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Open to Debate: For

Thulium Fiber Laser: Bringing Lasers to a Whole New Level

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Over the past few years, numerous trials have supported the fact that endoscopic enucleation of the prostate (EEP) is both safe and efficient, whether its compared to transurethral resection of the prostate (TURP) or other laser-based techniques (eg, photovaporization of the prostate) [1,2]. The international guidelines consider EEP to be one of the techniques of choice for relief of benign prostatic obstruction (BPO). Most of the data on EEP support the fact that irrespective of which device is used, the efficacy of EEP will remain the same. Despite all this evidence, the discussion regarding which instrument is best to use is ongoing. A recent systematic review by Pallauf et al. [1] suggests that different energy sources are similarly effective and would have a different effect on the intervention itself. Thus, is the jury still out on which is actually the best laser for the job?

The most recent addition to the pool of lasers—thulium fiber laser (TFL)—could potentially be considered at some point "the best device for EEP". In this short piece, we look at TFL from three major points: first, in the context of the evolution of lasers; second, as a device with unique physical properties; and third, as a laser that has great surgical potential and offers new promises and opportunities.

Ho:YAG, which was not fully recognized in BPO surgery when it was first introduced to the field, took the leading position in just a few years after Gilling et al. [3] developed the holmium laser enucleation of the prostate (HoLEP) technique. A few years after this development, Gilling et al presented the first results from a randomized trial comparing TURP and HoLEP, showing shorter catheter time and more durable BPO relief (according to urodynamics). However, despite the obvious advances, a few technical limitations remained. These included the long learning curve and the complexity of holmium enucleation for inexperienced surgeons [4]. This has prompted researchers to search for an instrument that is superior to Ho:YAG [5].

The introduction of Tm:YAG laser to endourology represented a great leap forward. As a continuous wave device, it has a better water absorption coefficient (eg, 52 cm^{-1} for Tm:YAG and 26 cm^{-1} for Ho:YAG, resulting in a shallower theoretical penetration depth of 0.2 mm vs 0.4–0.7 mm). As a continuous-wave device, Tm:YAG is also able to effectively coagulate tissues; in a perfused porcine kidney model, Tm:YAG showed a minimal bleeding rate of 0.16 ± 0.07 g/min in comparison to 20.14 g/min with TURP ($p < 0.05$) [6]. Despite its superior cutting and coagulation, Tm:YAG still has a number of limitations, such as a tendency for greater vaporization and prominent carbonization [7]. Further introduction of TFL in endourology took into consideration the advantages and drawbacks of Tm:YAG.

The first tests completed using low-power TFL showed that it is an effective cutting tool with high potential for hemostasis [8]. This is possible because TFL has a better absorption coefficient in water (114 cm^{-1}, which is twofold better than for Tm:YAG and fourfold better than for Ho:YAG). This allows a reduction in the theoretical penetration depth to a minimal 0.15 mm. Moreover, while Ho:YAG incision is characterized by ruptured and uneven edges on

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pathology (owing to the higher peak power of Ho:YAG), TFL tends to result in clearer and shallower cuts [9,10].

However, the dramatic improvement in penetration depth with TFL is not the only advantage of this device. The real TFL secret is in its medium, which is the most important component of each laser device. The most frequently used lasers are Ho:YAG and Tm:YAG (solid-state lasers), which are based on a medium made from a solid yttrium aluminum garnet (YAG) crystal. TFL is different in that the medium is made from woven silica fiber that is chemically doped with thulium ions. This construction means that TFL devices are much smaller then Ho:YAG and Tm:YAG and prevents extensive heating; an air cooling system is sufficient for TFL, in contrast to the water cooling systems required for Ho:YAG and Tm:YAG [11]. However, this is not the only advantage: solid-state lasers use flash lamps as the energy source for the firing, while TFL uses small diodes. This allows TFL to work in two modes, superpulse mode for stones and quasicontinuous mode (QCW) for soft tissues.

Ex vivo studies have shown that QCW TFL produces coniform ablation zones (2.7 ± 0.3 mm vs 1.6 ± 0.2 mm with Ho:YAG) with a rounded apex surrounded by a marked coagulation zone (up to 0.6 ± 0.2 mm vs 0.1 ± 0.1 mm with Ho:YAG). While the pulsed firing of Ho:YAG may lead to significant tissue rupture, TFL cuts showed clear edges with no ruptures. It also did not lead to extensive tissue carbonization, although any carbonization observed was more pronounced than with Ho:YAG [10]. The authors hypothesized that this result is likely to translate into superior cutting and coagulation abilities in clinical practice.

Considering the above-mentioned advantages, the question arises as to how they influence surgery. EEP is an energy-independent technique that results in acceptable results in terms of intraoperative safety, functional outcomes, and complications when compared to Ho:YAG, and Tm:YAG laser energy sources, among others [12,13].

The first clinical results show that TFL is pushing ahead of TURP and open simple prostatectomy (lower rate of bleeding and shorter catheterization time and hospital stay) [14,15]. In comparison to Ho:YAG, no advantages in terms of efficiency or safety were observed [16]. A recent randomized trial of HoLEP and TFL laser enucleation of the prostate (ThuFLEP) revealed that the deeper ablation and coagulation zones with TFL do not translate into higher rates of urinary incontinence and irritation after surgery (assessed with QUID, ICIQ-MLUTS) [17]. Despite a comparable bleeding rate in these trials, TFL, owing to its better coagulation ability, should still be promising in terms of lower bleeding rates and faster hemostasis, which was confirmed in ex vivo tests [11].

Another advantage is a shorter learning curve, as previously demonstrated. The ablation rate with ThuFLEP in the hands of trainees was higher than with monopolar enucleation ($p < 0.001$) with a slight advantage over HoLEP (1.0 vs 0.8 g/min; $p = 0.07$). The trainees mentioned that the low carbonization made ThuFLEP more convenient for them in comparison to monopolar surgery, whereas efficient tissue cutting allowed them to easily restore the enucleation plane when compared to HoLEP. However, this is difficult to assess objectively and is mostly based on surgeons' opinions [18].

As mentioned previously, TFL does not use flash lamps or water cooling, relying instead on a diode laser as source and air cooling. Thus, as a high-power machine, TFL uses a standard power outlet and has significantly lower noise in comparison to Ho:YAG [11]. Moreover, this may also increase the cost effectiveness of the device, as the diode laser used as a source has a longer lifespan than a flash lamp and the air-cooling system does not require coolant replacement [19]. However, all these statements need to be confirmed in subsequent trials.

To sum up, the technique of prostate enucleation itself might level out the disadvantages of the instrument used. Thus, if you are thinking about treating BPO, use EEP. Nevertheless, if you are looking for a universal instrument that has already proved itself to be effective as a solid-state device (Ho:YAG and Tm:YAG) and that has better physical properties, greater cost efficiency, and superior adaptation, then choose TFL.

Conflicts of interest: The authors have nothing to disclose.

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