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Scanning electron microscopy analysis of enamel and dentine irradiated by Holmium laser

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SUMMARY

The purpose of this study *in vitro* is to evaluate the future possibility of using a pulsed Ho:YLF (2,067μm) laser for endodontic surgery access, preparation of cavities, etching of dental enamel, and treatment of dental caries. Laser energies in the range of 120-750 mJ/p were used. Perforation of approximately 4mm depth with homogeneous and smooth aspect of its wall surfaces was obtained with no carbonization. Lower energies resulted in melted and recristalized surface. The results indicate that holmium laser may be useful for dentistry.

INTRODUCTION

Absorption of light depends on the specific properties of each tissue, its cromophores and its porcentage of water.The effects produced by the light absorption is related to lasers characteristcs such as energy density, pulse duration and the interaction time of the light in the tissue.

Holmium:YLF laser emitting in the wavelenght of 2,067 μm is nearer to the water absorption peak than the Ho:YAG laser at 2,1 μ m. The stronger absorption of water at 2 μm light produces superficially damaged zones, what makes the holmium laser an excellent choice for precision surgeries on cartilage and similar hard tissue. The 2 μm laser light, as an advantage, can be delivered by commercial silica fibers.

White [1] reported morfological changes in dentinary surface, under Ho:YAG laser irradiation of 67 mJ/p. One interesting finding of their work is that microhardness of the Ho:YAG modified surface increased 16% above controls. Under the condition of 78 J/cm^2/s Matsumoto et al [2] obtained enamel perforations with Ho:YAG laser.

Analysis of teeth irradiated by Ho:YAG laser, done by Lippas et al [3], resulted in cavited and roughened enamel surfaces with minimal charring. According to Goodis [4], Ho:YAG and Nd:YAG lasers remove smear layer and promote a microbial reduction in root canal.

The purpose of this study *in vitro* is to evaluate the future possibility of using a prototype of pulsed Ho:YLF laser for endodontic surgery access, preparation of cavities, etching of dental enamel and treatment of dental caries.

MATERIALS AND METHODS

A prototype of Holmium:YLF laser was developed at IPEN, where a crystal of Yttrium, Lithium, Fluoride, codoped with Holmium, Erbium and Thulium was grow. This laser emits single shots with pulsewidth of 300 μs (FWHM) at wavelength of 2,067 μ m. Laser energies in the range of 120-750 mJ per pulse were used in six extracted human teeth (dried) and six freshly extracted teeth. The specimes were irradiated under different energy densities (table 01). The study of morphological changes on enamel and dentine was conducted on light and scanning electron microscope at Showa University in Japan.

RESULTS AND CONCLUSIONS

In order to investigate the possibility of using holmium laser to prepare cavities the specimens were irradiated with 750 mJ per position, 30 pulses per position. Perforations of 4 mm depth, reaching the pulpar chamber, with very clear cavity border and no

TABLE 01- Ho:YLF irradiation conditions

	Samples	Energy Density (J/cm^2)	Pulses/ position
Preparation of Cavities (endodontic access)	#01	700	2
	#02	2200	30
	#03	2400	30
	#04	2400	30
Etching of Dental Enamel	#05	750	1
	#06	1000	1
	#07	1800	1
	#08	2800	1
	#09	4000	1
Cleaning of Pits and Fissures	#10	120	2
	#11	120	2
	#12	600	2

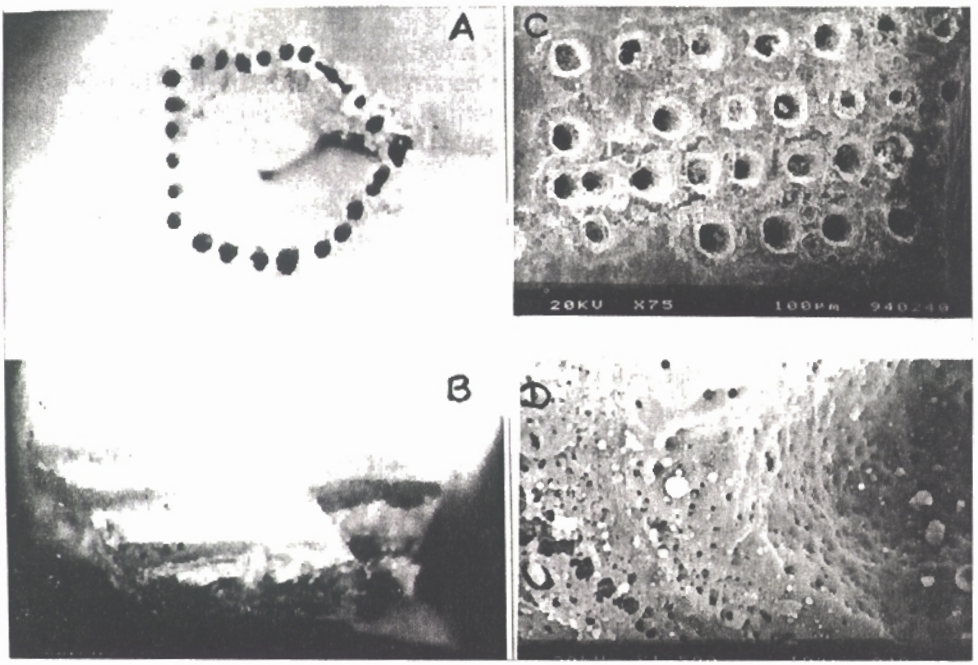

Figure 01- (A) Perforations on the occlusal face of a freshly extracted molar irradiated by Ho:YLF (# 3).

(B) Longitudinally splitted molar showing the depth of perforations. Notice the light aspect of the perforation walls with no carbonization (# 4).

(C) Buccal surface of a freshly extracted molar etched by Ho:YLF (# 7).

(D) High magnification of (C).

carbonization, were produced on the occlusal face of a molar. There were no crack zones (figures 01-A).

A longitidinally splitted molar showing the depth of perforations obtained with holmium laser can be seen on figure 01-B, where the clear and homogeneous aspect of the perforations can be observed.

Figure 01-C shows a buccal surface of a molar etched by Ho:YLF, irradiated with 400 mJ per pulse, 1 pulse per position. The perforations could make bonding effects between enamel and composite more effective.

In the magnification of figure 01- C (X 1500) a melted and recrystalized surface with small and shallow pits can be observed (figure 01-D).

Pits and fissures areas irradiated by Ho:YLF with 600mJ per pulse and 2 pulses per position resulted in partial remotion of the carious tissue, presenting white and smooth cavity borders.

In conclusion:

1- Morphological changes in enamel and dentine surfaces were observed after Ho:YLF irradiation. The results were very different from those of CO_2 and Nd:YAG lasers.

2- Perforations depth obtained with Ho:YLF depends of the applied energy, enamel thickness and the presence of sound or carious tissue. No crack zones or carbonization have occurred.

3- Desired depth can be controlled by irradiation conditions (750 mJ/p maximum) without thermal damage to the pulp. Measurements of temperature inside the pulpar chamber resulted in an increase of no more than 2,5° C.

4- Inside the cavities, melted and recrystalized materials were observed, than can seal open tubules.

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