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# A comparative study of two intraoral laser techniques for soft tissue surgery

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**Abstract**

Historically, 810nm has been the predominant wavelength used for intraoral surgery, when diode lasers have been discussed, due to their large numbers in the market place. The techniques used intraorally with the 810nm diode have been relatively similar in most cases. Low powers, 1 or 2 watts, using continuous wave, are employed.

The purpose of this study is to compare the thermal damage of the technique of using continuous wave at low powers, to using higher powers with a pulse mode and water for coolant, with the 980nm diode wavelength. During the study the laser fiber was held immobile eliminating surgical manipulation as an error.

The resultant histology proves, the volume of vaporization dramatically increases with the higher fluence, thus giving the clinician the ability to reduce the time for destructive conduction of excess heat for a given procedure and the amount of coagulation actually decreases in width and depth. As an added benefit charring, which has been implicated in delayed healing is virtually eliminated. This evidence, coupled with excellent clinical results, lends validity to the use of pulsed higher powers and water coolant for the 980nm diode laser.

**Keywords:** 980nm diode, high fluence technique, intraoral laser surgery.

## Introduction

Historically, the 810nm wavelength has been the predominant diode wavelength used for intraoral laser surgery, due to the wavelength's initial positioning and predominance in the market place. The techniques used with the 810nm diode have been relatively similar in all cases. Low powers, less than 1 and up to 2 watts, continuous wave, using articulating paper or a tongue blade, to activate the fiber are employed. This technique utilizes a hot tip for the predominance of its photothermal effects. This technique is utilized due to the low water absorbtion and high scattering of the 810nm wavelength and other NIR wavelengths. The predominant process of optical propagation for the 810nm and the other wavelength lasers that comprise the NIR portion of the spectrum is elastic scattering. Scattering, however, does lengthen the pathway that the photons travel and increases the probability for absorption, thus increasing that effect, when it occurs, but causing it to be more diffuse. The resultant effect, of this technique, in intraoral use is desiccated tissue that exhibits charring, unless very low power is applied. The application of very low power, however leads to an additional adverse effect when delivered over a period of time to connective tissue. This effect is a crème brulee like surface to the ablated connective tissue which resists any additional vaporization and lends itself to charring (figure 1).

Recently the 980nm wavelength has entered the arena for intraoral surgery. The 980nm wavelength is positioned at an absorption peak in the water absorption spectrum giving it 8 times higher water absorption than the 810nm wavelength and 3 times more water absorption than 1064nm. The 980nm wavelength was initially utilized with a technique similar to the 810nm wavelength, 1 or 2 watts, continuous wave, with

Fiber preparation for the 10 watt samples was accomplished in a similar manner, except the fiber initiation was accomplished by firing on the black ink of a business card rather than the articulating paper. The reason for the variation is to restrict the heat generated by the silica fiber to a minimum. When the diode laser fiber is initiated on articulating paper and fired in the air at 10 watts the fiber gets hot enough to melt. Initiating the fiber on a business card generates minimal fiber heat. This type of fiber initiation does not generate that level of fiber heat as when the fiber is fired in the air it doesn't even glow let alone melt. The reason for initiating the fiber is that some conductive energy will be used to reach vaporization threshold.

The 2 watt samples were individually placed in light contact with the laser fiber and the laser was set at 2 watts for a 5 second pulse, the computer in the laser therefore controlled the exposure to 2 watts continuous wave for 5 seconds. High speed dental evacuation was employed for possible biohazard evacuation and standardized cooling. The samples were immediately transferred to a biopsy bottle containing 10% neutral buffered formalin and appropriately marked. The total energy delivered to each sample being 10 joules.

The 4 watt samples were handled similarly with the exception that the laser was set on 4 watts for a 5 second pulse prior to placement of the samples in the biopsy bottles. The total energy delivered to each sample being 20 joules.

The 10 watt samples were placed similarly with the aid of the surgical operating microscope. The difference being threefold as indicated by the high fluence technique:

1. The power was set at 10 watts pulsed at a 50% duty cycle .05 seconds on and .05 seconds off or 10 hertz. A peak power of 10 watts and average power of 5 watts was delivered.
2. The pulse counter on the laser was set to deliver 50 pulses or exactly 5 seconds of total exposure time.
3. Water was used for cooling through the prototype cooling handpiece, from bioLitec. The water was delivered coaxially with the laser fiber through a 20 gauge cannula, with a flow rate of 7cc/min.

The samples were placed immediately after lasing in the appropriately marked biopsy bottles. The total energy delivered in this case to each sample being 25 joules. The major difference being the 25 joules were delivered in 2.5 seconds with 2.5 seconds of cooling.

The collected (oral) tissue was sent to Mass Histology Services. At the histology laboratory the individual tissues were retrieved from their shipping bottles, any excess tissue trimmed, and then placed on their long side in tissue holders (cassette) with the mucosal surface at 90 degrees to bottom of cassette. Tissues were then processed through a series of alcohol baths to dehydrate and fix them after which they were embedded in paraffin wax molds to hold their shape. Tissues were then trimmed from the wax molds using a standard microtome into 5-micron sections with the mucosal surface parallel to line of cut so that the depth and width of the laser penetration points (lesions) were visible. Cut tissues were then stained with standard Hematoxylin (stains nuclear DNA and RNA blue) and Eosin (stains cytoplasmic structures red) stains. The stained tissues on glass slides were then cover slipped to preserve them, numbered by group and sent to the pathologist for microscopic evaluation.

The microscopic pathology evaluation included assessments to insure: that the exact same board part of the lesion was present in each mucosal section submitted; that the accessory dermal structures outside the immediate penetration point were or were not involved in spread; and that morphological measurements of the width and depth of spread were done in the same manner for each section using a standard Leitz 2mm microscopic slide micrometer. All measurements and observations were then recorded in computer-based tables using Microsoft word 2000. Finalized data was then sent to researcher for analysis and incorporation into final report.

## 3. Data

**Laser Techniques Histology chart**

| | Widest Spread | Ablated Width | Lateral coagulation | Total depth of ablation | Vertical coagulation |
|---|---|---|---|---|---|
| **GROUP 1** | | | | | |
| 2W 5 sec #1 | 1.55 mm | 0.75 mm | 0.40mm | 0.85 mm | 0.25mm |
| 2W 5 sec #2 | 1.75 mm | 1.35 mm | 0.20 mm | 0.75 mm | 0.20 mm |
| 2W 5 sec #3 | 1.90 mm | 0.90 mm | 0.50 mm | 0.70 mm | 0.25 mm |
| 2W 5 sec #4 | 1.90 mm | 0.80 mm | 0.55 mm | 0.76 mm | 0.19 mm |
| 2W 5 sec #5 | 1.60 mm | 0.60 mm | 0.50 mm | 0.70 mm | 0.10 mm |
| 2W 5 sec #6 | 1.50 mm | 0.50 mm | 0.50 mm | 0.65 mm | 0.10 mm |
| 2W 5 sec #7 | 2.00 mm | 0.80 mm | 0.60 mm | 0.80 mm | 0.20 mm |
| 2W 5 sec #8 | 1.50 mm | 0.50 mm | 0.50 mm | 0.50 mm | 0.20 mm |
| 2W 5 sec #9 | 1.70 mm | 0.80 mm | 0.45 mm | 1.00 mm | 0.25mm |
| 2W 5 sec #10 | 1.70 mm | 0.90 mm | 0.40 mm | 0.65 mm | 0.15 mm |
| **Average** | **1.76 mm** | **0.79mm** | **0.46 mm** | **0.74 mm** | **0.19 mm** |
| **GROUP 2** | | | | | |
| 4W 5 sec #1 | 1.85 mm | 0.85 mm | 0.50 mm | 0.75 mm | 0.15 mm |
| 4W 5 sec# 2 | 2.10 mm | 0.80 mm | 0.65 mm | 1.40 mm | 0.20 mm |
| 4W 5 sec# 3 | 1.95 mm | 0.35 mm | 0.80 mm | 1.30 mm | 0.10 mm |
| 4W 5 sec #4 | 1.90 mm | 0.60 mm | 0.65 mm | 1.30 mm | 0.30 mm |
| 4W 5 sec #5 | 2.30 mm | 1.00 mm | 0.65 mm | 0.80 mm | 0.35 mm |
| 4W 5 sec #6 | 2.00 mm | 1.00 mm | 0.50 mm | 1.65 mm | 0.35 mm |
| 4W 5 sec #7 | 2.20 mm | 1.10 mm | 0.55 mm | 0.80 mm | 0.10 mm |
| 4W 5 sec #8 | 2.10 mm | 0.90 mm | 0.60 mm | 1.10 mm | 0,35 mm |
| 4W 5 sec #9 | 1.70 mm | 0.70 mm | 0.50 mm | 0.70 mm | 0,40 mm |
| 4W5 sec #10 | 1.70 mm | 0.60 mm | 0.55 mm | 1.52 mm | 0.22 mm |
| **Average** | **1.92 mm** | **0.79 mm** | **0.59 mm** | **1.13 mm** | **0.25 mm** |
| **GROUP 3** | | | | | |
| 10 Watt#1 | 1.55 mm | 0.95 mm | .30 mm | 1.25 mm | 0.15 mm |
| 10 Watt#2 | 1.65 mm | 0.95 mm | .35 mm | 1.40 mm | 0.10 mm |
| 10 Watt#3 | 1.00 mm | 0.80 mm | .10 mm | 1.10 mm | 0.25 mm |
| 10 Watt#4 | 1.80 mm | 1.10 mm | .35 mm | 1.25 mm | 0.20 mm |
| 10 Watt#5 | 1.70 mm | 1.10 mm | .30 mm | 1.40 mm | 0.25 mm |
| 10 Watt #6 | 1.50 mm | 1.20 mm | .15 mm | 1.25 mm | 0.10 mm |
| 10 Watt#7 | 1.45 mm | 1.05 mm | .20 mm | 1.05 mm | 0.20 mm |
| 10 Watt#8 | 1.20 mm | 0.70 mm | .25 mm | 1.25 mm | 0.05 mm |
| 10 Watt#9 | 1.75 mm | 1.25 mm | .25.mm | 1.30 mm | 0.25 mm |
| 10 Watt#10 | 1.90 mm | 1.60 mm | .15mm | 1.10 mm | 0.25 mm |
| **Average** | **1.58 mm** | **1.07 mm** | **.25 mm** | **1.24 mm** | **0.18 mm** |

substantiated by a comparison of hot tip techniques at 2 and 4 watts to a technique using 10 watts pulsed and water for cooling. In the high fluence technique for the 980nm diode laser two major differences occur. Pulsing is employed enabling the use of higher peak powers to be applied (for thermal precision and use of radiant energy for ablation) and water is used for cooling of the laser fiber and tissue. The water initially reduces the heat conduction from the laser fiber to the surrounding tissue and secondly reduces the conduction of excess heat through the tissue caused by a typically long laser pulse thus reducing excess thermal damage.

This study, however limited, shows that 10 watts using the High Fluence Technique produces less thermal damage than the standard technique with a greater amount of vaporization, when using the 980nm diode laser. Maximum controllable vaporization with adequate coagulation should be the goal of the general dentist. If either vaporization or coagulation is not sufficient excessive lasing time on the tissue will be required with the resultant increase in thermal damage due to excessive conduction.

More complete studies need to be performed in order to precisely elucidate the effects of the 980nm diode laser and its use in intraoral surgery. The advantage of the 980nm wavelength has already been shown for implant uncovery and decontamination, Ramanos[4]. Nearly 200 dentists world wide are now using the 980nm diode and "The High Fluence Technique" with no reports of adverse effects. More clinical cases will be seen published, in the near future, with this wavelength.

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