The Use of Nd:YAG laser as an Alternative to Prevent Dentin Wear

D.L. Pereira[1], C.B. Zamataro[1], D.M. Zezell[1], A.Z. Freitas [1], P.A. Ana[2]

1- IPEN–CNEN/SP, Av. Prof. Lineu Prestes, 2242 – Cidade Universitária – CEP 05508-000, São Paulo – SP – Brasil;

2- UFABC, Av. Dos Estados, 5001 – Bangu- CEP 09210-580, Santo André- SP- Brasil;

Author e-mail address: daisa@usp.br

Abstract: The aim of this study is to verify the potential of Nd:YAG laser and topical acidulated phosphate fluoride application (APF) on preventing dentin wear using the optical coherence tomography (OCT) on monitoring this process.

OCIS codes: (140.0140) Lasers and laser optics; (170.4500) Optical coherence tomography; (170.0170) Medical optics and biotechnology;

1. Introduction

Dental erosion has been extensively studied to be a risk factor for loss or damage to the tooth. Also, its prevalence has increased in last years [1−4], and it is related to an excessive consumption of acidic beverages and foods [5]. Due to the lifestyle of the people who live in developed countries, food habits have significantly changed, and their teeth are increasingly exposed to different types of acids. Furthermore, increased prevalence of erosion damage to the root surface may also be related to the presence, for a longer period of time, of the teeth in the oral cavity caused by the increase in life expectancy and improvement of oral hygiene of individuals [6].

So far, it is not possible to prevent or even stop the progression of mineral loss caused by dental erosion [2]. The use of high intensity infrared lasers has been very promising in preventing the appearance of carious lesions in both enamel and dentin, either when used alone or in combination with fluoride. Previous studies using neodymium laser (Nd:YAG) have shown the potential of this therapy for the prevention of erosion, especially because laser irradiation can promote the increase of the surface temperature of the dental hard tissues. Depending on the temperature rises, laser irradiation can induce chemical and morphological changes on enamel and dentin (mainly due to the surface melting); in this way, these changes can reduce the diffusion of acids, the structural loss and their deleterious effects [7,8].

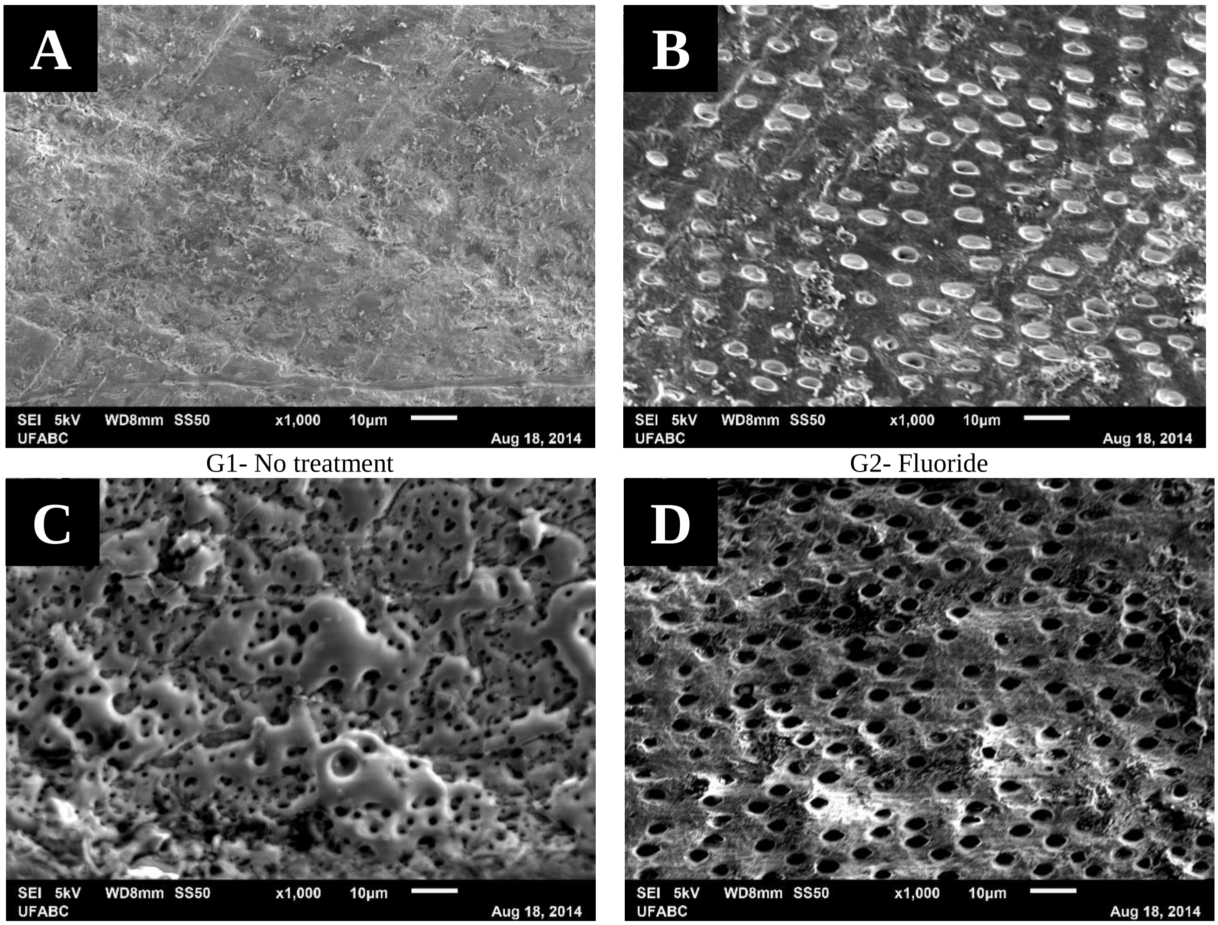
Considering the positive effects of Nd:YAG laser for preventing dental caries, the objective of this study was to evaluate the potential of Nd:YAG laser on preventing dentin wear.

2. Materials and Methods

After approval by Animal Ethics Committee of UFABC (004/2013), an *in vitro* study involved 192 of 8mm^2 blocks of bovine root dentin, which were randomly distributed in four experimental groups (n = 48): G1: without treatment; G2: treatment with acidulated phosphate fluoride (APF, F 1.23%, pH = 3.3 to 3.9); G3: irradiation with Nd:YAG laser (1064 nm, 0.6 W, 10 Hz, 84.9 J/cm^2); G4: application of APF followed by irradiation with Nd:YAG laser**.** After these protocols, all samples were submitted to a 15-days erosive and abrasive demineralization (Sprite Zero, pH=2.8, 90s, 4x/day), and remineralization (artificial saliva, pH=7) cycling. Twice a day, slabs were brushed for 15s using a 0 ppm F^- dentifrice. The depths of lesions were evaluated 5 measurements per sample, by optical coherence tomography (OCT, OCP930SR, Thorlabs Inc., USA): before treatment, after treatment, in the 5th, 10th and 15th day of erosion/abrasion cycling. OCT data were subjected to ANOVA/Tukey analyses at 5% significance level. Morphological evaluation of the surface was performed using scanning electron microscopy (SEM).

3. Results and Discussion

Electron micrographs obtained with SEM are showed in Figure 1. A regular surface with slight scratches was observed in the untreated group (G1) (Fig. 1A), in which the dentinal tubules are closed and covered by a smear layer, caused by the grinding of the samples. The APF group (G2) also presented a smooth surface; however, opened dentinal tubules were observed, as well as the absence of the smear layer and the presence of some globules on the surface, which suggests the formation of the CaF_2-like material. In the laser group (G3), it was observed a surface without cracks or smear layer, but with irregularities and depressions, which are typical of melting of the dentin surface, with zones of fusion and resolidification in a mosaic pattern, as can be evidenced in figure 1C. The APF + laser group (G4) showed an irregular surface with roughness pattern that resembles an ablation process. Smear layer was not observed and opened dentin tubules were detected.



G1- No treatment G2- Fluoride

G3- Laser G4- Fluoride+Laser

Figure 1: Electron micrographs of root dentin after all treatments. Original magnification = 1000 x.

Figure 2 showed that the irradiated laser groups (G3 e G4) had significantly lower dentin wear depths of erosion/abrasion in the 5th-day cycling (wear depth around 6.0µm) when compared to the untreated group (wear depth around 9.7µm) and the APF treated group (wear depth around 9.2µm). The APF application before laser irradiation did not result in significant changes in the dentin wear depth (wear depth around 6.0µm) when compared to the group that was only laser irradiated (wear depth around 5.9µm). In figure 3, it was observed that irradiated groups (G3 e G4) had lower dentin wear depths of erosion/abrasion in the 10th-day cycling (wear depth around 7.5µm) but only the APF+laser group (G4) presented statistically significant difference when compared to the other groups. It was observed a significant increase on dentin wear depth with the progression of cycling regimen for all treatments.

The literature evidences that [7–10] Nd:YAG laser promotes the formation of tetracalcium phosphate, as well as melting and recrystallization of the dentin surface, which agrees with the findings observed in the present study.

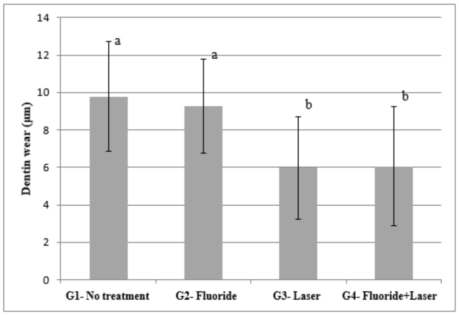


Figure 2: Dentin wear depths for all treated groups after 5-day cycling. Distinct letters indicate significant statistical differences by the Tukey test ($p < 0.05$).

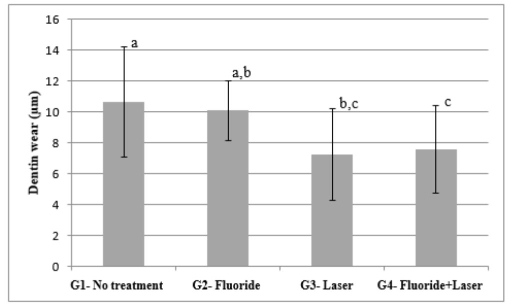


Figure 3: Dentin wear depths for all treated groups after 10-day cycling. Distinct letters indicate significant statistical differences by the Tukey test ($p < 0.05$).

A number of studies have shown that Nd:YAG laser irradiation promotes thermal effects on dental hard tissues and according to the temperature increase, chemical and structural changes may be induced. The organic matrix of the enamel and dentin is reduced at temperatures below 350°C; however, the beginning of the protein denaturation is observed when the temperature reaches 45°C. The mineral matrix constituents are more thermally stable. The carbonate elimination starts after heating at 100°C and is completely eliminated when the tissue temperature reaches 1100°C. At this temperature, it was related the formation of new crystal structures, such as α and β phase of tricalcium phosphate, as well as tetracalcium phosphate. These effects can be the responsible for the increase of the tissue resistance to demineralization [7–10]. In figures 1C and 1D it is showed melting and resolidification of dentin tissue, which indicates that high temperatures were achieved with laser irradiation and thus crystallographic changes can be occurred in dentin structure, rendering the tissue more resistant to demineralization and, in this way, to erosive attack.

In figures 2 and 3, the progress of erosion damages was observed. However, for the lased groups (G3 and G4), the lesion depth was lower when compared to the G1 and G2 groups. In this way, we demonstrated that laser irradiated dentin became more resistant to demineralization.

4. Conclusion

It is possible to conclude that Nd:YAG laser irradiation decreases the formation and progression of erosive/abrasive lesions, reducing the depth of lesions formed in different cycling times.

5. Acknowledgements

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