REVIEW ARTICLE

Thulium Fiber Laser in Urology

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Minimally invasive surgery (MIS) has seen large uptake in recent decades, with increasing numbers of such procedures being performed. Laser technology is widely used in the management of urological diseases, including urolithiasis, benign prostatic enlargement (BPE), and urinary tract malignancies.[1,2]

Laser lithotripsy was first adopted by urologists in the 1980s, with Holmium:Yttrium-Aluminium-Garnet (Ho:YAG) becoming the laser of choice in the mid 1990s[3,4]

Compared to other lithotripsy techniques, the Holmium:YAG laser presents several important advantages:

(1) suitability for fragmentation of all known urinary stone types into small stone particles [3,4];

(2) ability to operate with thin and flexible delivery fibers with limited energy losses and with core diameters as small as 200 µm [5,6];

(3) favorable safety profile with minimal tissue penetration depth and low risk of undesirable tissue damage due to the relatively high absorption coefficient of the Holmium:YAG laser wavelength in water[7]

In recent years, there has been a surge of interest in Thulium Fiber Laser (TFL) which has a 4x higher absorption coefficient in water-containing tissue, smaller operating fibers (50–150 µm core diameter), lower energy pulses (0.025 J), and higher pulse rate capability (up to 2 KHz).[2]

One advantage of TFL is its higher water-absorption coefficient compared with Ho:YAG, which means that water absorbs TFL energy around four times higher than it does with Ho:YAG laser energy. Using water absorption as a model for cell absorption, the implication of this is that more energy from TFL is absorbed by cells and therefore they are better ablated [8,9]

Clinical application

Stone surgery

In one study conducted by Enikeev et al[10] The authors observed no correlation between stone density and laser on time or operative time, suggesting that density does not affect the ablation efficiency of thulium fiber laser (TFL). With reference to the theoretical advantages of minimal retropulsion and enhanced visibility of TFL: retropulsion that interfered with operative progress was reported in 1.4% of cases and insignificant retropulsion was reported in 11.7% of cases; and suboptimal visibility was reported in 14.6% of cases

Addressing the safety of TFL, the authors suggested that the high-powered lasers (25–40 W) used for lithotripsy should have no detrimental effect on urinary tissue, with the authors finding no cases of strictures or stenosis at 3 month follow-up.

Another study conducted by Shah et al. investigated the use of TFL in mini-percutaneous nephrolithotomy (PCNL) with suction in a prospective study.[11] The authors sorted through stone sizes using sieves to calibrate the TFL settings to perform mainly dusting and therefore allowing the use of concurrent dust aspiration to decrease operative time.

They achieved a 100% stone-free rate at one month, with a mean operative time of 39.9 minutes.[11]

Regarding Flexible Ureterorenoscopy with Lithotripsy (FURSL), Enikeev et al. prospectively studied the use of SuperPulsed TFL for 10–30 mm renal calculi, focussing on comparing two regimens for dusting: 0.5 J x 30 Hz = 15 W and 0.15 J x 200 Hz = 30 W.[12] They found that both ablation efficiency and speed were higher in 200 Hz mode without the drawbacks of increased laser-on time nor increased intraoperative complication rates.

Prostate Laser Enucleation

As with lithotripsy, Ho:YAG has been the mainstay for endoscopic laser enucleation of prostate (HoLEP) with recurrence rates of less than 5%.[13] However, HoLEP is considered technically challenging with a steep learning curve.[14]

In a randomized study, ThuFLEP was compared with HoLEP and MEP. The authors found that ThuFLEP was associated with simple learning curve, achieving proficiency in as few as 8–16 procedures. This illustrates a key advantage over HoLEP which typically requires 50–60 procedures.[14] However, the authors found no significant difference in enucleation rates between ThuFLEP and HoLEP. A popular setting for prostate enucleation is 0.5–1J x 30–80Hz.

Enikeev et al retrospectively compared ThuFLEP with Open simple Prostatectomy (OP) for large volume prostate, focussing on comparing lower urinary tract symptoms, quality of life, maximum urine flow rate, and postvoid residual urine volumes.[(15)] The two procedures had comparable operative times and resection speed. ThuFLEP was associated with a shorter hospital stay and catheterisation time when compared to OP.

Bladder tumor

Transurethral resection of the bladder tumor was used for decades in the treatment of bladder masses as part of the initial treatment and part of staging of the tumor, more recently Ho:Yag LASER was used for the enblock resection

A recent randomised controlled trial compared cTURBT (using monopolar electrocautery) with Holmium laser ERBT (HolERBT), demonstrating promising results for the laser-based approach.[39] HolERBT conferred a lower residual tumour rate (7% vs 27.7%), improved detrusor muscle sampling (98% vs 62%), as well as shorter catheterisation time and hospital stay.[(16)]

TFL offers several theoretical advantages over Holmium, such as mentioned decreased penetration depth and the decreased carbonisation because of good water absorption.

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