A comparative study between acid-etching and Er,Cr:YSGG laser irradiation on enamel surface evaluated by OCT and SEM

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Abstract: This study aimed to evaluate the effects of Er,Cr:YSGG laser irradiation and acid-etching on enamel surface, aiming to improve the bond strength between enamel and composite materials, through optical coherence tomography and scanning electron microscopy.
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1. Introduction

The acid etching, introduced by Buonocore in 1955, made possible the bond strength between the bracket base and the tooth surface, through the creation of mechanical retentions over the enamel surface, leading to resin imbrication in microporosities produced by the acid. Conditioning enamel surface with various concentrations of phosphoric acid is a conventional method for creating microporosities, providing micro-mechanical interlocking of the enamel–sealant interface [1].

Recently, alternative methods have been studied to improve the bond strength by increasing the enamel's energy surface, such as laser irradiation, which its main advantage consists in the inhibitory effect of caries on the irradiated enamel, already observed in some studies [2].

Laser irradiation promotes physical and chemical changes on the enamel surface, increasing the energy surface and, consequently, improving the bond strength to enamel. Furthermore, laser irradiation of dental hard tissues has been reported to create microirregularities and no smear layer and modifies the calcium-to-phosphorus ratio, reduces the carbonate-tophosphate ratio, and leads to the formation of more stable and less acid-soluble compounds, thus reducing susceptibility to acid attack and caries [3].

There has been a growing research interest in the conditioning effects of erbium, chromium:yttrium–scandium–gallium–garnet (Er,Cr:YSGG) laser on tooth surfaces. The etching effects of Er,Cr:YSGG laser on dental hard tissues have been investigated mostly via microleakage evaluation and mechanical tests made on composite restorations applied to primary and permanent tooth cavities [4].

The aim of this study was to evaluate the conditioning ability of the dental surface irradiated with Er,Cr:YSGG laser, by comparing and measuring to the traditional way of conditioning with phosphoric acid at 37%.

2. Methods

This study was carried out after approval by Ethics Committee on Animal Experiments at Universidade Federal de Pernambuco, under protocol number 23076.015869/2015-65.

Eighty bovine incisors were randomly divided into four groups (n=20): group I, teeth were conditioned with 37% phosphoric acid (Condac 37%, FGM, Brazil); groups II, III and IV irradiated with Er,Cr:YSGG laser (Waterlase MD, Biolase Technology Inc., USA), 2780 nm central wavelength, with three different power settings: the energy and output power selected were 54.1mJ/1.1W, 83mJ/1.7W and 120mJ/2.41W, respectively. For all groups the laser equipment operated at 20 Hz, MSP mode (Medium Short Pulse mode) for 15 sec and 140-200 µs pulse duration. Laser energy was delivered through a fiber optic cable to a sapphire tip terminal 600 µm in diameter and 6-mm long. Irradiation parameters were defined after the pilot study previously conducted. In order to standardize the laser irradiation, a step motor was employed to move the sample at a constant speed of 3,8 m/s and a fixed post as a support, so the distance between the tip of the laser hand piece and the dental surface is always the same (1 mm) in every specimen, thus maintaining the irradiation energy.

All specimens undergone scanning electron microscopy (SEM) and optical coherence tomography (OCT) analysis after acid- or laser etching, as it can be seen in figure 1. Morphological evaluation was performed by SEM (TM 3000, Hitachi, Japan) with original magnification of 200x. The OCT system employed was a commercially available model, Callisto SD-OCT (Thorlabs Inc, USA), operating at 930 nm central wavelength, spectral bandwidth of 100 nm, and maximum output power of 5 mW, axial resolution of 7/5.3 μm (air/water), lateral resolution of 8 μm, maximum imaging depth at 1.6 mm, and axial scan rate 1.2 kHz, capturing two frames per second with 105 dB of sensitivity. Two-dimensional (2D) images were captured with 2000 columns x 512 rows; whilst three-dimensional (3D) images were captured with 400 x 400 x 400 columns in each of XZ, YZ, XY axis. The use of these two techniques complement each other, due to their very different spatial resolutions.

3. Results and Discussion

The ablation promoted by 54.1mJ laser irradiation (group II) was lower than that obtained with the other irradiations. Both 54.1mJ, 83mJ and 120mJ laser irradiations (groups II, III and IV) were able to etch the enamel more clearly than the acid etching (group I). These findings were confirmed by scanning electron microscopy and optical coherence tomography (Figure 1).

Laser irradiation on the dental surface can protect the enamel against the carious attack, which is one of its advantages. Nevertheless, the use of Er,Cr:YSGG laser when treating enamel surfaces and dentin has been presenting diverse results when it comes to dental adhesion [1-4].

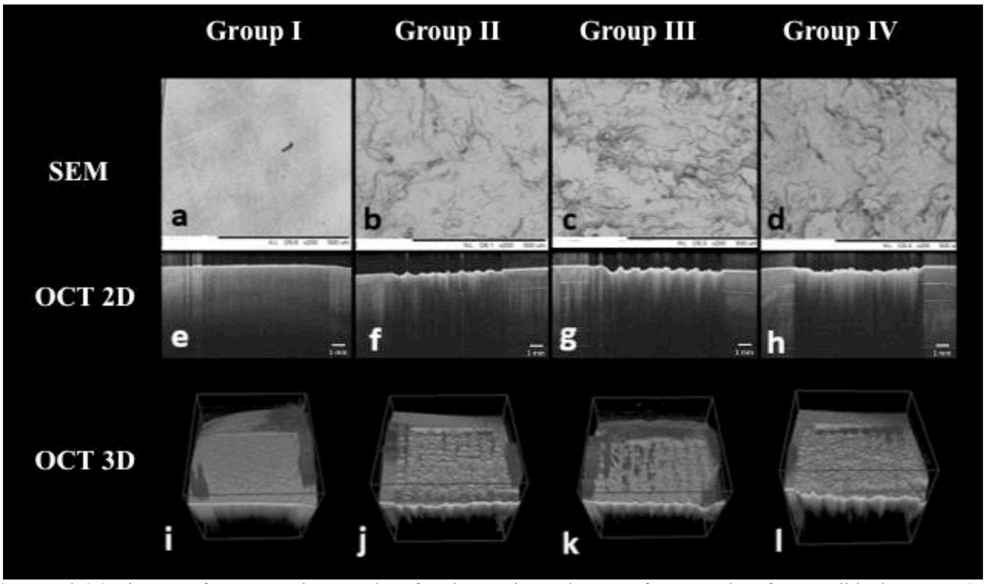

Figure 1. SEM and OCT images of representative samples of each experimental group after enamel surface conditioning. **(a-d)** SEM images, 200x magnification, showing the changes on the enamel surface. **(e-h)** cross-sectional 2D OCT images, observe the surface roughness and internal changes, especially to irradiated groups. **(i-l)** 3D OCT images, in which is possible to observe the changes on the enamel surface and also in subjacent layers. Scale bars represent original magnification of 200x for SEM images and 1 mm for 2D OCT images.

4. Conclusion

The enamel surface etching obtained with an Er,Cr: YSGG laser (groups II, III and IV) is qualitatively higher than that obtained with acid etching. This research had the objective of testing these parameters and establishing reproducible norms for further studies.

5. References

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