

The Use of the 2 micron Continuous Wave Revolix Laser in Urology

Lasers have been used in Urology for many years, however it is only recently that a new laser has been introduced into the operating room that is specifically designed to vaporize and excise soft tissue. This laser has two important features that make it more suitable for soft tissue, a) the wavelength is 2013nm which has an absorption 2.5 times higher than the pulsed Holmium laser, b) it is a continuous wave laser which produces better hemostasis than a pulsed laser.

KEY WORDS – Revolix, 2 micron, urology, lasers, continuous wave, fiber, fiber delivery, fiber optic, BPH, strictures, bladder tumors Holmium, prostate, KTP, Nd:YAG, Ho:YAG

Laser solutions for Urological procedures.

In the past the pulsed Holmium laser has been used for many urological procedures from lithotripsy to strictures and enucleation of the prostate. The wavelength of the Holmium laser (Ho:YAG) is 2123nm, which means that the target chromophore is water which is present in all tissue. Optical penetration at this wavelength is about 0.35mm. The peak power that is produced from the pulsed Holmium laser is extremely high (5,000 – 15,000 watts and can be useful when it is used to fragmenting calculi. However, it is not the best form of energy when it comes to cutting and ablation of soft tissue.

The Carbon Dioxide laser (CO₂) has for a long time been the universal surgical laser with a wavelength of 10600nm and also targets water. However it is limited in its surgical use because of the lack of a flexible fiber delivery system. This wavelength does not produce good hemostasis. The Neodymium YAG (Nd:YAG) laser has a wavelength of 1064nm with a target chromophore of hemoglobin. It does have a flexible fiber delivery system, however the depth of penetration in tissue can be as much as 2 centimeters. The KTP laser with a wavelength of 532nm also has a target chromophore of hemoglobin. The penetration of the KTP laser heavily depends on the degree of tissue vascularity. Both these lasers Nd:YAG and KTP are capable of producing deep injuries if there is no hemoglobin present in the tissue.

Laser Physics

Wavelength – Lasers are manufactured with a range of different wavelengths spanning from the ultraviolet to the infrared. These different wavelength have differing characteristics when they are applied to tissue.

Fig 1 shows the absorption curve for three of the body chromophores at different wavelengths. There are two pieces of information that can be obtained from the curve. Both Carbon Dioxide and Holmium lasers have a high absorption in water, while the Nd:YAG and KTP laser have almost no absorption in water but a high absorption in hemoglobin.

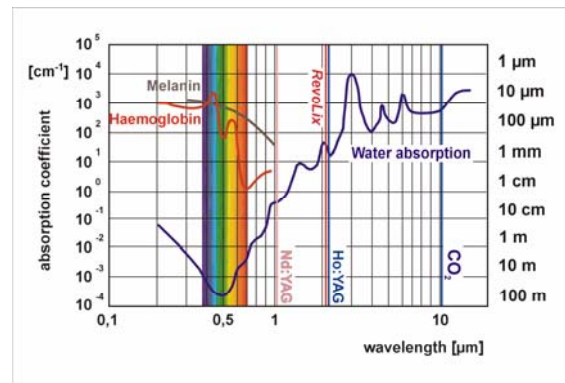


Fig 1 Absorption Curve

The depth of penetration can be obtained from the right vertical axis. In tissue (mainly water) the CO₂ laser and the Holmium laser have depths of penetration of 0.05mm and 0.8mm respectively, while the Nd:YAG and KTP lasers can penetrate up to 20mm in tissue where there is no or little hemoglobin present.

Pulse vs Continuous Wave – Another characteristic of a laser that is important is the temporal characteristic. Laser scientists distinguish laser systems which may be operated in a continuous wave mode from those which are pulsed only by their nature. The Nd:YAG is a typical member of the continuous wave class whereas the Holmium is a pulsed only laser

The Holmium laser is excited by flashlamps and can produce pulses with peak powers as high as 15,000 watts the pulse width in the range of 150 to 800 microsec. This pulsed feature along with the shallow penetration of the Holmium wavelength in water, makes it an ideal stone breaker.

Most continuous wave lasers can be operated in a continuous and a pulsed mode as well. In continuous mode these lasers may produce a maximum of say 100 watts, but when pulsed it can produce pulses with a peak power of 10,000 watts. The tissue response to peak power is very different than the continuous wave.

The RevoLix 2 micron laser is a continuous wave laser and can be only modulated, the peak power is the same as the continuous wave power that has been selected, i.e. there is no high peak power pulse.

Peak Power – Peak power has different effects within the body. It is extremely useful when fragmenting calculi, but it is detrimental when cutting soft tissue because a very rapidly expanding and contracting steam bubble is created with every pulse of the laser (Moses Effect). This bubble dynamics tears the tissue apart. This mechanical effect dominates the laser impact on soft tissue. The Holmium laser produces a rough cut and does not allow thermal energy to propagate and produce hemostasis. The continuous wave laser does not have this problem and therefore is much better suited to cutting and excising soft tissue. Also because of the lack of this large steam bubble, sensitive structures that are close to the surgical site do not suffer from mechanical trauma from this steam bubble. Another problem with the bubble effect is that there is reduced visibility when operating in a fluid environment.

Laser Safety

There are a number of issues that need to be addressed with laser safety.

- Eye and Skin Safety
- Fire Risk
- Smoke or Plume

Lasers are classified by the US Federal government depending upon their safety risk. Class 1 being the most safe, while Class 4 has the highest risk and therefore needs the greatest safety. Laser systems are clearly marked to show the class of each laser used within a system. The class of laser will dictate the necessary safety measures that need to be put in place to ensure safety for both the patient as well as the medical staff.

There are number of agencies that govern the safe use of the laser, see Appendix A

Per ANSI health centers should have a Laser Safety Office and a Laser Safety Committee who will oversee the safe use of the laser within the healthcare facility.

Delivery Systems

The laser energy is transmitted to tissue via flexible silica fiber optics that vary in size from 200 to 1000 microns in diameter. The selection of the fiber diameter depends upon the flexibility that is required (larger diameters are stiffer and therefore will not bend easily, while smaller diameters are more flexible but are also more delicate) and the spot size or power density that is required (watts per square centimeter .or joules per square centimeter).

Typically there are two different configuration,

- a) End firing reusable fibers that allow the laser energy to exit the fiber in a parallel axis to the fiber.
- b) Sidefiring single use fibers that allows the energy to be delivered at an angle approx 70 to 90 degrees to the optical axis of the fiber

These fibers can be introduced into various rigid and flexible scopes devices.

Note that some smaller fiber diameters have limits on the amount of laser power that they can safely handle. Refer to the fiber packaging for any power limits.

Fibers are either single use, which means that they are disposed of immediately after the procedure or they are reusable, which means that with the correct processing they can be re-sterilized and used again. Labeling on the fiber packaging will clearly show the allowable processes that must be used to re-sterilize the fiber. Distal fiber tips may have to be cleaved and the fiber jacket stripped back.

RevoLix Laser

The RevoLix laser has been specifically designed to vaporize and incise soft vascular and non vascular tissue with good hemostasis and without damage to surrounding structures. This is a continuous wave diode pumped laser with a wavelength of 2013nm or 2 microns. It is available in three power levels, a 15 watts, 50 watts and 70 watts. Another important feature is that this laser wavelength uses clear safety glasses that do not produce any color distortion

RevoLix Jr – 15 watts

This laser is a compact unit that weighs 45lbs, it is portable and operates on a standard 110V outlet. It has an output that can be varied from 1 watt to 15 watts in 0.1 watt increments.



Urological Procedures

- Bladder Tumors
- Strictures
- Bladder Neck Incisions
- Any other soft tissue resection or ablation

RevoLix 50 and 70 watts

These lasers are mobile units and operate on a single phase 220V 16 amp supply. No external cooling water is required



Urological Procedures

- Bladder Tumors
- Strictures
- Bladder Neck Incisions
- BPH – vaporization and resection (HOLEP and HOLRP)
- Any other soft tissue resection or ablation

The RevoLix laser is inherently safe when operating in a saline or water environment because the depth of penetration in water is less than 0.8mm. Structures at a distance further than 2mm away from the fiber tip will not be affected by the laser energy. When operating in an air environment the laser beam diverges rapidly as it exits the fiber tip and the power density will reduce with the square of the spot diameter, however care must be taken at all times to ensure that the fiber is not pointed at sensitive structures.

Surgical Procedures

BPH is a common disease for men, that is solved surgically with either a KTP laser or a Holmium laser. These lasers are used to vaporize the prostate with a single use sidefiring fiber however both of these laser procedures have pitfalls

Cost – the cost of single use sidefiring fibers is very high, approx \$900. Sometimes more than one fiber is necessary to treat a single patient.

Chromophore – the target chromophore of the KTP laser is hemoglobin. If the prostate is blanched or fibrous and lacks hemoglobin then the vaporization rates (gm/min) will be reduced and the amount of thermally damage prostate will be increased. This necrotic tissue will have to be sloughed

which can cause dysuria. The RevoLix has a water absorption which is 2.5 times higher than the Holmium laser

Hemostasis – The pulsed Holmium laser does not produce good hemostasis because the steam bubble that is produced by the peak power tears the tissue apart and does not allow for thermal energy to seal the vessels.

Color Distortion – Colored safety glasses are required the KTP laser where orange safety glasses must be worn. See the paper “Color Vision Deficits and Laser Eyewear

Protection for Soft Tissue Laser Applications” by Joel M. H. Teichman, George J. Vassar, J. Terry Yates, Bryan N. Angle, Anthony J. Johnson, Monte S. Dirks AND Ian M. Thompson published in The Journal of Urology March 1999.

The RevoLix laser has none of these pitfalls, fibers are autoclavable and reusable. Because the target chromophore is water the vaporization rate is unaffected by the amount of hemoglobin present in the prostate. Since the bubble effect is minimal with the RevoLix laser, the hemostasis is always excellent. The RevoLix laser does not need colored safety glasses so visualization is always good.

Bladder Tumors are easily treatment with the RevoLix laser. Because of the short absorption length the 2 micron laser is well suited to be used in one of two different modes. Either the tumor can be ablated, or if a biopsy is required the tumor can be excised. Both techniques produce excellent hemostasis. Continuous irrigation is recommended to maintain maximum visibility since small particles of tissue will be create a “snow storm effect”

Strictures – Since the target chromophore of the RevoLix 2 micron laser is water it is well suited to treat both vascular and non vascular tissue. Both ureteral and urethral strictures can be treated .

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ENDOSCOPIC CYSTOVENTRICULOSTOMY AND VENTRICULOCYSTERNOSTOMY USING A 2.0 MICRON FIBER GUIDED HIGH POWER DIODE PUMPED SOLID STATE LASER IN CHILDREN WITH HYDROCEPHALUS

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There are a number of agencies that control the use of the laser in the medical field. A list of agencies is given below

ANSI	American National Standards Institute
CDRH	Center for Device & Radiological Health
OSHA	Occupational Safety & Health Administration
NIOSH	National Institute for Occupational Safety & Health
AORN	Association of Operating Room Nurses
ASLMS	American Society for Lasers in Medicine and Surgery

The main standard that governs the use of the laser in medicine is ANSI Z136.3 Safe Use of Lasers in Health Care Facilities.