Structural Characterization of Dentin Irradiated with Er,Cr:YSGG Laser and Fluoride for Caries Prevention

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Abstract: Er,Cr:YSGG laser induces the formation of bruxite and tetracalcium phosphate, as well as decreases the content of protein and water on dentin tissue, even when associated with a fluoride gel and at low energy densities.
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1. Introduction

Er,Cr:YSGG is a widely used laser for several procedures in dentistry. Considering the higher absorption for both water and hydroxyapatite [1], which are the main constituents of dental hard tissues, this wavelength can be used for caries prevention due to its thermal action, which can induce some morphological, chemical and crystalline changes on irradiated tissue [2].

Literature studies show a promising effect of Er,Cr:YSGG laser for preventing caries development and progression on enamel, mainly when associated with fluoride [3,4]. The acidulated phosphate fluoride gel (APF-gel) is a well-known agent for preventing dental caries, and its main action is due to the formation of calcium fluoride-like material on the surface. A previous study from your group [3] showed a synergistic action of Er,Cr:YSGG laser and APF-gel on enamel; however, there are no studies that relate this effect on dentin.

Taking into account that Er,Cr:YSGG laser can induce chemical and crystallographic changes on enamel, even at low energy densities [5], the present study aimed to evaluate if this laser, when used for preventive purpose, can induce similar changes on dentin. As well, it was evaluated if the association of APF-gel had some influence on the effects promoted by laser irradiation.

2. Methodology

A blind *in vitro* study was performed in which forty bovine root dentin slabs were obtained from the cervical root surfaces of bovine teeth. The samples were randomized into 4 groups of 10 specimens each: G1- untreated; G2 – treated with acidulated phosphate fluoride gel (APF-gel, Dentsply, USA, 1.23% F^-, 4 min); G3 – irradiated with Er,Cr:YSGG laser (WaterLase iPlus, Biolase Inc., USA, $\lambda = 2.78$ µm) at 0.25 W, 20 Hz and 6 J/cm^2; G4 – treated with APF-gel followed by Er,Cr:YSGG laser irradiation.

After treatments, samples were submitted to compositional and crystallographic analysis. The compositional analyses were performed using the attenuated total reflection technique of the Fourier transformed infrared spectroscopy (ATR-FTIR). The ATR-FTIR spectra of each sample were obtained with 4.0 cm^{-1} resolution, on a Varian 610 spectrometer equipment (Varian Inc., EUA), with a diamond crystal. Each spectrum had a background spectra subtracted during acquisition and was obtained with 80 scans in the range of 4000 to 600 cm^{-1}.

The crystallographic analyses were performed using the X-ray diffraction technique at XRD1 synchrotron beamline (LNLS, Campinas, Brazil, $\lambda = 0.0954$ nm). It was used a step scanning diffractometer ($2\theta_{step} = 0.01°$) equipped with a scintillator photon counter. A single diffraction pattern was determined, in order to reduce statistical errors, as the sum of the two individual scans corresponding to two dentin samples of the same experimental group. The patterns obtained were compared to the positions of Bragg peaks expected for crystalline hydroxyapatite – $Ca_5(PO_4)_3OH$ – (JCPDF 09-0432, HAP), and also with the Bragg peaks of tetracalcium phosphate – $Ca_4(PO_4)_2O$ – (JCPDF 25-1137, TetCP) and bruxite (International Centre for Diffraction Data – ICDD, 2005).

3. Results and Conclusion

The Figure 1 shows the normalized ATR/FTIR spectra of the samples of all experimental groups. These spectra display all the peaks corresponding to the mineral content of dentin tissue — 826-888 cm^{-1} (ν_2 carbonate vibration), 888-1185 cm^{-1} (ν_3 phosphate vibration), 1300-1516 cm^{-1} (ν_3 and ν_4 carbonate vibration); as well as the peaks corresponding to the organic content —1590-1720 cm^{-1} (amide III vibration), 1515-1590 cm^{-1} (amide II + carbonate vibration), 1185-1300 cm^{-1} (amide III vibration), water (2500-3664 cm^{-1}) and of the C-H stretching mode of the

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lipids (2835-2980 cm^{-1}). It is evidenced that laser irradiation decreases the content of amides and water, with reflects the thermal action of laser on dentin. As well, the application of APF-gel increases the content of amides, mainly due to the thickener used in the commercial gel preparation.

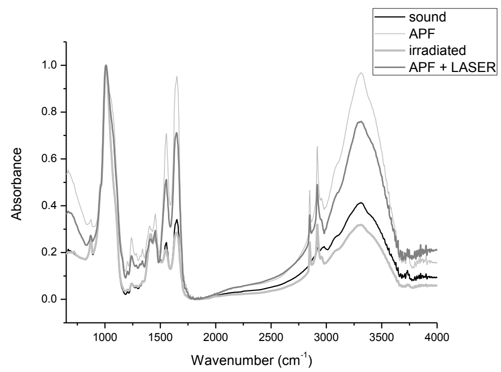

Fig. 1. Infrared absorption spectra of bovine root dentin after treatments proposed in the present study.

The X-ray diffraction analyses of all samples of the present study are showed in Figure 2. It is noticed the formation of a new diffraction peaks (black arrows), which is close to a peak of bruxite (Figure 2A) and tetracalcium phosphate (Figure 2B). These peaks were evidenced only in samples irradiated with Er,Cr:YSGG laser or APF + laser; the application of APF-gel alone did not promote any significant changes on X-Ray patterns.

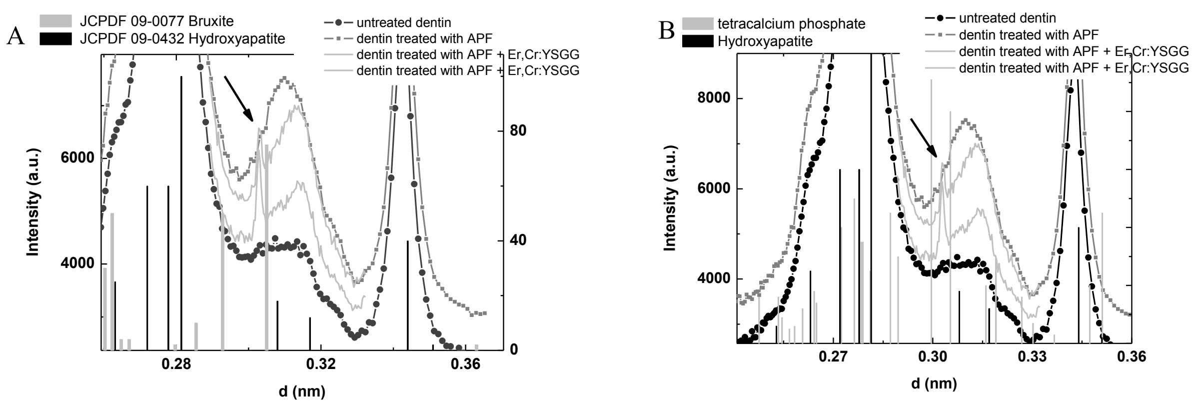

Fig. 2. X-ray diffraction analyses of all samples of the present study. Arrows evidence the peaks corresponding to bruxite (A) and tetracalcium phosphate (B), respectively.

According to these results, it is possible to infer the potential of Er,Cr:YSGG laser for prevention of dentin caries, since it was noticed chemical and crystalline changes due to laser irradiation. The application of fluoride gel promotes chemical changes, but does not interfere on crystallographic patterns of dentin.

4. Acknowledgements

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