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Influence of the irradiation distance and the use of cooling to increase enamel-acid resistance with Er:YAG laser

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ABSTRACT

Objectives: The aim of this study was to assess the influence of irradiation distance and the use of cooling in the Er:YAG laser efficacy in preventing enamel demineralization.

Methods: 84 enamel blocks were randomly assigned to seven groups ($n = 12$): G1: control group – no treatment, G2–G7: experimental groups treated with Er:YAG laser (80 mJ/2 Hz) at different irradiation distances with or without cooling: G2: 4 mm/2 mL; G3: 4 mm/no cooling; G4: 8 mm/2 mL; G5: 8 mm/no cooling; G6: 16 mm/2 mL; G7: 16 mm/no cooling. The samples were submitted to an in vitro pH cycles for 14 days. Next, the specimens were sectioned in sections of 80–100 μm in thickness and the demineralization patterns of prepared slices were assessed using a polarized light microscope. Three samples from each group were analyzed with scanning electronic microscopy. Analysis of variance and the Fisher test were performed for the statistical analysis of the data obtained from the caries-lesion-depth measurements (CLDM) (alpha = 5%).

Results: The control group (CLDM = 0.67 mm) was statistically different from group 2 (CLDM = 0.42 mm), which presented a smaller lesion depth, and group 6 (0.91 mm), which presented a greater lesion depth. The results of groups 3 (CLDM = 0.74 mm), 4 (CLDM = 0.70 mm), 5 (CLDM = 0.67 mm) and 7 (CLDM = 0.89 mm) presented statistical similarity. The scanning electronic microscopy analysis showed ablation areas in the samples from groups 4, 5, 6 and 7, and a slightly demineralized area in group 2.

Conclusions: It was possible to conclude that Er:YAG laser was efficient in preventing enamel demineralization at a 4-mm irradiation distance using cooling.

1. Introduction

Goldman et al.[1] began the studies on ruby-laser interaction with the organic components of dental hard tissue. Ever since, one of the main fields of investigation in laser studies is the use of different wavelengths to prevent caries, as the laser treatment of enamel surfaces may be able to alter enamel in such away as to prevent or inhibit the demineralization caused by caries process.[2] In this sense, Er:YAG laser has been tested and has shown significant effects in the increase of dental enamel-acid resistance.[3–6]

The use of laser in caries-prevention treatments is based on the reduction of microorganisms[7] and the chemical[3,8,9] and morphological alteration[4,10] of the enamel structure.

For this purpose, Er:YAG laser has been used at low energies aiming at chemical and structural alterations of the surface that could influence enamel demineralization prevention without causing dental-tissue ablation or even fusion.

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Nevertheless, most studies employed Er:YAG laser in the focused mode, in others words the beam is focused on the target tissue and the maximum energy density was obtained, which according to Cechinni et al. could cause tissue loss with the exposure of enamel prisms in the irradiated area when analyzed in scanning electronic microscopy.[10] The knowledge of erbium laser effects in the non-focused mode and the ideal irradiation distance are important factors to consider in seeking more significant results for caries prevention.

The use of cooling water during irradiation has also been discussed and satisfactory results have been achieved with or without the use of cooling, although its function is yet to be clearly established.[4]

Therefore, the aim of the present study was to assess the efficacy of Er:YAG laser in increasing enamel-acid resistance considering the irradiation distance and the use of cooling in a laboratory study. The null hypothesis tested was that the different irradiation distance from the target tissue does not influence on the enamel-acid resistance.

2. Materials and methods

2.1. Experimental design

This study presented the Er:YAG laser-irradiation distance from the target surface as the studied factor: no treatment (control), 4 mm, 8 mm and 16 mm, associated or not with cooling.

The experiment sample consisted of 84 buccal-surface enamel fragments from non-erupted human third molars. The specimens were randomly divided into 7 groups ($n = 12$). The response variable was the enamel demineralization depth assessed by polarized light microscopy (mm) and the morphological analysis through scanning electronic microscopy.

2.2. Samples preparation

Eighty-four sound human posterior teeth collected under the guidelines approved Ethics Committee of the Ribeirão Preto School of Dentistry, USP were stored in a 1% formaldehyde solution in a phosphate buffer (pH 7.4) and selected under a stereomicroscope. They were cutted disto-mesially into two halves by a diamond disc under cooling coupled to a cutting machine. The lingual fragment was discarded and 84 buccal-surface enamel fragments (4x4 mm) remained. Then, the fragments were covered with acid-resistant nail varnish with only a 2.5-mm^2 circular area of exposed enamel remaining. The circular area was bounded using a tape size pre-determined.

The flowchart of the procedure is shown in Fig. 1.

2.3. Laser treatment

In the control group (G1), the specimens were not submitted to any type of surface treatment.

At the experimental-group samples (G2–G7), on each section, an Er:YAG laser – a 2.94-μm wavelength (Kavo Key Laser II) was used to irradiate the circular area of exposed enamel. The parameter used was 80 mJ of energy and a 2 Hz frequency on all specimens. The pulse duration was of 250–500 μs and the 2051 handpiece was used. The focused mode of this laser is on 12 mm of distance of the target, however at this experiment the laser was not used on this mode, thus the irradiation distances were on mode pre-focused (4 mm and 8 mm) or unfocused (16 mm) according to each group (Table 1). When the cooling was employed the water flow used was of 2 ml/min (Table 1) at 25 °C, checked with a thermometer.

For the standardization of the distance, a device that couples the laser handpiece at a pre-established distance was used. The segment was positioned on a moving base, allowing the entire surface to be irradiated at the same distance.

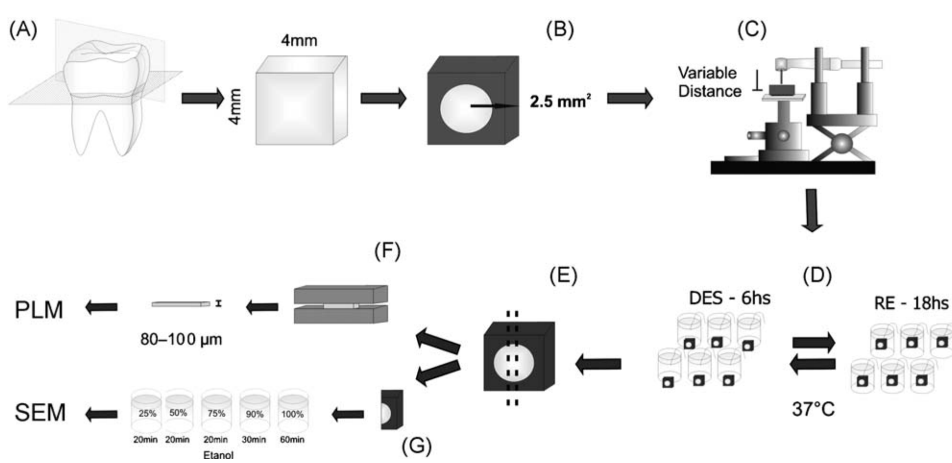

Fig. 1 – *Flowchart of the study methodology.* (A) The crowns were cutted disto-mesially into two halves obtaining buccal-surface enamel fragments; (B) the fragments were covered with acid-resistant nail varnish with only a 2.5-mm^2 circular area of exposed enamel remaining; (C) laser treatment (80 mJ/2 Hz) using a device that couples the laser handpiece at a pre-established distance; (D) pH cycling for cariogenic challenge; (E) longitudinally sectioning through the center of the lesions; (F) manually reduction of section with the help #1200 sandpaper and a glass plate sandpaper under cooling until an 80-μm to 100-μm in thickness for PLM analysis; (G) the remaining sections of the sectioned specimen were dehydrated for SEM analysis.