

The Effect of Root Canal Irrigation Solution on Flexural Strength of Dentin

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Abstract

Objectives: This study was to investigate the effect of a variety of root canal irrigation solutions on flexural strength of dentin. **Materials and Methods:** Fifty intact, extracted human mandibular third molars were used in this study. Each tooth was sectioned using diamond cutting disc to create dentin bar (1X1 mm, with 7 mm in length). All dentin bars were randomly assigned into 5 groups of 10 each. Group 1, dentin bars were immersed in 5% NaOCl; group 2, in 2.5% NaOCl; group 3, in 15% EDTA; group 4, in 0.2% chlorhexidine gluconate (CHX); and group 5, in saline (as control) respectively. Each group was immersed for 2 hours. Each dentin bar was subjected to a three-point bend using MTS Universal Testing Machine to test the flexural strength. Data were analyzed using one way Anova, followed by Tukey's test performed at the 0.05 level of significance. **Results:** All irrigation solution have an effect on the flexural strength ($P < 0.05$). EDTA caused the greatest effect on dentin mechanical properties, which revealed the lowest flexural strength (100.64 ± 7.23). In contrast, 0.2% CHX generated the least influence on dentin mechanical properties, which demonstrated the greatest flexural strength (189.85 ± 6.44). **Conclusion:** Root canal irrigation solution can induce effect on flexural strength of dentin. Chlorhexidine gluconate demonstrates the best irrigation solution since it has a slight effect on dentin mechanical properties, particularly flexural strength.

Keywords: Irrigation solution, dentin mechanical properties, flexural strength

Introduction

It is generally believed that endodontic treatments render teeth weaker than normal vital teeth. The reduction in tooth structure and the effect of dehydration on dentinal tubules are widely

considered to be the main reasons associated with increased weakness and brittleness of pulpless teeth¹. Cleaning is necessitated during root canal treatment to remove all contents of the root canal system before and during shaping.

Successful cleaning entails the use of instruments to physically remove substances, irrigating systems to flush loosened materials away, and chemicals to dissolve contents from inaccessible regions. Irrigation is presently the best method for the removal of tissue remnants and dentin debris during instrumentation².

Several commonly used irrigants for root canal treatment are sodium hypochlorite (NaOCl), ethylenediaminetetraacetic acid (EDTA), chlorhexidine gluconate (CHX) and saline^{3,4,5}. Each irrigant solution used during root canal treatment has advantages and disadvantages. NaOCl has been shown to be an effective agent in dissolving organic tissue, and a good antimicrobial effect, and seems to be the most effective undiluted at 5.25% concentration. Despite these attributes, NaOCl is not an ideal irrigant, since it does not remove the smear layer, is not effective against *Enterococcus faecalis*, and has been shown to be toxic particularly at high concentration^{4,5}. Studies have revealed that lower concentrations of NaOCl are effective in cleaning and disinfecting root canal system. It would thus be prudent to select a suitable concentration which has minimal effects on the mechanical properties of the tooth whilst

achieving the desired debridement effect⁶. Chelating agents such as EDTA have been the irrigant of choice to demineralize dentin and aid in the removal of the inorganic component of the smear layer; however it has no antibacterial activity and has the ability to erode the dentin⁷. Recently, CHX has been recommended as a root canal irrigant, and many studies have demonstrated its broad spectrum antimicrobial action, substantivity, and its low grade toxicity. However, the inability of CHX to dissolve organic materials has been a problem⁸.

During irrigation, root canal dentin is exposed to irrigation solutions. Since dentin consists of organic and inorganic components, exposure of dentin to irrigation solution may alter its mechanical properties of dentin, such as flexural strength. Due to a major part of the tooth structure consist of dentin, any change in the mechanical properties of dentin after irrigation is likely to have an impact on the overall strength of the tooth^{9,10}. However, the alterations of dentin mechanical properties have not been studied extensively. The purpose of this study was to investigate the effect of a variety of root canal irrigation solutions on flexural strength of dentin.

Materials and Methods

Fifty intact, extracted human mandibular third molars were used in this study. After removal of calculus and soft-tissue debris, the teeth were stored in saline solution. Dentin bars were prepared using diamond cutting disk (Edenta, Swiss). This resulted in 1X1 mm dentin bars with at least 7 mm in length.

All dentin bars were randomly assigned to 5 groups of 10 each. Then, all groups were treated as follows: group 1: dentin bars were immersed in 30 ml of 5% NaOCl (Alfa Kimia, Indonesia); group 2, in 30 ml of 2.5% NaOCl (Alfa Kimia, Indonesia); group 3, in 30 ml of 15% EDTA (Largal Ultra, France); group 4, in 30 ml of 0.2% CHX (Bisco, USA); and group 5, in 30 ml of saline solution (Otsuka, Indonesia), which served as control. Each group was immersed in each irrigation solution for 2 hours.

At the completion of the treatment, all dentin bars were rinsed with copious amounts of water, dried and tested immediately. The specimens were tested for flexural strength on a three-point bend testing apparatus using MTS Universal Testing Machine (Type AMU-5-DE, Tokyo Testing Machine, MFG, Co., LT, Tokyo, Japan) at a cross-head speed of 1 mm/min. The width

and thickness of dentin bars were measured using electronic calipers (Mitutoyo, Japan), and then the specimens were positioned on two points to create a 5-mm test span with the cross-head centered in this span (Figure 1). The load required to fracture the specimens was recorded and expressed in MPa (Figure 2). The mode of fracture was recorded as complete or incomplete fracture. The flexural strength was calculated from the following equation:

$$\text{Stress} = \frac{3 \times \text{Load} \times \text{Length}}{2 \times \text{Width} \times \text{Thickness}^2}$$

The data were statistically analyzed using one-way ANOVA, and the comparisons of means were conducted using Tukey multiple comparison test. The analysis was performed at the 0.05 level of significance.

Results

The means and standard deviations of flexural strength of all irrigation solution groups are listed in Table 1. Compared to the control group, all irrigation solutions (5% NaOCl, 2.5% NaOCl, 15% EDTA and 0.2% CHX) significantly decreased the flexural strength of dentin ($p < 0.05$) and 15% EDTA caused the lowest flexural

strength of dentin, whereas irrigation using 0.2% CHX produced the greatest flexural strength.

While, Tukey multiple comparison test demonstrated that a statistically significant differences were found between irrigation solutions ($p < 0.05$) (Table 2).

Discussion

The possible effects of irrigant solution on the structure and physical properties of endodontically treated teeth have not been extensively investigated. In this study, the effects of a variety of root canal irrigation solutions on flexural strength of dentin were examined. All irrigation solutions tested in this study reduced the flexural strength as compared to saline solution as a control. The decrease in flexural strength is clinically relevant as it indicates that far less force

is required for the cohesive bonds within dentin to fail⁹. It was also revealed that 0.2% CHX caused the less decrease flexural strength compared to other treated irrigant solutions.

Dentin composition has been described based on organic and inorganic components. Calcium (Ca) and phosphorus (P) present in hydroxyapatite crystals are the major inorganic components of dental hard tissue. It has been reported that some chemical agents caused alteration in the chemical structure of human dentin and changed the Ca/P ratio of the dentin surface, which in turn, caused dentin to be dissolved⁸. This study showed that 15% EDTA generated the lowest flexural strength. It is due to the chelating action of EDTA to remove smear layer, demineralize, as well as soften inorganic content of dentin. This action caused alteration

Tabel 1. The means and standard deviations (Mean \pm SD) of the flexural strength of dentin for each irrigation solution (in MPa)

| Irigasi solution | N | Flexural Strength ($\bar{X} \pm SD$) |
|------------------|----|--|
| 5% NaOCl | 10 | 135.72 \pm 7.83 |
| 2.5% NaOCl | 10 | 168.17 \pm 8.09 |
| 15% EDTA | 10 | 100.64 \pm 7.23 |
| 0.2% CHX | 10 | 189.85 \pm 6.44 |
| Saline (control) | 10 | 200.04 \pm 8.66 |

Table 2. Statistical analysis using One way ANOVA on flexural strength of dentin

| Source of variation | df | SS | MS | F | P-value |
|---------------------|----|---------|-------|--------|---------|
| Between groups | 4 | 66680.2 | 16670 | 282.23 | 0.000 |
| Within groups | 45 | 2657.9 | 59.1 | | |
| Total | 49 | 69338.1 | | | |

Ca/P ratio, resulting in reducing the flexural strength of dentin^{8,11}.

In contrast, 0.2% CHX produced the greatest flexural strength. It is because 0.2% CHX has no effect in dissolving organic and inorganic component of dentin in root canal wall⁴. Therefore, 0.2% CHX may not alter the chemical structure of human dentin. Although 0.2% CHX reduced slightly the flexural strength of dentin, the effect of 0.2% CHX was in the range of flexural strength of normal dentin¹¹.

Sodium hypochlorite, one of the most widely used root canal irrigants, significantly lowered the flexural strength of dentin after 2-hour exposure, thereby possibly contributing to the weakening of root canal-treated teeth. A 2-hour exposure time was chosen for the maximum time a tooth would be exposed to an irrigant for multi-visit endodontic treatment⁶. Previous study demonstrated that a decrease in flexural strength

values to 55% of that of normal bone¹². This reduction due to the change in mechanical behavior of the altered bone must result from dissolution of the collagen or the collagen-mineral bond. It would seem reasonable to speculate that the same phenomenon occurs in dentin. In addition, the dentin bars which had been immersed in 5% NaOCl appeared bleached and chalky in texture. This appearance indicated a significant decrease in flexural strength and rigidity compared to other groups. The change in mechanical properties could be explained by the loss of the organic matrix within the dentin⁹.

There has been much controversy over the concentration of NaOCl used in root canal treatment. The result of this study demonstrated that the higher concentration of NaOCl would have greater effect on the properties of dentin. This is most likely because of the proteolytic action of concentrated NaOCl on the collagen

matrix of dentin¹³. Even though the higher concentration has the greater effect in removing the organic and inorganic materials, the effect on dentin structure also the highest. Therefore, it has been recommended that only minimal exposure time to high concentration of NaOCl should be used to diminish undesirable effect of the irrigation solutions¹⁴.

The pH of irrigation solution can affect the properties of dentin. As the pH increases, the protein structure is able to be dissolved, which in turn, weaken the dentin structure. Conversely, as the pH decreases, the inorganic will be dissolved¹⁴. Therefore the pH used in this study was neutral to avoid the side effect of pH. Saline, which served as control, was used as a standard neutral solution, hence, is not considered to be different in its effect on dentin from that exerted by distilled or tap water⁹.

The reduction in tooth structure due to caries or access cavity preparation, and the effect of root canal treatment are considered to be the factors that may predispose to fracture in endodontically treated teeth¹⁵. Therefore, if encountered clinically, endodontists need to be selective and cautious in using root canal irrigation solution, particularly those which can alter the

mechanical properties of dentin, such as flexural strength. However, several factors in employing irrigation solutions also need to be considered in related to cause the brittleness of teeth, such as the length of exposure to root canal dentin, the concentration, and the pH of irrigation solutions used^{6,9,10}.



Figure 1. Dentin bar was positioned on two points with the cross-head was put in the center

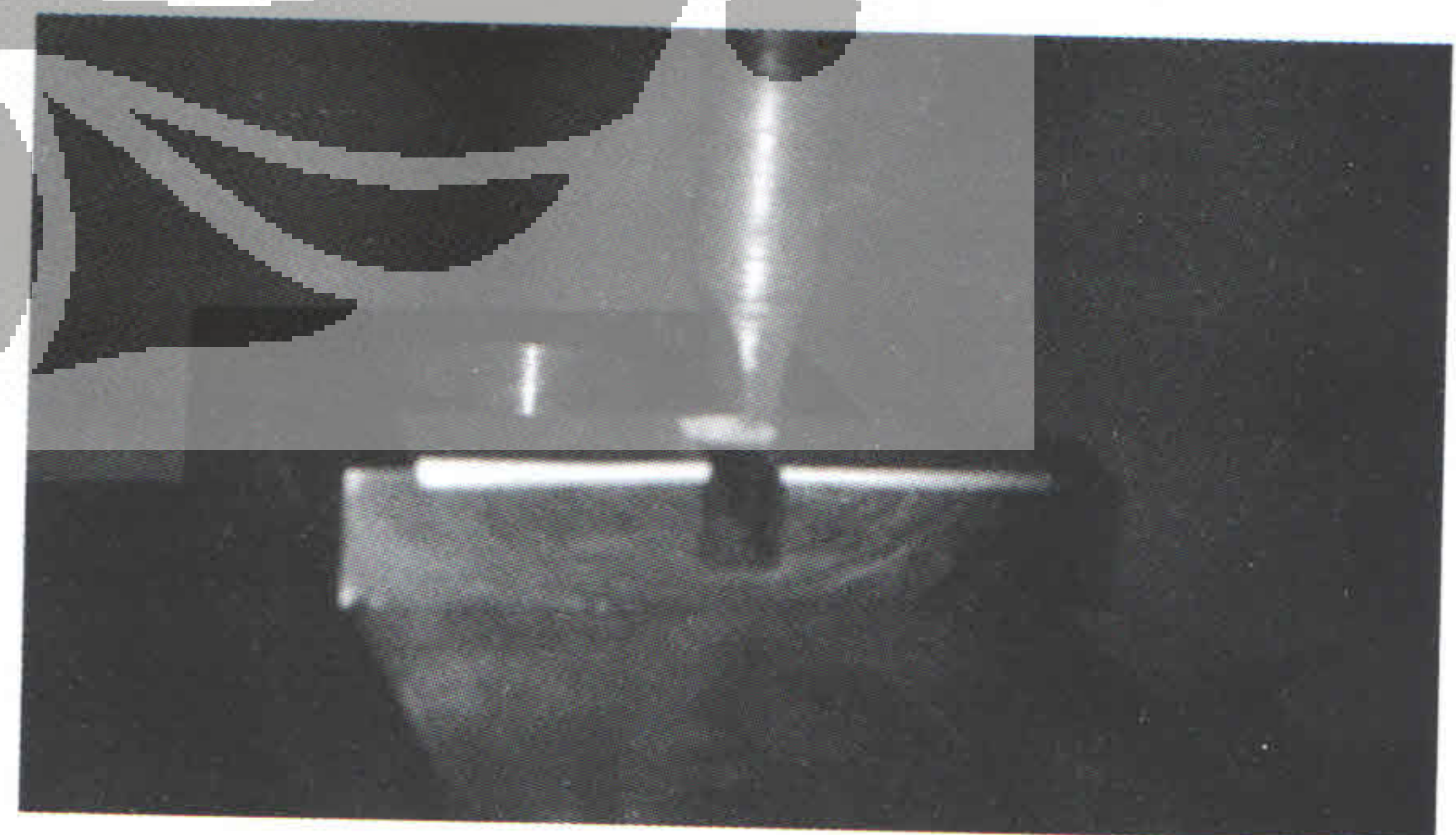


Figure 2. A load was compressed on dentin bars until fracture

Conclusion and Suggestion

Root canal irrigation solution can induce effect on flexural strength of dentin. From all of irrigation solutions tested, 0.2% chlorhexidine gluconate demonstrates the best irrigation solution since it has slight effect on dentin mechanical properties, particularly flexural strength.

Based on this study it is recommended to employ 0.2% chlorhexidine gluconate for irrigation solution. Further study need to be undertaken with regards to the effect of 0.2% chlorhexidine gluconate in combination with other irrigation solutions, such as NaOCl and EDTA on mechanical properties of dentin.

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