Comparison of Major Laser Technologies for Treating Benign Prostatic Hyperplasia (BPH)

Depth of Coagulation:

KTP/LBO (Green Light) Laser
- 1 - 2 mm
  (AMS Web Site, 180W setting)

Tm:YAG (Thulium) Laser
- 0.2 - 0.4 mm
  (Quanta System testing; EAU Guidelines on Lasers and Technologies, 2014)
Holmium (Ho:YAG) | Green Light (KTP/LBO) | Thulium (Tm:YAG)

- **Depth of Coagulation:**
  - **Holmium (0.4 mm)** (Zarrabi, Gross, et al., *The evolution of lasers in urology, Ther Adv Urol*, 2011)
  - **Green Light (1 - 2 mm)** (AMS Web Site, 180W setting)
  - **Thulium (0.2 - 0.4 mm)** (Quanta System testing; *EAU Guidelines on Lasers and Technologies, 2014*)

**Pulse-Mode Operation Creates Tearing Action at Incision Site, Resulting in a Cloudy Surgical Field**

- Pulse-mode operation and generation of super-heated bubbles at tip of holmium laser creates an irregular or “tearing effect” on soft prostate tissue. Holmium laser energy characteristics turn soft tissue into a cloudy white color, and generates bubbles and debris which tends to obscure the surgical field of view.

**Higher Necrosis Risk from Greater Coagulation Depth; High Energy Requires Use in Side-Fire Mode Only**

- Green light laser energy penetrates deeply into fluid and fluid-bearing soft tissue, creating a deeper coagulation zone and necrosis risk compared to either holmium or thulium laser systems. 532 nm wavelength characterized by high energy attraction to hemoglobin, which requires use of a side-fire tip and modification of surgical procedure to avoid application of laser energy to unwanted areas, such as bladder wall or ureteral orifices. Because the laser energy at the fiber tip must be angled for side-fire operation, energy output is also reduced.

**Continuous Energy Mode and Shallow Coagulation Depth Can Provide Lower Dysuria Risk**

- Shallow penetration and coagulation depth and high water absorption at 2010 nm wavelength creates ideal conditions for clear and effective vaporization and enucleation of prostate tissue, regardless of vascularity. High water absorption enables safe operation using a front-firing tip, with minimal danger of excess energy penetration into the bladder wall, ureteral orifices, or external sphincter.
Urological surgeons currently have a number of treatment options available for surgical treatment of Benign Prostatic Hyperplasia (BPH). Transurethral Resection of Prostate (TURP), using electrocautery, has been the efficacious standard of treatment for BPH surgery. However, this older technology carries with it the known and meaningful risks of hemorrhage, transurethral resection syndrome (TURS), and erectile dysfunction.

Laser BPH Treatment: The Emerging Standard in BPH Treatment

To avoid the risks associated with TURP, a growing number of urological surgeons have now switched to laser systems for prostate ablation and enucleation, providing superior performance and patient outcomes, greatly reduced risk of intraoperative bleeding, and elimination of the risk of TURS, which occurred in 1.4% of patients in a large TURP reported series (Gratzke, Bachmann, et al. J Urol 2008).

There are three widely-used laser technologies available for BPH treatment: “Green light” (KTP/LBO) laser, holmium (Ho:YAG) and thulium (Tm:YAG) laser. All of these laser systems offer clear advantages over TURP in lower risks and better patient outcomes for BPH surgery. However, there have been significant advancements in laser technology that provide important advantages to more newly-evolved laser systems over other laser systems using older technology.
Newest Laser Technologies Produce Less Tissue Coagulation and Necrosis, Reducing Potential Post-Operative Dysuria Risk

Compared to other laser technologies, such as KTP/LBO (“green light”) and Ho:YAG (holmium) lasers, newer laser technologies like thulium provide a substantially lower depth of coagulation. A deeper penetration depth of laser energy produces a greater area of necrotic tissue, which carries the risk of damage to the sphincter muscle or neurovascular bundles (Bach, Muschter, Sroka, et al., Eu Urol 2012). Lower coagulation depth significantly reduces the severity of tissue necrosis that can cause post-operative dysuria and retention risks (Te, Rev Urol 2006).

As well, there are other significant differences between the three types of laser technology used in BPH procedures, and it is important for urological surgeons to recognize these differences when considering the impact of each technology on their own surgical technique, and, most importantly, on patient outcomes for BPH treatment.

Green Light (KTP/LBO)Laser

KTP (potassium titanyl phosphate) and LBO (lithium triborate), or “green light” laser, is a popular and well-established laser technology for BPH treatment. Green light laser technology evolved over its predecessor, the original Nd:YAG laser system, whose performance in soft tissue surgery was not as effective as today’s modern laser technology.

While the green light laser is a popular system that has enjoyed widespread use, it does have some inherent shortcomings due to the nature of its laser energy output. For example, the wavelength of the green light laser is strongly absorbed by hemoglobin, and penetrates vascular tissue by no more than a few micrometers. In soft tissue having high vascularity, the green light laser will efficiently vaporize tissue during the treatment. However, after the first pass is made, coagulated tissue is left behind, where the energy of the laser beam on each subsequent pass can be scattered on contact with this coagulated tissue, which reduces the vaporizing effect of the beam on the next layer of tissue.
Low Water Absorbtion of Green Light Laser Results in Excess Tissue Coagulation

The wavelength energy of green light lasers is also characterized by low absorption in water. When the hemoglobin molecule is not present in the beam path at the incision point, the beam will penetrate deeply into soft tissue or irrigant fluid. This characteristic of green light laser energy reduces the efficiency of the beam and leads to inconsistent performance when used in areas of the prostate having both necrotic and vascularized tissue. As a result, more energy is often applied to the incision site, and often at distances further than the 3 mm optimal operating distance for the KTP/LBO laser. This creates excess coagulation at the site of the first pass, which makes the next pass more difficult because the tissue was not vaporized, leading to use of more energy than is necessary for efficient tissue vaporization. According to one study of BPH procedures using the KTP/LBO laser, an unexpected necrotic tissue depth of up to 16.5 mm was reported during an immediate post-operative ultrasound; deeper coagulation may be a key factor influencing increased dysuria rates and other post-procedural complications (Bodin, Bruyere, et al., J Urol 2014).

This characteristic of tissue absorption also requires use of a side-firing tip to allow the surgeon to gain better visual control of the exact location of the laser’s firing point to avoid unwanted tissue damage. The laser energy at the tip of the fiber must be angled to create the side fire tip, which results in greater energy loss. The side-firing tip also causes fibers to degrade more rapidly, as the side-fire port tends to become clogged with tissue during the BPH procedure. The moxy fiber used in KTP/LBO laser has been shown to exhibit a loss of power output of 20% or more during BPH procedures, degrading operating performance (Poyet, Grossmann, Wettstein, et al., J Urol 2014). Additionally, side-firing fiber tips have a more limited operating life due to carbonization at the point of laser beam output, which must be remediated by continuous flushing of irrigant fluid along the fiber (Bach, Muschter, Sroka, et al., Eu Urol 2012).
Use of Side-Firing Tip in Green Light Laser May Force Some Surgeons to Change Their Surgical Technique

Green Light Laser’s Side-Fire-Only Mode Forces Changes in Surgical Techniques

Use of a side-firing tip forces the surgeon to adopt their surgical technique to perform lateral incisions during the BPH laser procedure, which may not be an optimal technique for many surgeons.

Additionally, due to the green light laser’s wavelength, the operating surgeon must wear bright-orange safety glasses to avoid eye injury. This is a common complaint of surgeons using green light lasers, because use of orange safety glasses creates a monochromatic effect which tends to obscure the operating field of vision through the cystoscope and degrades the quality of the surgeon’s field of view.

Holmium (Ho:YAG) Laser

Another popular laser system used in BPH surgery, the holmium yttrium-aluminum-garnet (Ho:YAG) laser, operates at a wavelength of 2.1 microns and is characterized by pulse-mode operation, as opposed to both green light (KTP) and thulium (Tm:YAG) systems, whose laser energy is emitted in continuous mode.

The pulse-mode operation of the holmium laser emits a burst of laser energy every 200 to 1300 microseconds, with an absorption coefficient in water that is less than the thulium laser. This pulse mode, while being useful and effective in other surgical procedures, such as lithotripsy, makes interaction with soft tissue more difficult compared to either green light or thulium laser.


For example, the pulse-mode operation of the holmium laser, combined with its higher absorption coefficient in

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Overview of Key Thulium Laser Advantages for Treating BPH: The Surgeon’s Perspective

Doctors using thulium laser systems in BPH procedures have described the following major advantages of thulium (Tm:YAG) laser operation over both green light (KTP/LBO) and holmium (Ho:YAG) laser systems:

More Natural and Intuitive Tissue Cutting Effect

Due to its front-firing tip and extremely rapid tissue/water vaporization characteristics, the thulium laser provides a smoother, more natural “feel” in use, enabling the surgeon to operate with a higher level of precision at the treatment site;

Front-Firing Operation Provides Better Visualization of Each Incision

The front-firing mode of the thulium laser not only provides for more intuitive operation during soft tissue surgery, but also gives the surgeon a clear view of the cutting point of the laser at all times, for maximum control of each incision. This is a major advantage compared to green light lasers, which can only operate in side-fire mode, which forces the surgeon to direct the laser energy at tissue without being able to visualize the interaction at all times;

Inherently Safer Laser Energy Wavelength

Because the wavelength of the thulium laser is highly absorbed in water, the only effect of the laser is what is seen by the surgeon. The green light laser penetrates more deeply in tissue when no hemoglobin is present, which increases the risk of stray laser energy accidentally damaging unwanted tissue along the bladder wall, ureteral orifices, and external sphincter, and other areas;

Clearer View of Surgical Field During the Procedure

Contrasted with green light and holmium laser operation, the instantaneous tissue vaporization of thulium laser leaves a clearer, unclouded, debris-free view of the procedure area before, during, and after each laser cut;

Enhanced Clarity of Surgical Field Using Clear Protective Eyewear

This effect is enhanced by the fact that doctors do not have to wear highly tinted protective eyewear while using the thulium laser (optically clear Tm:YAG safety glasses only). This is in contrast to using the green light laser, which requires the surgeon to wear bright-orange laser safety glasses, which tend to reduce the clarity of the field of view, adding an unwanted monochrome effect;

Versatility for a Wide Range of Urological Surgery Applications

In addition to BPH surgery, thulium laser systems are well suited for other common surgical procedures, such as urologic tumors, strictures, and general surgical needs; due to their operating characteristics, KTP/LBO (green light) laser systems are limited to BPH surgery.

Reusable Fibers Reduce Operating Costs for Each BPH Procedure

Compared to KTP/LBO (green light) laser systems, fibers used with the thulium laser are reusable, at a lower cost per procedure, compared to green light laser fibers, which require a new fiber for each procedure, at a significantly higher cost for each procedure.
Holmium Laser Energy Creates Bubbles, Debris, and Unwanted Color Changes to Tissue, Clouding Surgical Field

During operation, bubbles are created at the tip of the holmium laser fiber, which are responsible for tearing away tissue at the incision point. Tissue which absorbs energy from the holmium laser takes on a white fibrous appearance, which clouds the surgical field and reduces its clarity to the surgeon.

Due to the operating characteristics of the holmium laser in BPH treatment, different surgical techniques are recommended based on prostate size. For glands less than 40 grams in volume, Holmium Laser Ablation of Prostate (HoLAP) is recommended for vaporization of prostate tissue, and Holmium Laser Enucleation (HoLEP) is recommended for segmental resection for larger prostates. It should also be noted that the HoLEP procedure also requires a significant learning curve when using the holmium laser.

Thulium (Tm:YAG) Laser System for BPH Treatment

The newest technological evolution in laser treatment for BPH, Tm:YAG (thulium) laser, operates at a continuous wavelength of approximately 2 µm. Because of its continuous wave output, the thulium laser exhibits better performance in soft tissue surgery compared to the burst-mode operation of the holmium (Ho:YAG) laser, producing a better incision cut quality than holmium in soft tissue.

Since the wavelength of the thulium laser is close to the absorption peak of water, this characteristic, combined with its short depth of penetration, focuses a high level of energy on contact with tissue, resulting in smooth, rapid vaporization of water and tissue. This continuous-wave vaporization action...
of the thulium provides superior, smooth cutting action in tissue, in contrast to the burst-wave energy output of holmium laser, which creates an irregular incision path, characterized in one research study as a “tearing action” (Hermann, Liatsikos, et al., European Association of Urology, 2011).

Consistent Power Delivery of Thulium Laser Delivers a Clear, Smooth Cutting Effect, Without Debris, Bubbles, or Blood in Surgical Field

In BPH surgery, the thulium laser generates an instantaneous vaporcut (tissue vaporization) effect, which allows the surgeon to deliver a precise hemostatic incision at the front of the laser’s fiber tip, as contrasted to the green light (KTP/LBO) laser, which can only be operated in side-fire mode so as to avoid unwanted tissue damage ahead of the front fiber tip. In continuous firing mode, thulium laser removes tissue to a depth of 0.2 mm (or deeper at higher energy settings), with a shallow coagulation depth of 0.2-0.4 mm. This provides the surgeon with a tool that is optimized for enucleation and ablation in prostate tissue, while having an extremely confined thermal effect on surrounding tissue.

In operation, thulium laser provides precise and simultaneous vaporization of tissue, shallow depth of coagulation along the incision margin, and hemostasis at the incision site. After each incision, each coagulated seam of tissue still contains sufficient water to allow for adequate energy absorption for each subsequent laser pass to the treatment site, without the power degradation of the green light laser.

Since the operating energy of the thulium laser is highly absorbed by water, there is much less risk of stray laser light accidentally damaging surrounding tissues, such as the prostatic capsule, sphincter, ureteral orifices, or bladder wall.

The wavelength of the thulium laser, being considered ideal for BPH surgery, vaporizes tissue regardless of its level of vascularity, providing more effective control of bleeding (hemostasis) without creating the risk of deep coagulative necrosis of surrounding tissue. Most important, the rapid tissue ablation rate of thulium laser, combined with its shallow...
absorption and coagulation depth, also reduces the risk of dysuria to the patient from the BPH procedure.

The Final Factor: Making the Choice for Better Patient Outcomes

While all three laser systems have been recognized as safe and effective for surgical BPH treatment, surgeons must consider the inherent capabilities of each of these systems, their effects, and their potential impact on patient outcomes, the latter being the most important factor in any surgical procedure.

The first consideration is safety during the procedure. Due to its low energy absorption in water, the green light (KTP/LBO) laser penetrates more deeply into soft tissue and bears the risk to the patient of directing unwanted energy to surrounding tissues not directly seen in the surgical field of view. When compared to the KTP/LBO laser in a clinical study, the higher soft tissue energy absorption rate of the thulium laser demonstrated a larger ablation capacity, resulting in a reduced bleeding rate and a shallower zone of coagulation (Wendt-Nordahl, Huckele, Honeck, et al., J Endourol, 2008).
When compared to the holmium laser in a clinical trial, researchers reported lower comparable patient blood loss in use of the thulium laser (Zhang, Shang, et al., Zhonghua Nan Ke Xue, 2009). Because of the substantially reduced bleeding rate during BPH procedures, the thulium laser is also a safer laser technology treatment method for patients taking anti-coagulant medications.

Additionally, comparisons of clinical study results show early indications of lower catheterization times and hospital stays with the thulium laser system. Compared to a major study (Bachmann, Tubaro, Barber, et al., EU Urol 2014) showing average catheterization times of 40.8 hours and hospital stay lengths of 65.5 hours, another study (Carmignani, Picozzi, et al., One Day Surgery in the Treatment of Benign Prostatic Enlargement with Thulium Laser; A Single Institution Experience, 2014) showed greatly reduced average catheterization times of 14.8 hours and hospital stays of 24-36 hours resulting from BPH surgeries utilizing thulium laser.

Substantially lower depth of coagulation, leading to substantially reduced necrotic tissue risk, combined with a better surgical surgical advantages and higher potential for better patient outcomes, make the thulium laser worthy of careful evaluation for surgeons considering the use of laser technology in their BPH treatment procedure.
About Cyber TM

Founded in 1985, Quanta System S.p.A., developer of the Cyber TM Thulium Laser system, is a worldwide leader and manufacturer of advanced laser technology systems for a wide range of medical, industrial, and commercial applications.

The Cyber TM Thulium Laser is the leading thulium laser treatment technology in the U.S. for the BPH laser surgery procedure. Quanta System’s Cyber TM Thulium Laser, available in both 150 W and 200 W power output models, provides the optimal combination of high efficiency cutting and effective coagulative effects, making it an ideal laser instrument for surgical BPH applications. Additionally, the Cyber TM Thulium Laser has been proven effective in other urological procedures, including excision of tumors, ureterotomy, urethrotomy, and partial nephrectomy.

Quanta Systems and its exclusive distributor, International Medical Lasers, provide comprehensive training and support for all of its laser systems in the U.S.

For further information, please contact us by phone or e-mail.