

# In Vitro Study of Intrapulpar Temperature Changes When Using Er:YAG Laser for Class V Cavity Preparation

Aldo Brugnera Júnior<sup>b,c</sup>, Fátima Zanin<sup>c</sup>, Melissa A. Marchesan<sup>a</sup>,  
Reginaldo S. da Silva<sup>a</sup>, Jesus D. Pécora<sup>\*a</sup>

<sup>a</sup>Faculdade de Odontologia de Ribeirão Preto, Universidade de São Paulo, Ribeirão Preto, SP, Brasil

<sup>b</sup>Faculdade de Odontologia, Universidade Federal do Rio de Janeiro, Rio de Janeiro, RJ, Brasil

<sup>c</sup>Universidade Camilo Castelo Branco, São Paulo, SP, Brasil

## ABSTRACT

Various studies have recommended parameters for the use of Er:YAG laser for the treatment of caries of the enamel and dentin without studying the increase in temperature caused by laser in the individual groups of teeth. The Er:YAG laser has been indicated for the removal of caries, cavity preparation and preparation and disinfection of root canals. The authors studied the intrapulpar temperature change in 10 incisors, 10 canines, 10 pre-molars and 10 molars during Class V cavity preparation with short pulse (250 ms/pulse) and very short pulse (80-120 ms/pulse) Er:YAG laser, using the following parameters: 10 Hz frequency, 500 mJ potency, 6 s, 10 mm distance, 25 ml/min water flow, at 23°C and 65% humidity. The greatest increase in temperature was found in the incisors and the least increase in the molars at both pulse modes. The very short pulse mode caused less of an increase in temperature in the pulp chamber in all teeth than the short pulse mode.

Key Words: temperature, pulp, Er:YAG laser, pulse.

## 1. INTRODUCTION

The effects of different tooth preparations and restorative dental procedures on pulp tissue have been researched. Heat transferred through the enamel and dentin into the pulp<sup>1</sup> during dental restorative procedures can harm the pulp and lead to irreversible damage<sup>2</sup>. Historically, intrapulpar tissue damage caused by temperature increases has been based primarily on the in vivo work of Zack & Cohen<sup>3-4</sup>. Their experimental method used continuously applied heat by a hot soldering iron to the crowns of monkey teeth for a length of time which increased intrapulpar temperatures. They described demonstrable but reversible histological pulpal changes with temperature increases of 3.3°C. As temperatures increased to 5.6°C, loss of vitality in 15% of the test teeth was seen.

Several researchers have reported that the Er:YAG laser ablates dental hard tissues more efficiently and effectively, with less thermal damage to the tooth, than other lasers<sup>5</sup>, especially in a wet field with water spray<sup>6</sup>.

The purpose of this study was to evaluate intrapulpar temperature changes in 4 groups of teeth with different dentine thickness (10 incisors, 10 canines, 10 pre-molars and 10 molars), during Class V cavity preparation with short pulse (250 ms/pulse) and very short pulse (80-120 ms/pulse) Er:YAG laser.

## 2. MATERIAL AND METHODS

Ten incisors, 10 canines, 10 pre-molars and 10 molars, obtained from laboratory stock and conserved in 0.1% thymol at 9°C until use, were sectioned at 2 mm below the cemento-enamel junction for the placement of the thermocouple in the pulp chamber.

Each group of teeth was divided into two subgroups and then class V cavities were prepared with Er:YAG laser (Fotona, *Fidelis*) applied with a short pulse (250 ms/pulse) or a very short pulse (80-120 ms/pulse), using the following parameters: 10 Hz frequency, 500 mJ potency, 6 s, 10 mm distance, 25 ml/min water flow, at 23°C and 65% humidity.

The teeth were placed at the cervical root portion in a plastic device with the crown at the bottom for the placement of the thermocouple. A copper-constantan (type T) thermocouple (Consitec, São Paulo, Brazil) was placed in the pulp

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chamber of each tooth. This device was coupled to a multimeter (Tektronix DMM916), which was calibrated in ice and at room temperature for temperature measurement. The millivolt changes measured by the multimeter were used to calculate the change in external surface temperature. The time required for return to room temperature was recorded

### 3. RESULTS

The intrapulpal temperature increases for both types of pulse in each dental group are reported in Table 1.

Table 1. Increase in temperature (°C) in root pulp during class V cavity preparation with Er:YAG laser.

	Teeth			
	incisors	canines	pre molars	molars
Short	2.8 ± 1.0	2.8 ± 1.1	1.6 ± 0.5	0.6 ± 0.1
Very Short	2.6 ± 0.9	0.9 ± 0.2	0.9 ± 0.1	0.4 ± 0.1

The very short pulse increased the canine pulp temperature less than the short pulse (Student t test,  $p < 0.01$ ); however, the time required for the temperature to return to normal was similar for both groups of canines (short pulse: 23-102 s; very short pulse: 43-79 s). The very short pulse also increased the pre-molar pulp temperature less than the short pulse (Student t test,  $p < 0.05$ ) and the time required for the temperature to return to normal was similar for both groups of pre-molars (short pulse: 31-96 s; very short pulse: 43-83 s). There was no statistical difference (Student t-test,  $p > 0.05$ ) in pulp temperature increase or time required to return to normal temperature between the short and very short pulses for incisors (short pulse: 56-109s; very short pulse: 29-64s). and molars (short pulse: 17-45s; very short pulse: 27-30 s).

### 4. DISCUSSION

Among the currently used lasers that emit in the near and mid-infrared spectral ranges, the absorbability of the Er:YAG laser in water is the greatest, because its 2.94  $\mu\text{m}$  wavelength coincides with the large absorption band for water<sup>7</sup>. Water-mediated explosive ablation with the Er:YAG laser shows a higher efficiency for hard tissue ablation than does the thermal vaporization caused by other lasers.

When lasers are applied to hard tissue, ablation thermal side-effects are a major problem. Many factors can influence the heating of the dentine-pulp complex. Some degree of heat generation is inevitable with the Er:YAG laser because it emits in the infrared region. The use of water spray minimizes heat generation by cooling the irradiated area and absorbing excessive laser energy<sup>6</sup>. Under adequate water cooling and with a careful irradiation technique, the Er:YAG laser system causes only minimal thermal damage to the tooth structure<sup>8</sup>.

Another factor that influences the transmission of heat to the pulp is the thickness of the remaining dentine. Dentine is a weak conductor of heat and when dentine thickness is reduced, its thermal isolation capability is decreased. Because the thickness of dentine is different in each group of teeth, temperature increases will vary. In vivo intrapulpal temperature increases by an accidental exposure of dentine during soft tissue laser excision or intentional exposure for the treatment of dentine sensitivity may be lower due to an intact periodontal ligament, bone, and pulpal circulation, all of which may reduce temperature effects. The temperature rises that would be seen in multiple rooted teeth (bicuspid and molars) would be expected to be less due to the increase in mass of the tooth structure<sup>9</sup>.

Different types of pulses are emitted by various brands of Er:YAG laser. The Fotona laser emits various types of pulses and we chose to evaluate the short (250 ms/pulse) and very short (80-120 ms/pulse) pulses. We suggest that the very short pulse causes less temperature increase because, although it has the same wavelength, the laser remains active for a shorter time period.

### 5. CONCLUSIONS

*In vitro* use of the Er:YAG laser during class V cavity preparation with very short pulse increased temperature less than the use of the short pulse. However, the temperature remained within an acceptable range for both pulses not resulting in pulp damage from heat diffusion. During cavity preparation water cooling spray must be used to reduce the risk of an increase in temperature resulting in tissue damage. The parameters studied did not exceed safety limits for the tooth thickness of different groups of teeth, however the operator must evaluate the remaining dentine thickness and adjust the laser settings based on clinical experience and other factors such as the presence of caries, attrition, abrasion or erosion on the crown surface.

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Request for reprints: Melissa Andréia Marchesan, Rua Pau Brasil 310, Jardim Recreio, 14040-220 Ribeirão Preto, São Paulo, Brazil. E-mail: meljul@universe.com.br