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## **980 nm Diode Laser and Fiber Optic Resectoscope in Endourological Surgery**

source: European Biomedical Optics Week, BiOS Europe '96

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### **Abstract**

The 980 nm Ceralas D50 diode laser, produces homogeneous lesions on tissues of different nature. In our endourological tests we used the Ceralas D50 coupled with Comeg 24 ch laser resectoscope, and we treated 22 patients: n.5 bladder cancers, n.3 uretero pelvic junction obstructions (UPJ), with hydronephrosis, n.3 urethra stenosis, n.1 ureter stenosis, n.4 multiple upper tract transitional cell carcinomas, n.6 BPH treatments with VLAP modalities. Using the 1000 µm delivery fibers with different shaped tips, we obtained a bloodless sharp cut and easily vaporisations with minimum carbonisations, with power output in the range of 8-12 W, and 18-24 W for VLAP.

Keywords: Diode Laser, Ceralas D, Laser Resectoscope, BPH, Side fiber.

### **1. Introduction**

The instruments used together in laser surgery, the source, the optical fiber, the handpiece or endoscopic instrument; must be considered the fundamental elements of a "system" and must have particular requisites in order to be adept for clinical use. In the 1989 we conceived and developed an optical fiber with a prismatic cut at the distal tip which emits radiation orthogonally, named side fiber <sup>(1)</sup>. In the 1992, the first articles about the use of

side fibers with Nd-YAG source in urology for laser treatment of benign prostatic hypertrophy (BPH) appeared. In the same period we designed and developed the SAW, transurethral resectoscope; a traditional resectoscope which can be used with the side fiber, making treatment of BPH possible<sup>(2,3)</sup>. About 3 years ago we began to collaborate with CeramOptec Company in the development of a diode laser source which is completely integrated with optical fibers. We start with a preliminary study of photobiology aimed at identifying the wavelength at which the ideal tissue absorption and power-cost ratio could be found. In the water transmission spectrum, ranging from 800 and 1100 nm, we identified a strained layer of quantum well of  $\text{In}_{0.2}\text{Ga}_{0.8}$ . As diode laser with emission at 980 nm, as potentially adapt source for use in clinical applications. At a wavelength of 980 nm, water radiation absorption is about 3 times as much as that at 1064 nm of Nd-YAG laser. This led us to presume that, since the water content of the body tissue is from about 60 % to 80 %, more than twice as much radiation would be absorbed by the tissues at the former wavelength than at the latter, and that the photothermal effects (coagulation, sterilization, vaporization) were also possible at that wavelength. In fact, the coefficient of transmission is about 95 % at 810 nm at which the Diomed diode laser emitted<sup>(4)</sup>, is 85 % at 1064 nm and 65 % at 980 nm<sup>(5)</sup> (see fig. 1).

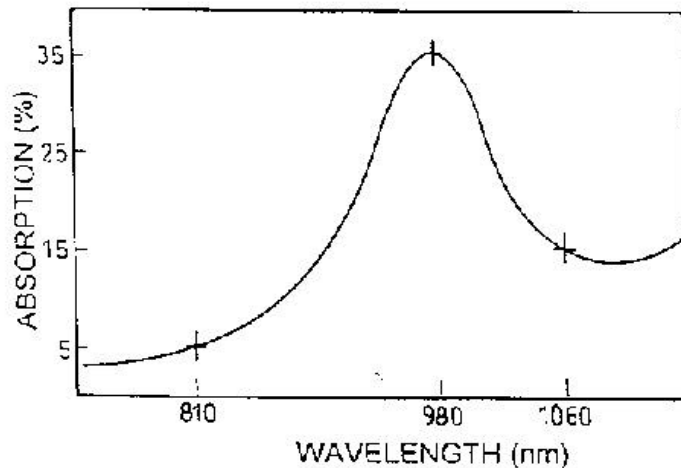


Figure 1: Water absorption between 750 and 1100 nm

## 2. Materials and Methods

The diode laser called Cerals D of CeramOptec is made with 72 quantum well type diodes in MOCVD configuration. The important characteristics of these diodes include an high damage threshold and elevated efficiency (40 %) especially when compared to diodes at 800 nm. The radiation of 72 diodes at 980 nm, together with the aiming laser diode at 670 nm are grouped in a bundle of 73 fibers with NA 0.14 which is, in turn, grouped in the 1000  $\mu\text{m}$  delivery fiber connected by an SMA 905. A 486 microprocessor which can implemented with specific programs and protocols is used to regulate the funktion of the entire system. The Ceralas D is easily transportable since it is of contained dimensions and weight only about 16 kg.

In working with this instrument we established the following parameters:

- a) Maximum emission power from the delivery fiber with a flat tip.
- b) Water absorption: 10 W emitted by the diode were measured at the exit point of couvette (optical path 10 mm) before and after filling it with distilled water.
- c) Fresh prostatic and muscular tissue was irradiated using first a 980 nm diode and then 1064 nm Nd-YAG laser, using a diffusive fiber with 18 mm x 2 mm tip dimension. The volume of the coagulated tissue was evaluated after irradiation for 6 min at low power output.
- d) Relative thermal gradients were then measured at the distance of 5 mm from medium lateral fiber tip, using a 400  $\mu$  Omega needle thermocouple.
- e) The vaporization threshold of prostatic and muscular tissue was then established with one millimeter of spot size diameter.

### 3. First Results

- a) The maximum power measured at the exit of the fiber tip was 52 W.
- b) 6.5 W were measured at the water optical path of 10 mm, absorption of 35 % (fig. 1).
- c) The volume of coagulated tissue obtained with the diode was up to 5 times more than obtained with the Nd-YAG laser (fig. 2).
- d) Peak temperature in the tissues was higher for the diode than the Nd-YAG laser (fig. 3).
- e) The vaporization threshold for the Ceralas D was 8 W, approximately 1/4 that of Nd-YAG laser with minimum variation from muscular and prostatic tissue <sup>(5)</sup>.

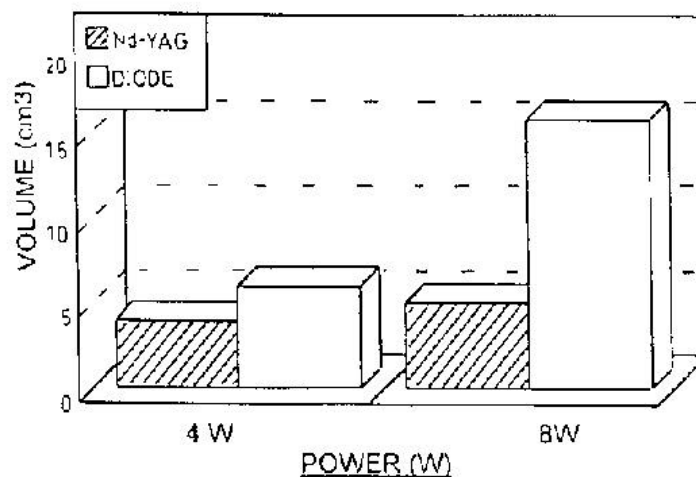


Figure 2: Coagulation volume of prostate tissue (Nd-YAG vs CERALS D)

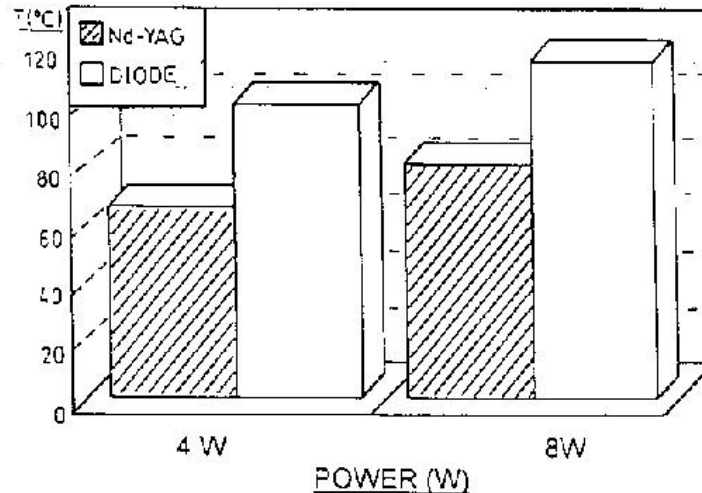


Figure 3: Max temperature into prostate issue (Nd-YAG vs CERALAS D)

#### 4. Preliminary Clinical Experiences

Our laser surgical system used in endourological trial was composed by Ceralas D50, laser resectoscope Comeg 24ch, named Guazzieri, and 1000  $\mu\text{m}$  core optical fibers with conical tips, flat tips, ball tips and side fibers.

We treated 22 patients according to the following procedures:

n.5 bladder cancer, conical ( $90^\circ$ ) and flat tips in contact and without contact, pulse mode (1 sec on, 1 sec off) with 8-10 W emitted power,

n.3 uretero pelvic junction obstructions (UPJ), with hydronephrosis, conical tips ( $60^\circ$ ) in contact, pulse mode (1 sec on, 1 sec off), with 8-10 W emitted power,

n.3 stenosis urethras (one with a stent), conical tips ( $60^\circ$ ) in contact, continuous and pulse mode (1 sec on, 1 sec off), with 10-12 W emitted power,

n.1 stenosis ureter, conical tip ( $60^\circ$ ) in contact, pulse mode (0.8 sec on, 1 sec off), with 10 W of power,

n.4 multiple upper tract transitional cell carcinoma, flat and conical tip ( $60^\circ$ ) in contact, without contact, continuous and pulse mode (1 sec on, 1 sec off) with 8-10 W emitted power,

n.6 BPH treatments with VLAP modalities, 4 using ball tips in contact, 2 using side fibers in contact and without contact, continuous mode, with 18-24 W of emitted power.

#### 5. Discussion

- According to our experience the radiation emitted by the 980 nm diode laser has a lower tissue penetration than that emitted by the Nd-YAG laser. During superficial and interstitial treatments with the 980 nm diode laser the temperature measured in the tissue was higher, and consequently the vaporization threshold was 4 times lower than with the Nd-YAG laser. Moreover, the volume of coagulated tissue with 8 W, was 5 times greater with the 980 nm diode than with the Nd-YAG laser.
- The Ceralas D produces lesions on the tissue which are independent of the optical parameters of tissues, consequently, the same power output produces homogeneous lesions on tissue of different nature. The same cannot be said for the Nd-YAG laser.
- Due to the high thermal gradient recorded on the tissue after irradiation with 8 W at 980 nm a cutting effect with a good coagulation and minimal carbonization we have obtained in vitro, (muscle and prostatic tissue) using in contact a 1000  $\mu\text{m}$  tapered fiber.
- In our preliminary clinical experience, using the 1000  $\mu\text{m}$  delivery fibers, put into contact and no contact procedure on vascularized tissue, we obtained a bloodless sharp cut and easily vaporization with minimum carbonization and edema, using a very low level of power output, in the range of 8-12 W, and for VLAP 18-24 W. Using the 600  $\mu\text{m}$  core optical fibers and maintaining the same power density will correspond respectively about 3-5 W and 8-10 W.
- In summary, the Ceralas D represent a good compromise between absorption and coagulative effects on the tissue with the possibility of modulating the photothermal effects.  
Therefore, small 980 nm diode laser sources with a maximum power of less than 25 W, with very low dimension and cost, should replace laser sources of older conception such as the Nd-YAG laser in the near future.

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