Effect of EDTA and Citric Acid Solutions on the Microhardness and the Roughness of Human Root Canal Dentin

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Abstract

The purpose of this study was to evaluate the effect of citric acid and EDTA solutions on the microhardness and the roughness of human root canal dentin. Forty-five human teeth sectioned longitudinally were used. Specimens were randomly divided into three groups of 30 teeth each and were treated as follows: (a) one molar (19%) citric acid ($C_6H_8O_7$) for 150 s followed by 5.25% NaOCl; (b) 17% EDTA for 150 s and rinsed with 5.25% NaOCl; (c) rinsed with distilled water and served as control. Three groups were then divided into two subgroups of 15 specimens each. The specimens, in first subgroup were subjected to Vicker's testing whereas the second subgroup underwent surface roughness testing. The results were analyzed using one-way ANOVA and Tukey tests. Significant differences were observed in microhardness among the test groups, citric acid group being the least hard (p 0.05). Also, citric acid significantly increased surface roughness.

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The success of root canal therapy depends on the method and the quality of instrumentation, irrigation, disinfection, and three-dimensional obturation of the root canal. Endodontic instrumentation using either manual or mechanized techniques, produces a smear layer and plugs of organic and inorganic particles of calcified tissue and organic elements such as pulp tissue debris, odontoblastic processes, microorganisms, and blood cells in dentinal tubules (1).

Though the influence of this layer on the success rate of endodontic treatment has not yet been definitely determined, it is currently considered important to promote techniques and products that can prevent the formation or elimination of this layer (2). Different irrigant solutions have been used to remove the smear layer. Decalcifying solutions such as citric acid and EDTA have been reported as suitable to remove the smear layer (3, 4). Various EDTA solutions have been studied for their ability to ease instrumentation and for effective removal of the smear layer (4) and their effects on radicular dentin microhardness was evaluated (5). Irrigating the root canals with 10 ml of 17% EDTA, followed by 10 ml of 5% NaOCl has been recommended as an effective method to remove the smear layer (6).

Another chelating agent that is used in the canal for smear layer removal is citric acid. This acid removes smear layers better than many acids such as polyacrylic acid, lactic acid, and phosphoric acid (7). Although this solution is not as effective in removing smear layer as EDTA, Ando (8) reported that citric acid is less cytotoxic to tissue. Wayman et al. (3) showed that best results are gained if smear layer is removed by sequential use of citric acid and NaOCl solutions.

It has been reported that these kind of chemical agents caused alterations in the chemical structure of human dentin and changed the Calcium/Phosphorus (Ca/P) ratio of the dentin surface (9). The alterations in Ca/P ratio may change the original ratio between organic and inorganic components that in turn change the permeability, solubility characteristics of dentin and may also effect the adhesion of dental materials to hard tissues (10, 11).

As microhardness is sensitive to composition and surface changes of tooth structure (12, 13), the effects of some chemicals such as gutta percha solvents (14), hydrogen peroxide, sodium perborate (15), EDTA, and combination of hydrogen peroxide and sodium hypochlorite (16), EDTAC, CDTA, and EGTA (5) solutions on the reduction of dentin hardness were previously evaluated.

The purpose of this in vitro study was to evaluate the effect of 19% citric acid and 17% EDTA solutions on the microhardness and the roughness of human root canal dentin by using these solutions alternately with 5.25% NaOCl solution.

Materials and Methods

Forty-five human mandibular anterior teeth, recently extracted for periodontal reasons were collected from patients of both sexes ranging between the ages of 35 to 40 and were used in this study. The selection of teeth was made on the basis of relative dimensions, similarity in morphology, and absence of any cracks or carious defects especially within the root portions. Debris and soft tissue remnants on the root were cleaned with a sharp scalpel and all the teeth were stored in phosphate buffered saline at 4°C until used.

The crowns were removed at the cemento-enamel junction using a high-speed bur under water-cooling. Each root was sectioned longitudinally by starting from cervical

with a low speed diamond saw (Isomet, Buehler Ltd., Lake Bluff, NY) and separated into buccal and lingual segments making a total of 90 segments. The root segments were horizontally mounted in autopolymerizing acrylic resin so that their dentin was exposed. The dentin surfaces of the mounted specimens were grounded smooth with a series of increasingly finer emery papers (Shor International Corporation, Mt. Vernon, NY) under distilled water to remove any surface scratches, and finally polished with 0.1 μm alumina suspension (Ultra-Sol R, Eminess Technologies Inc., Monroe, NC) on felt cloth.

Ninety specimens were divided into three groups and prepared as follows.

Group 1: The specimens were treated with 17% EDTA (Disodium salt of EDTA; Merck Co. Darmstadt, Germany) (pH = 7.7) for 150 s and then rinsed with 5.25% NaOCI for 150 s.

Group 2: The specimens were treated with 19% citric acid solution (citric acid monohydrate; Merck Co.) (pH = 1.3) for 150 s and then with 5.25% NaOCl (Çağlayan Kimba, Konya, Turkey) (pH = 11.85) for 150 s.

Group 3: The specimens were treated with distilled water and this group served as control.

Every group was then divided into two subgroups of 15 specimens each.

The specimens, in groups 1a, 2a, and 3a were used to determine the surface hardness of the root dentin with a Vicker's Hardness Tester (Matsuzawa MHT2, High Quality Microhardness Tester, Matsuzawa SEIKI Co., Ltd., Tokyo, Japan) (Fig. 1). The indentations were made with a Vicker's diamond indenter at a minimum of three widely separate locations. The locations were chosen at 0.5-mm level to root canal wall in apical, middle, and cervical region of the roots. The indentations were made on the cut surface of each specimen using 300 g load and a dwell time of 20 s. The values were averaged to produce one hardness value for each specimen. These measurements were converted into Vicker's numbers.

The specimens in groups 1b, 2b, and 3b were used for the determination of surface roughness (Ra, μm) of root dentin with a computerized roughness tester (Mitutoyo Surftest Analyser, Matsuzawa SEIKI Co., Ltd.). Three tracings of different locations on each of the specimens were made. The Ra mean and standard deviations were determined. The Ra parameter describes the overall roughness of a surface and can be defined as arithmetical average value of all absolute distances of the roughness profile from the centerline within the measuring length.

The microhardness and roughness values were statistically analyzed by one-way ANOVA and the comparison of means was conducted using a post hoc Tukey multiple comparison test.

Results

The mean and SD values of the root dentin microhardness data for 17% EDTA and 19% citric acid treated groups and control groups are listed in Table 1. The hardness values of EDTA treated (group 1), citric acid treated (group 2), and control (group 3) groups were as follows, respectively; 53.11 ± 7.4, 46.35 ± 5.77, and 69.73 ± 7.89. Differences in microhardness were statistically significant among the test groups ($p < 0.05$). Reduction in hardness was statistically significant for EDTA and citric acid groups when compared with the control group ($p = 0.037$ and $p = 0.0001$, respectively).

The mean values and SD of the root dentin roughness values for 17% EDTA and 19% citric acid treated groups and control groups are listed in Table 2. The roughness values of groups 1, 2, and 3 were as follows, respectively; 0.50 ± 0.16, 0.70 ± 0.13, and 0.39 ± 0.10. When the results of surface roughness values were analyzed, the differences between EDTA and citric acid groups and citric acid and control groups were found statistically significant ($p < 0.05$). The comparison of the changes in dentin roughness after the use of both smear removal solutions indicated that, the increase in dentin roughness after citric acid treatment was significantly greater than the EDTA treated ($p = 0.001$) and the control groups ($p = 0.0001$).

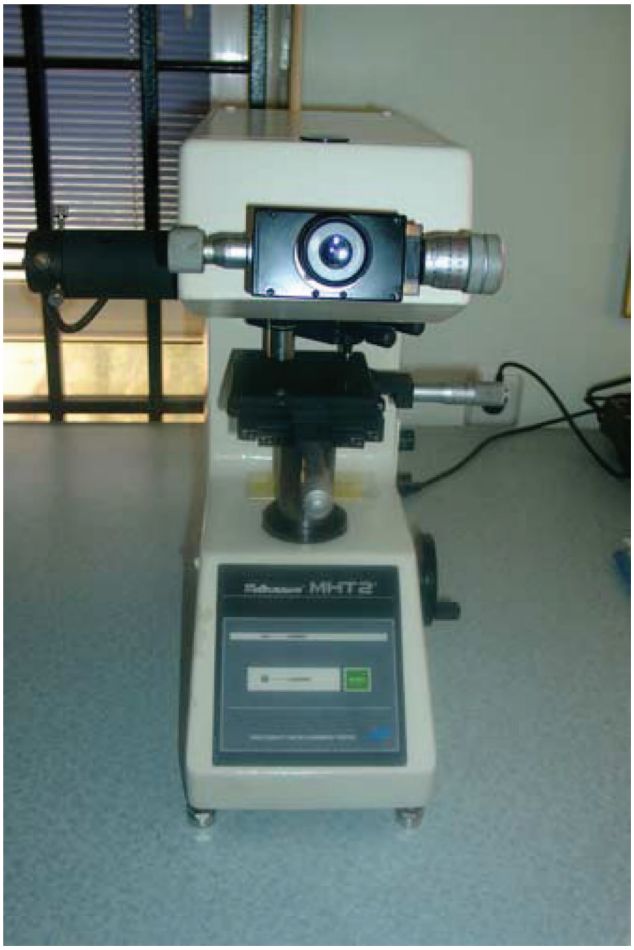

Fig 1. Vicker's hardness tester.

TABLE 1. The means and standard deviations of the root dentin microhardness values for experimental and control groups.

Groups	*n*	Microhardness values (Mean ± SD)*
EDTA	*n* = 15	53.11 ± 7.4[b]
Citric Acid	*n* = 15	46.35 ± 5.77[c]
Control	*n* = 15	69.73 ± 7.89[a]

* The different letters in the column mean statistically significant difference ($p < 0.05$).

TABLE 2. The means and standard deviations of the root dentin roughness values for experimental and control groups.

Groups	n	Roughness values (Mean ± SD)*
EDTA	n = 15	0.50 ± 0.16[b]
Citric Acid	n = 15	0.70 ± 0.13[a]
Control	n = 15	0.39 ± 0.10[b]

* The same letters in the column are not statistically significant ($p > 0.05$).