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The Effect of Mineral Composition Contents on Cracks Formation of Teeth Subjected to Er, Cr: YSGG 2780 nm Laser Irradiation

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ABSTRACT

Objective: *The aim of this study was to investigate the relation between dentinal cracks and dentin mineral contents after irradiation with Er, Cr: YSGG laser.* ***Settings and Design:*** *Average power was 3.75 W, the frequency was 15 Hz, 30% water, 60% air, the energy density was 31.84 J/Cm^2.* ***Material and method****: Ten teeth of single canals were biomechanically prepared and obturated then the root end was resected using carbide cross cut bur at 0° bevel. The retrograde cavity was prepared using Er, Cr: YSGG 2780 nm laser delivered through MZ6 glass tip of 660 µm diameter. Samples were prepared for SEM and examined to evaluate dentinal cracks then examined using Energy dispersive X-ray spectroscopy (EDX) which was performed to measure the mineral contents of dentin at the retrograde cavity.* ***Results:*** *High fluctuation of dentinal cracks´ occurrence from absence to 7 cracks.* ***Conclusion:*** *EDX showed no correlation between the occurrence of dentinal cracks and the weight % of Ca and P within the dentin in the retrograde cavity.*

Keywords: EDX, Dentinal cracks, Er, Cr: YSGG laser, Ca, P

INTRODUCTION

Dentin composed of 70% mineral phase, 20% organic phase and 10% water (on a weighted base). The periphery of the tooth coronal part is occupied by mantle dentin which is of 15-30 mm thickness while most of the dentin layer represented by circumpulpal dentin at which intertubular dentin form most prominent part of it [1]. The mineral phase of dentin represented by concentrations of calcium (Ca) and phosphorus(P) while carbon (C) represent the organic matrices [2]. The Energy dispersive X-ray spectroscopy (EDX) can determine the mineral contents of both enamel and dentin using accurate and nondestructive analysis of the examined samples. The technique involves bombarding electron beam of high voltage into the sample´s surface which will emit wavelength for each mineral that considered as a fingerprint of that mineral. Different concentrations on the sample´s surface results in the emission of different wavelength, this characteristic can be used in dental research to determine different levels of mineral content within enamel and dentin [3]. Several studies evaluated the effect of laser on mineral contents of dentin [4-7] but there was no study which evaluated the relation between dentinal crack and the amount of mineral component which are subjected to laser irradiation. Therefore the aim of this study was to investigate the relation between the occurrence of dentinal cracks and its mineral contents following using Er, Cr: YSGG 2780 nm laser for retrograde cavity preparation.

MATERIALS AND METHODS

Ten extracted human single-rooted teeth of the single canal and mature apices have been used in this study after approval of the University of Baghdad on the research proposal (number 17 on 12 July 2017). Teeth with cracks, calcification, root resorption or root anomalies were excluded from the study. Tooth surfaces were cleaned from debris and hard deposits using hand scaler, then each tooth was kept hydrated in 0.1% thymol at 4˚C until the time it has been used in this study. After the access cavity preparation, the pulp was removed with Barbed broach and the working length was determined with the aid of K-files #10 which was set to be 0.5 mm shorter than the apical foramen. Root canals were biomechanically prepared as following: first, the canal instrumentation performed using hand-operated ProTaper files beginning from SX file to F4 file, the irrigation protocol was set to be 1 ml of 5.25% NaOCl before instrumentation with SX file and 2 ml of it between each file till F4, finally 1 ml of 17% Ethylendiaminetetraacetic acid (EDTA) for one minute washed with 3 ml of 5.25% NaOCl then 5 ml of normal saline. The canals were dried with ProTaper paper point F4, and obturation with cold lateral condensation technique using Gutta-Percha F4 (DiaDent, Korea) and accessory Gutta-Percha as well as AH Plus sealer (Dentsply, Maillefer, USA). The coronal access cavity was filled with Tetric-N ceram. Teeth were kept in isolated tubes filled with normal saline (sodium chloride, BP 0.9% w/v) at 37°C in a water bath.

The root end resection was performed using cross-cut carbide bur (ELA, Germany) along with slow speed surgical handpiece (40,000 rpm) at 3 mm from the apical end and at 0° to the long axis of the root. Root end cavity preparation of 1 mm diameter was prepared using Er, Cr: YSGG 2780 nm pulsed laser (Biolase, waterlase, Iplus, CA, USA) delivered through MZ6 glass tip of 660 µm diameter and 6 mm length and a calibration factor 1.00. Laser device was set at average power 3.75 W, frequency 15 Hz, fluence 31.84 J/cm^2, water level 30% and air level 60% (according to manufacturer instruction of class I comfort preparation). The MZ6 tip was placed at 1.5 mm away from the root end. At every 1 mm cavity preparation depth, the cavity was irrigated with normal saline using a 30-gauge irrigation needle of the double-sided vent to prevent charring inside the root end cavity. Each single laser tip was used for single root-end cavity preparation and then was discarded.

SEM-EDX Preparation

Crown was separated from the root at the cement-enamel junction and a longitudinal cut was made to divide the root into two equal halves using a diamond wafering blade (Ted Pella, USA) under a copious amount of water flow. The samples were fixed and dehydrated according to Marchesan et al. preparation protocol [8]. The specimen was metalized with a layer of gold using a vacuum evaporation and then they were fixed on aluminum stubs. Those specimens were examined using scanning electron microscope (SEM) at 50 X and at 10 kV to detect the dentinal crack on the surface of the root end cavity wall as shown in Figure 1, then evaluated using Energy dispersive X-ray spectroscopy (EDX) which accompanied SEM at 25 kV accelerating voltage. Samples were examined using SEM-EDX to investigate the relationship between presence or number of dentinal cracks and Ca and P weight percentage through relating the data obtained from EDX with the number of cracks in the same sample and finally comparing it with another sample with about the same data and number of cracks.

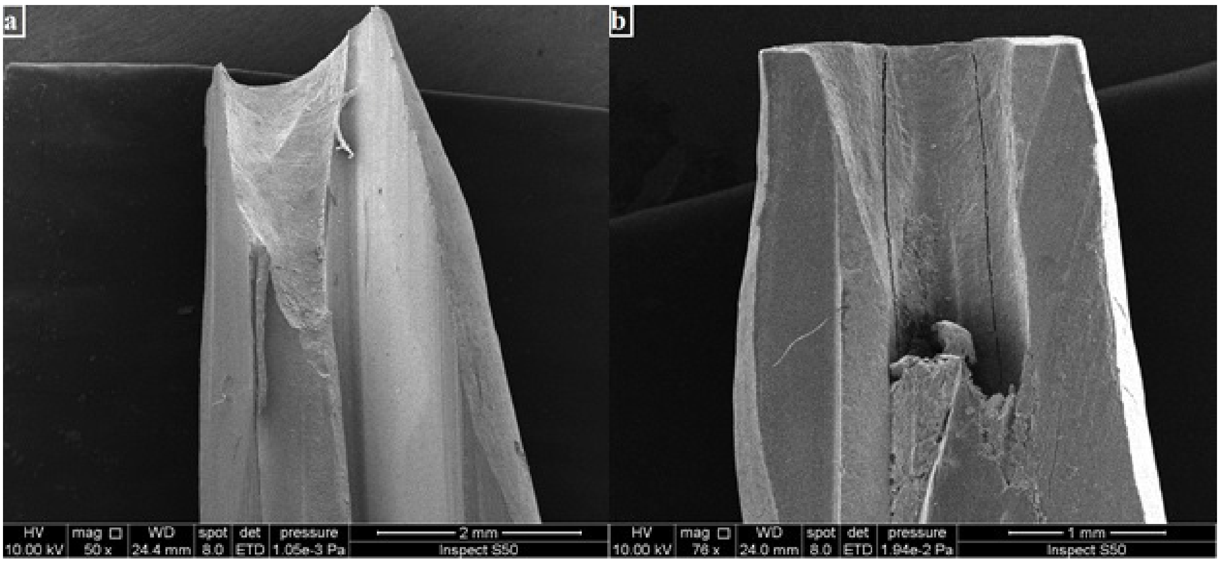

Figure 1 SEM evaluation of root end cavity at 50 X (a) sample without cracks (b) sample with two cracks

RESULTS

Ca (weight%) and P (weight %) in each sample of laser retrograde cavity group were correlated with the incidence or the number of cracks within that sample. The data obtained revealed high fluctuation in the number of dentinal cracks, as shown Table 1 and Figure 2.

Table 1 EDX of the sample illustrates Ca and P (weight %)

Sample	Number of cracks	Ca (Weight %)	P (Weight %)
1	2	27.77	14.57
2	2	26.79	12.61
3	3	30.85	15.25
4	3	31.2	19.29
5	0	29.31	14.01
6	2	32.22	12.07
7	7	30.93	19.41
8	0	28.38	18.06
9	2	35.03	17.69
10	5	31.79	20.07

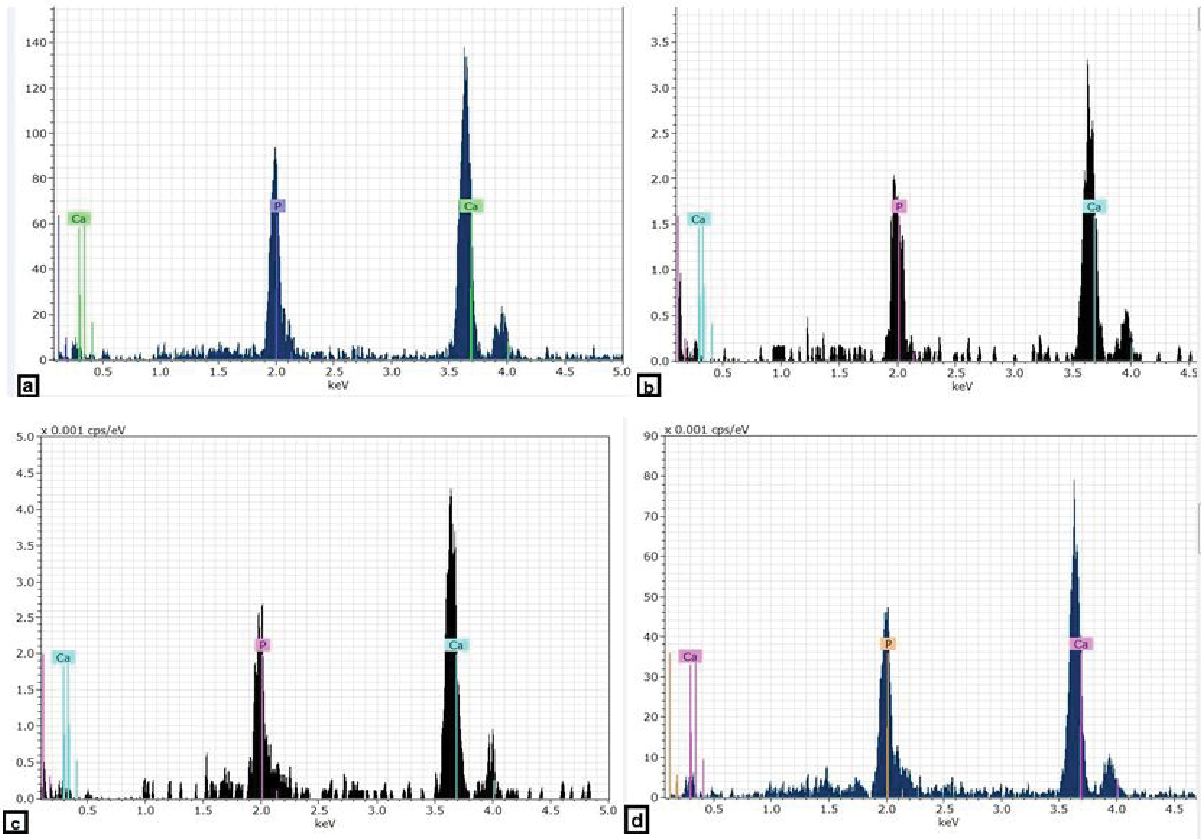

Figure 2 (a) Ca (weight%) is 29.31% and P (weight %) is 14.01% in sample no. 5 without crack, (b) Ca (weight%) is 31.79% and P (weight %) 20.07% in sample no. 10 with 5 cracks, (c) Ca (weight%) is 28.38 % and P (weight %) is 18.06% in sample no. 8 without crack, (d) Ca (weight%) is 31.20% and P (weight %) 19.29% in sample no. 4 with 3 cracks

DISCUSSION

As there was high fluctuation in the number or the incidence of cracks between individual samples within the same group at root end cavity prepared using Er, Cr:YSGG laser, the samples were evaluated with SEM-EDX to investigate if those differences were due to the variation in Ca and P weight percentage between the samples of the same group. SEM-EDX can be used to determine the quality and quantity of the elemental composition within the hard tissue. Therefore, the tooth inorganic constituent can be determined represented by both Ca and P weight % [4]. This study revealed no correlation between the occurrence or the number of cracks and the weight percentage of both P and Ca in the teeth as shown in Figure 2. Although sample 4 and 10 with higher Ca and P weight % than samples 8 and 5 respectively, those samples (4 and 10) showed 3 and 5 cracks respectively while samples 8 and 5 showed no crack.

On the other hand, on the level of Ca or P individually, there were samples with high ca weight % but with 2 cracks (such as sample 9), another sample with high P weight % (such as sample 7 and 10) but with high number of cracks (7 and 5 respectively) as shown in Table 1. Those results agree with Parker et al. who assumed that many publications about the effect of laser on hard tissues had immortalized the misleading statements that those wavelengths absorbed strongly by dental minerals and this will cause misdirection of the use of those laser wavelengths. In a matter of fact, a major part of those wavelengths absorption is caused by water effects which are far dominated than that of the hydroxyl group in the (carbonated) hydroxyapatite mineral of the hard tissues in which only small absorption occur at around 2800 nm wavelength [9].

CONCLUSION

Within the limitation of this study, it was found that Er, Cr: YSGG laser effect on the dentin surface doesn't depend on the amount of Ca and P within the dentin treated surface.

DECLARATIONS

Conflict of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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