

The use of optical coherence tomography for the evaluation of the effects of an infrared laser on dentin demineralization

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Abstract: The effect of Er,Cr:YSGG laser on dentin demineralization was evaluated by optical coherence tomography, which was able to quantify and to evidence that this laser is a promissory alternative for preventing dentin caries. © 2018 The Author(s)

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1. Introduction

Taking into account the prevalence of dental caries worldwide, it has been proposed the use of high-intensity infrared lasers for prevention of enamel and dentin demineralization considering their long-lasting effect [1]. Er,Cr:YSGG is a well succeeded laser for several dental procedures, such as caries removal and prevention on enamel tissue [2]; however, its potential for preventing dentin demineralization is little discussed on literature.

The optical coherence tomography (OCT) is a non invasive technique to monitor caries development and progression, since it is a non-destructive technique that allows the real-time imaging and the quantification of the demineralization by the determination of the total optical attenuation coefficient [3]. Considering this fact, this study proposed to evaluate the ability of OCT to monitor the effects of Er,Cr:YSGG laser on dentin demineralization *in vitro*.

2. Methodology

It was conducted a blind randomized *in vitro* study in which forty five bovine dentin slabs were prepared and randomly distributed into three experimental groups (n = 15): G1 – untreated; G2 – treated with acidulated phosphate fluoride gel (APF-gel, 1.23% F) for 4 min; G3 – irradiated with Er,Cr:YSGG laser (WaterLase iPlus, Biolase Inc., San Clemente, CA, USA, $\lambda = 2.78 \mu\text{m}$) at 0.25 W, 20 Hz and 6 J/cm². The irradiations were performed using a computer managed motion control system (Newport, Irvine, CA, USA) adjusted to a speed of 7.6 mm/s, and was kept at 1 mm distance from the dentin surfaces.

After treatments, all samples were submitted to an 8-day pH-cycling regimen. For that, the slabs were kept individually in a demineralizing solution for 4 h (6.25 mL/mm²) and in a remineralizing solution for 20 h (3.12 mL/mm²) each day, at 37° C. The demineralizing solutions were composed by 1.4 mM calcium, 0.91 mM phosphate, 0.06 ppm F in 0.05 M acetate buffer, pH 5.0, and the remineralizing solutions were composed by 1.5 mM calcium, 0.9 mM phosphate, 150 mM of KCl, 0.05 ppm F in 0.1 M TRIS buffer, pH 7.0.

All samples were evaluated by OCT technique (Callisto, Thorlabs, New Jersey, USA), operating in a spectral domain using a superluminescent diode light source centered in 930 nm wavelength. Of each sample, it was obtained 5 different images. The images were analyzed using a dedicated computer program developed in Matlab (Mathworks Inc., Natick, MA, USA), in which it was calculated the average of the total optical attenuation coefficient for each caries lesion. After that, all samples were half-sectioned, embedded in acrylic resin and submitted to the evaluation of cross-sectional microhardness, using a microhardness tester with a *Knoop* diamond with 10 g load for 5 s. Three rows of 12 indentations each were made from the dentin surface (at 10, 20, 30, 40, 50, 60, 70, 80, 100, 120, 140 and 160 μm). For the statistical analysis, it was used ANOVA followed by Tukey test, at 5% significance level.

3. Results and Discussion

The Figure 1 shows the average of the total optical attenuation coefficients calculated for all the experimental groups of this study. The irradiated group evidenced a significant higher mean value when compared to the other experimental groups, according to the Tukey test. This fact evidenced that the exponential decay of light was lesser in lased group when compared to the other ones, probably due to the crystalline changes promoted by laser irradiation due to the thermal action [4]. In fact, the literature is divergent when considering the total optical

attenuation coefficient of sound and carious samples, and our results agree with some previous studies that indicate that the attenuation coefficient of light decreases at demineralized areas [5].

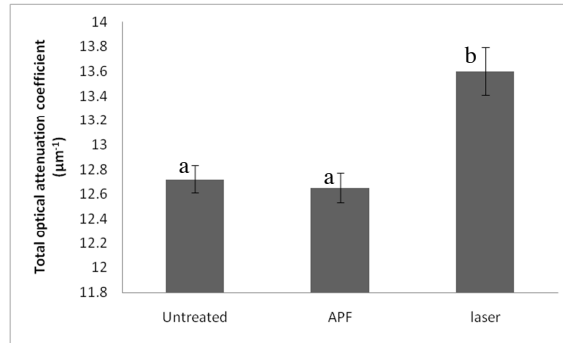


Fig. 1. Average of the total optical attenuation coefficients calculated for all the experimental groups of this study. Bars denote standard deviations. Distinct letters evidence statistical differences according to Tukey's test, at 5% significance level.

The results of microhardness analysis is showed in Figure 2, in which it is possible to evidence that lased group had similar values when compared to APF group. This result indicates a preventive effect of laser irradiation, in a similar way than that promoted by fluoride, which agrees this previous results observed in enamel. However, further studies are necessary to evaluate the synergism of laser and fluoride on dentin caries prevention and progression.

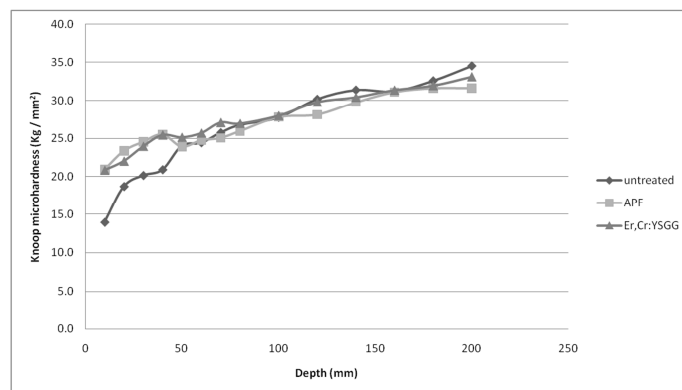


Fig. 2. Means of enamel Knoop hardness (kg/mm²) according to treatments and the distance (µm) from the surface.

4. Acknowledgements

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5. References

- [1] D. M. Zezell, H. G. D. Boari, P. A. Ana, C. P. Eduardo and G. L. Powell, "Nd:YAG laser in caries prevention: a clinical trial," *Lasers in Surgery and Medicine*, vol. 41, no. 1, pp. 31-5, 2009.
- [2] P.A. Ana, C.P.M. Tabchoury, J.A. Cury, D.M. Zezell, "Effect of Er,Cr:YSGG laser and professional fluoride application on enamel demineralization and on fluoride retention," *Caries Res.*, 46(5), 441-51 (2012).
- [3] A.C. B. Cara, D.M. Zezell, P.A. Ana, E.P. Maldonado, A.Z. Freitas, "Evaluation of two quantitative analysis methods of optical coherence tomography for detection of enamel demineralization and comparison with microhardness," *Lasers Surg Med.*;46(9): 666-71 (2014).
- [4] L. Bachmann, K. Rosa, P.A. Ana, D.M. Zezell, A.F. Craievich, G. Kellermann, "Crystalline structure of human enamel irradiated with Er,Cr:YSGG laser", *Laser Phys Letters*, 6(2), 159-162.
- [5] A.M.A. Maia, A.Z. Freitas, S.L. Campello, A.S.L. Gomes, L. Karlsson, "Evaluation of dental enamel caries assessment using Quantitative Light Induced Fluorescence and Optical Coherence Tomography," *J. Biophotonics* 9(6): 596-602 (2015).