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EFFECT OF DIFFERENT IRRIGANT SOLUTIONS ON MICROHARDNESS AND SURFACE ROUGHNESS OF HUMAN ROOT CANAL DENTIN

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ABSTRACT

Context: Smear layer is a negative factor which prevents adhesion of the filling material to the dentinal walls. Chelating agents are used during cleaning and shaping of the root canals to remove the smear layer.

Aims: To evaluate the effect of 17% EDTA, 19 % citric acid and 7 % malic acid solutions on microhardness and surface roughness of root canal dentin.

Materials and Methods: Eighty root halves of single-rooted teeth were divided into four groups (20 specimen for each) and subjected to different chemical treatments as follows: Group I – 17 % EDTA, Group II – 19 % citric acid, Group III – 7 % malic acid and Group IV - Saline as a control group. Each group was divided into two subgroup 'a' and 'b' (10 specimen for each). 'a' group were subjected to microhardness testing and 'b' group were subjected to surface roughness testing.

Statistical Analysis Used: Results were subjected to One-way ANOVA and Tukey's test.

Results: Difference in microhardness values was significant among all investigated groups. Malic acid decreased the overall microhardness of the root canal dentin more than other irrigants. Citric acid caused minimum reduction in microhardness. Maximum increase in surface roughness was seen in malic acid group and minimum increase in EDTA group.

Conclusions: Malic acid, EDTA and citric acid drastically reduce the microhardness and increase the surface roughness of radicular dentin. Citric acid caused minimum reduction in microhardness and malic acid caused maximum increase in surface roughness.

KEY WORDS: EDTA, Citric acid, Malic acid, Microhardness, Surface roughness, Irrigant solutions, Radicular dentin.

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INTRODUCTION

Root canal cleaning using effective irrigation during shaping of root canals is consider one of the most importatant steps in determining the success of endodontic treatement [1].

Chemical debridement of the root canal system serve different purposes including disinfection, dissolution of vital or necrotic pulp tissues and removal of the inorganic smear layer [2].

It was found that the canal irrigant solutions may induce adverse changes in microhardness and surface roughness of root dentin that consequently may affects the clinical performance of endodontically treated teeth [3,4].

Human dentin mainly composed of about 70% inorganic material, while its organic material mainly composed of 90% collagen [5]. Irrigating solutions may interfere with the chemical structure of dentin by altering its original proportion of organic and inorganic components, and cause changing in the Ca/P ratio, which in turn decreases the microhardness of dentin and can increase its surface roughness [6,7].

Ethylene diaminetetra acetic acid (EDTA), citric acid and malic acid irrigant solutions can decrease dentin microhardness by demineralization and softening of dentin through its chelating action [8,9].

It has been reported that the malic acid showed the greatest reduction in dentin microhardness when compared with EDTA [9]. Other investigations reported that malic acid when compared with EDTA produced insignificant reduction in dentin microhardness, howevere malic acid significantly increases the dentin roughness[7].

Altought root canal instrumentation can be facilitated by the decreases in microhardness of root dentin, but it may also weaken root structure [10].

Surface roughness of root dentin is important for micromechanical bonding of different adhesive materials that have different physical and chemical characteristics to root dentin, therefore the scientific understanding of the characteristics of the surface is important to obtain adequate adhesion [11].

The aim of this study was to compare the effects of different chemical irrigation agents on the surface microhardness and roughness of root dentin. The tested hypothesis was that the agents studied would affect the physical properties and structure of radicular dentin.

MATERIALS AND METHODS

Tooth selection and preparation: forty non-carious, non- hypoplastic, free from cracks or any defects within root portions, freshly extracted single-rooted human teeth were collected for the study. Tissue and debris remnants on the root surfaces were removed, and all teeth were stored in distilled water until use [11].

The teeth were decoronated at the cementum-enamel junction using a low-speed diamond disk under coolant water. Sectioning was performed again at the level of apical foramen to ensure that only the canal dentin was analyzed. Each root was then bisected longitudinally to obtain the eighty root halves needed for the study [11].

The root halves were embedded in autopolymerizing acrylic resin, leaving the dentin surface exposed.

The samples were polished with 400, 600, and 1200 grit silicon carbide abrasive papers under constant water to obtain standard surface roughness.

Then the samples were randomly divided into four groups (n=20) based on tested irrigant solution used [11].

Grouping:

The root sample of each group was immersed in the tested irrigant solutions for 5 minutes in closed glass plates at 37 ^{0}C [10].

Group I: 17% EDTA solution for 5 min.

Group II: 19 % citric acid solution for 5 min.

GroupIII: 7 % malic acid solution for 5 min.

Group IV: 9 % saline as a control group.

At the end of active treatment period (5min) in according to De Deus et al. [12], and Sayin et al. [13], the samples were rinsed with 30 mL sterile saline and dried with sterile paper points [10]. Every group was then randomly devided into two subgroups of 10 each according to test.

Micro-Hardness Testing:

The samples were mounted on Vicker's Microhardness Tester (SIOMM, HV-1000DT, Shanghi, China).

The indentations were made with Vicker's diamond indenter that was focused at the midroot portion which is halfway from the outer surfaces. The indentations were made using 200 gms load and dwell time of 10 seconds. These indentations were measured and converted into Vickers hardness number (VHN) values by the monitor [14].

Surface Roughness Testing:

The samples were placed on a flat table surface and the needle of the Computerized Roughness Tester (Mitutoyo, SJ-210, Japan) was placed on the tooth surface.

The locations were in the apical, middle and cervical regions of the root canal wall. The tested surface roughness values were displayed digitally on the screen of the roughness tester. The roughness values are expressed as Ra (µm).

The Ra parameter describes the overall roughness of the surface and defined as arithmetical average value of all abslute distances of the roughness profile from the center line within the measuring length [14].

Statisical analysis used:

Data were statistically analyzed using One-way analysis of variant (ANOVA) and the comparison of means was conducted using Tukey's multiple test.

RESULTS

Results of study were evaluated and tabulated as follows.

Microhardness results:

The Vicker's microhardness values (mean ± SD) for the irrigating regimens are summarized in [Table 1] and shown in [Figure 1]. Statistically significant difference was detected among the irrigating solutions. The results showed that all irrigating solutions, except for distilled water (control), decreased dentin microhardness.

Tukey's test showed that there was a statistically significant difference between maliec acid, EDTA and citric acid, but there was no significant difference between cetric acid and control group. Malic acid had the greatest overall effect on dentin microhardness, causing a sharper decrease compared with the other solutions, followed by EDTA solution, while cetric acid had the least effect on dentin hardness.

TABLE (1) Vicker's microhardness values (mean ± SD) of root canal dentin among the effect of irrigation.

Group	Mean	SD	Rank	*P*-value
Control	45.9	3.93	C	0.000
Citric acid	45.3	1.10	C	
Malic acid	14.8	1.79	A	
EDTA	22.6	0.89	B	

Different letters indicate statistically significant difference (p<0.05).

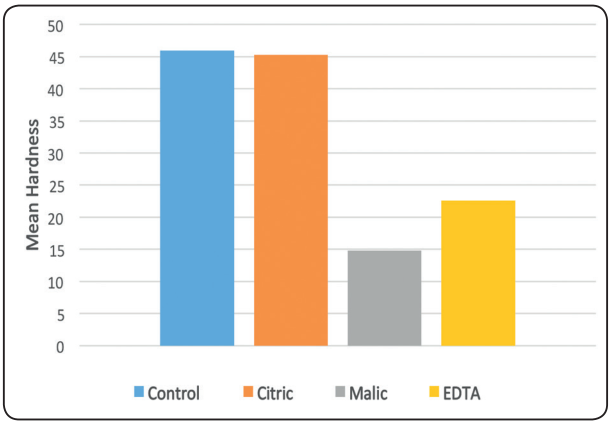

Fig. (1) Bar chart of Vicker's microhardness mean values of root canal dentin among the effect of irrigation.

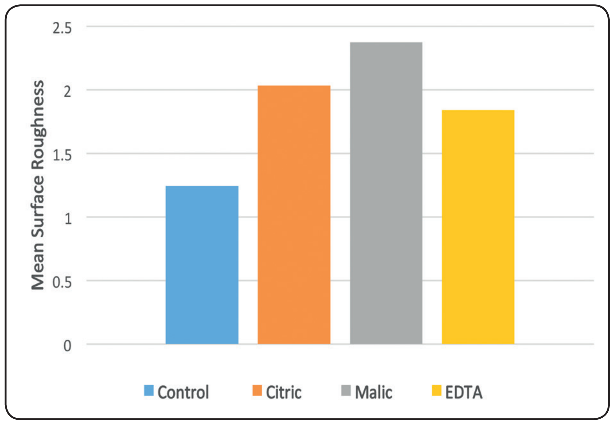

Fig. (2) Bar chart surface roughness mean values of root canal dentin among the effect of irrigation.

Surface roughness results

The surface roughness values (mean ± SD) of the root canal dentin after irrigation are summarized in [Table 2] and mean shown in [Figure 2]. The result showed that no statistically significant difference was detected among the effect of the irrigating solutions. All irrigating solutions, except for distilled water (control), increased dentin roughness. Malic acid showed the highest mean followed by citric acid however EDTA revealed the lowest effect on surface roughness among the irrigant solution, except for distilled water (control).

TABLE (2) Surface roughness values (mean ± SD) of root canal dentin among the effect of irrigation.

Group	Mean	SD	*P*-value
Control	1.243	0.13	0.51
Citric acid	2.032	0.24	
Malic acid	2.376	0.57	
EDTA	1.841	0.40	

** significant at $p \leq 0.05$.*

DISCUSSION

The succes of root canal therapy depends mainly on the method and quality of instrumentation, irrigation, disinfiction, and three-dimensional obturation. Irrigation is the most effective method for removal of root tissue remnants and smear layer debris to enhance the adhesive ability of endodontic sealer to dentin and lubricantion during instrumentation [15,16]. EDTA, citric acid and malic acid use as irrigating solution because they have effective role in removal of the smear layer in radicular dentin [17].

In the present study, anterior teeth were selected to help in ease of separating these single-rooted teeth longitudinally. The roots were separated longitudinally to expose the root dentin surface for testing. The sectioned roots were embedded in acrylic resin to have a proper base and support for further testing.

The sections were cut under water cooling to prevent dissication of teeth while sectioning. The sectioned root were ground polished to have even and polished surfaces for microhardness and roughness testing [14].

The measurement of the hardness of a material is one of the simplest non destructive mechanical characterization methods. Hardness is measured as the resistance to penetration of an indentor that is necessarily harder than the sample to be analysed [12]. Microhardness measurement could provide indirect evidence of mineral loss in dental hard tissues [18].

Selection of Vickers microhardness tester over Knoop hardness tester was due to the suitability and practicality of Vickers test for evaluating surface changes of deeper dental hard tissues. Knoop hardness tester is used for superficial dentin at 0.1 mm rather than for deep dentin[19].

Dentin microhardness declined when tested from superficial to deep regions, because the increased number of widely opened dentinal tubules that free of peri-tubular dentin near the pulp will showing reduction in dentin resistance to microhardness testing especially at the cervical region of the root. David Pashley et al. proposed that there is an inverse correlation between tubular density and dentin microhardness[20].

Chelation is a physicochemical process that prompts the uptake of multivalent positive ions by specific chemical substances. In the case of root dentin, the chelating agent reacts with the calcium ions in the hydroxyapatite crystals [12].

The most commonly used chelating solutions are based on different concentrations of EDTA. An in vitro study showed that chelating solutions significantly reduced dentin microhardness [12].

Citric acid is a weak organic acid, that was reported to be an effective root canal irrigant when used alternately with sodium hypochlorite. Both 10% and 19% citric acid removed calcium ions from dentinal matrix[21,22]. Di Lenarda et al reported that after three minutes of irrigation, both 19% citric acid and 15% EDTA opened the dentinal tubules [23].

Many studies stated that malic acid showed the greatest reduction in dentin microhardness followed by EDTA,[24,25] possibly because of its strong demineralizing effect owing to its high acidity and the ability to calcify root dentin, with most calcium and phosphorus extracted during its application compared with EDTA[25].

The malic acid had the higher effect on dentin roughness may be due its high acidity and its better demineralizing effect within a shorter period of time, [25] while EDTA had the lowest effect on dentin roughness may be because it was not effective in complete removal of the smear layer in young and old root canal dentin. This may be attributed to the increased surface tension of 17% EDTA (0.0783 N/m) compared with 7% malic acid (0.06345 N/m) [26, 27].

There is no consensus on the optimum contact time which an irrigant solution to be kept in root canals for smear layer removal. Yamada et al. [28], suggested that a duration for 1 min with EDTA is sufficient. However, others advised a longer period of 15 min for optimal results. Paqueet et al. [29], reported that dentin in the apical third of the root canal is sclerosed. Hence, EDTA may not have such a pronounced action on sclerosed dentin in the apical third, it requires an application time of not less than 15 min for obtaining optimal results.

A possible limitation of the current study is that the volume of the irrigant in a root canal clinically is small compared with the immersing root dentin in irrigating solutions. However, standardized circumstances for all study groups allowed for comparable results.

CONCLUSION

Within the limitation of this study, malic acid with an application time of 5 minuets induced the highest reduction in root dentin microhardness followed by EDTA and citric acid. While malic acid can also increases the surface roughness of root dentin followed by citric acid and EDTA.

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