na_2S_2O_3$ is a neutralizing agent of NaOCl, it recovers bond strength loss because of irrigating solutions (17). In present study, it was found that irrigation with $Na_2S_2O_3$ improved fracture resistance to vertical forces when compared to irrigation with DW ($P < 0.001$). This result can be attributed to antioxidizing effect of $Na_2S_2O_3$. According to our literature research, there is no similar study in the literature. Therefore, a direct comparison cannot be performed. Nassar et al. (25) reported that irrigation with sodium ascorbate after using NaOCl enhanced bond strength of Epiphany SE sealer to dentine. Lai et al. (26) and Vongphan et al. (18) showed that using sodium ascorbate after using NaOCl significantly increased bond strength of adhesive systems. Pimentel Correa et al. (17) found that using $Na_2S_2O_3$ after using NaOCl and citric acid provided bond strength of composite resin to the dentine to enhance. Although a direct comparison is not possible, results of these studies are along with results of the present study.

Irrigation with DW showed lower fracture resistance values when compared to irrigation with $Na_2S_2O_3$ ($P < 0.001$). It has been postulated that this could be attributed to lack of DW in removing oxygen layer compared to $Na_2S_2O_3$.

It has been shown that CHX changes surface energy and wetting angle, thus it improves penetration and bond strength of an epoxy resin-based root canal sealer and wettability of dentine (27, 28). CHX may protect collagen from host-derived proteases, which degenerate

collagen in demineralized dentine (29, 30). Despite these properties of CHX, in present study, it was found that irrigation with CHX did not affect fracture resistance to vertical forces (P = 0.759). However, interaction between using DW or $Na_2S_2O_3$ and using or not using CHX had a significant effect on fracture resistance to vertical forces (P < 0.001). This result may be attributed to white colored precipitate which forms due to irrigation with CHX after $Na_2S_2O_3$. This precipitate may decrease fracture resistance to vertical forces.

Since adaptation, penetration and bond strength of root canal sealers decrease in presence of smear layer on root canal walls (31, 32), removal of this layer may enhance fracture resistance of teeth to vertical forces (33). Therefore, it is required to use an organic dissolvent and an inorganic dissolvent for final irrigation. In the present study, 5% EDTA and 2.5% NaOCl were used in order to remove smear layer in all of the groups.

Since using NaOCl remains an oxygen-rich layer decreasing bond strength of root canal sealer to root dentine (19-21), irrigation was not finished with hypochlorite in any of group in present study.

The main limitations of this in vitro study were that teeth were decoronated in order to obtain a standardized length and periodontal ligament was not simulated.

Conclusion

The results of present study demonstrated that irrigation solutions have a significant impact on fracture resistance of root canal treated teeth to vertical forces. According to results of the present study, it can be claimed that irrigation with 5% $Na_2S_2O_3$ enhances fracture resistance values of root canal treated teeth when compared to irrigation with DW.

Conflict of Interest

The authors deny any conflicts of interest related to this study.

Acknowledge

The authors deny any conflicts of interest related to this study. This study was presented at the 19th European Society of Endodontology (ESE) Congress, 11-14 September 2019, Vienna, Austria.

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