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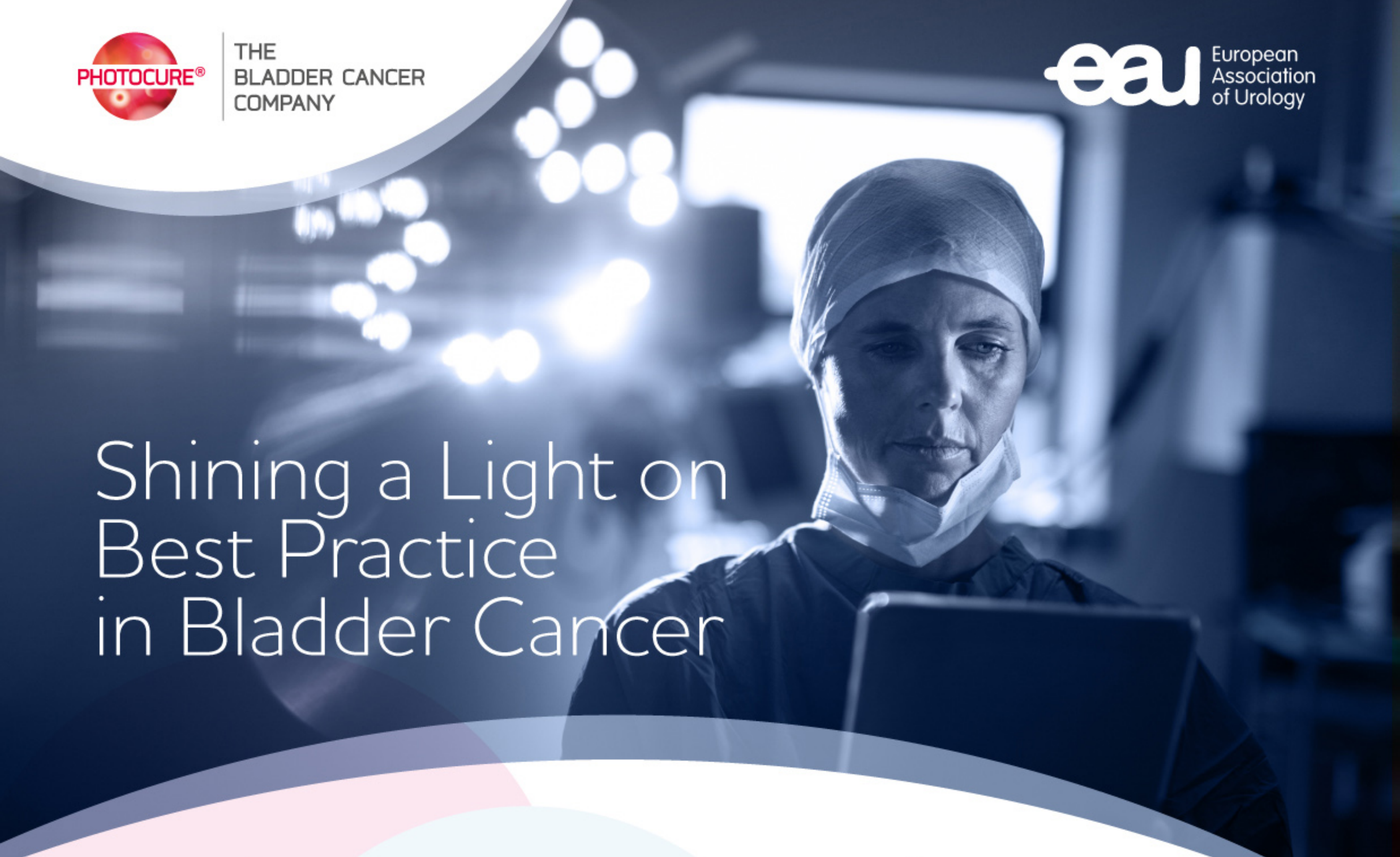

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Review

Current status of thulium fibre laser lithotripsy: an up-to-date review

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Objective

To perform an up-to-date review to scope the current status of the thulium fibre laser (TFL) in the setting of stone lithotripsy and provide a guide for the clinical urologist.

Methods

A review of world literature was performed to identify original articles on TFL for stone lithotripsy. Our clinical experiences of using the technology have also been shared.

Results

To date there have been 11 clinical studies published on TFL for stone lithotripsy. Three of these have been in the setting of miniaturised percutaneous nephrolithotomy (mini-PCNL) and the remainder have been on ureteroscopy (URS). There has only been one randomised study on this technology, which has been for URS. For URS, the range of settings has been 0.1–4 J × 7–300 Hz for both URS and mini-PCNL. Stones ranging from 0.4–3.2 and 1.5–3 cm have been treated with URS and mini-PCNL, respectively. The final stone-free rate for TFL has ranged from 66.6% to 100% and 85–100% for URS and mini-PCNL, respectively. The average length of stay ranged from 0.5 to 2.4 days in the URS group, but no studies have been reported this for mini-PCNL. Operative times in all the studies (both URS and mini PCNL) were <60 min.

Conclusion

Initial clinical studies reveal that TFL appears to be efficacious in the setting of stone lithotripsy. However, further randomised trials are warranted to delineate its formal position, as well as determine the optimal settings for use in clinical practice.

Keywords

thulium, urinary stones, fibre laser, urolithiasis, fragmentation, #KidneyStones, #EndoUrology, #UroStone

Introduction

Endourology has witnessed a number of turning points in its history. This includes the inauguration of percutaneous nephrolithotomy (PCNL) in 1976, the introduction of the ureteroscope in 1980, and the advent of shockwave lithotripsy by Chaussy *et al.* [3] later that same year [1–3]. Alongside this, the evolution in minimally invasive stone surgery has been propagated further by the development of fibre optic delivery systems and miniaturisation of standard equipment [4]. As a result of this, the surgeon is able to reach nearly all areas of the urinary tract in the modern era. The incorporation of laser (Light Amplification by the Stimulated Emission of Radiation) technology into this area of surgery was also a notable milestone [5]. For >20 years, the holmium: yttrium-aluminium-garnet (Ho:YAG) laser, referred to in this article as holmium laser, which operates at a wavelength of 2120 nm, has served as the cornerstone laser platform for intracorporeal endoscopic stone lithotripsy, despite the addition of numerous alternatives [6]. Accordingly, it is recommended as the 'gold standard' among several international guidelines [7]. In order for a new laser to be established and achieve dissemination, it is required to demonstrate several key properties. This includes clinical efficacy, principally high stone-free rate (SFR), as well as safety and durability. Delivery in a small fibre, especially if pulse energy (PE – total energy released from the fibre in a single pulse) is not compromised, reduces retropulsion, and supports improved manipulation of a flexible scope, as well as augmented irrigation [8]. Further practical considerations include generator size, type of power supply, and cost. The thulium fibre laser (TFL) is the latest laser technology, which has gained increased attention for its role in stone lithotripsy since its application for this purpose was first described in 2005 as part of an *in vitro* study [9]. Since then, there have been an increasing number of studies investigating its application in both pre-clinical and clinical settings. Despite these advances and largely due to the rapid surge in interest in a short time period, critical evaluation remains under reported. In the present review, our aim to was to perform an up-to-date review to scope its current status in stone lithotripsy and provide a guide for the clinical urologist.

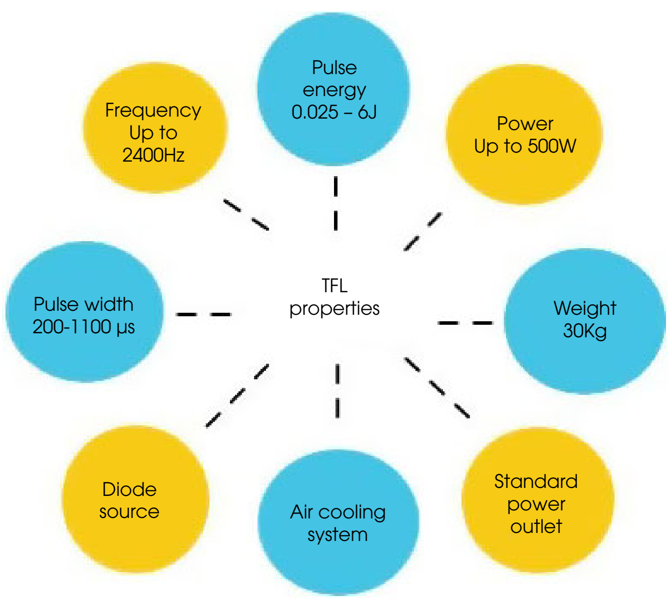
The Evolution of Holmium Laser

The holmium laser was introduced to urological practice in 1992 and soon established dominance over predecessors such as the pulsed dye laser [10]. In contrast to the latter and neodymium:YAG laser, its mechanism of action to achieve stone fragmentation relies on a photothermal rather than photoacoustic effect [11]. Its endourological potential has continued to expand and it can treat all stone types [12]. No longer in its infancy, earlier limitations such as low frequency and low power have been overcome [8]. For example, through combining multiple laser cavities (resonators) in a machine, a high-power (e.g. 100 W) system can be manufactured, which allows for higher frequency (e.g. 50–80 Hz). However, a high-power system cannot facilitate manipulation of other parameters such as PE [13]. Continued research has supported its evolution to achieve its current status [14]. To this end, the surgeon is now able to control these parameters as well as pulse duration (also referred to as pulse width) using next-generation systems. A range of hybrid techniques are now also possible. This includes the ability to combine low energy (e.g. 0.2–5 J) and high frequency (e.g. 40–50 Hz) in contact mode, which has borne the phenomenon of 'dusting', whereby the stone is pulverised to fine (submillimetre) particles, which evacuate spontaneously [15]. Stone clearance can be enhanced further by switching to non-contact lithotripsy, the so called 'pop-dusting' or 'popcorn' technique. This potentially obviates the need for basket retrieval and can reduce both operative time as well as use of a ureteric access sheath (UAS), which can incur additional complications [16]. Of note, this technique is feasible using both low-powered (e.g. 30–40 W) and high-powered lasers (e.g. 100–120 W). Two key limitations associated with the holmium laser are its energy transmission through water and retropulsion [17]. The latter becomes more of an issue as PE is increased. As a result of greater distance between the fibre tip and stone surface, less energy reaches the target site and ablation is impaired. Time efficiency is also diminished as a result of stone migration secondary to retropulsion. In regard to manipulation of pulse width, implementation of long pulse (LP) mode can reduce retropulsion as well as lessen degradation of the laser fibre tip ('burn-back') [18]. More recently, Moses technology™, using a 120 W generator (Lumenis Pulse P120H) as well as the Vapor Tunnel™ (Quanta System, Samarate, Italy), was introduced as another possible solution to this, which has made adaptations based on previously described principle of the 'Moses effect' [19]. Through its characteristic pulse shaped modulation, energy is delivered in two parts. Firstly, the water between the laser fibre tip and stone is divided and then the energy is directed through this channel or 'vapour cavity' to the stone. This phenomenon of a split pulse, results in less energy lost in transmission. It can be performed in contact ('Moses A', 1 mm) and distance ('Moses B', 2 mm) mode [8,19]. In 2020, Ibrahim *et al.* [20] published findings from a randomised trial comparing regular and Moses mode of holmium laser lithotripsy. The latter was associated with both shorter fragmentation (21.1 vs 14.2 min, $P = 0.03$) and procedural time (50.9 vs 41.1 min, $P = 0.03$). However, there was no significant difference in the SFR (83.3% vs 88.4%, $P > 0.05$) at the 3-month follow-up.

Properties of Thulium Laser

The higher water absorption coefficient (WAC) and shorter aqueous optical penetration depth result in a lower ablation threshold (up to four-times) compared to the holmium laser (Fig. 1) [8,21,22]. The TFL employs a diode source rather than a flash lamp system. Because of this, energy loss in the form of heat is less and only a built-in simple air-cooling system is required [8]. This type of cooling system allows for high-power settings to be achieved (up to 500 W in super pulse mode).

Fig. 1 TFL properties.



The apparatus weighs ˜30 kg and a standard power outlet (120–240 V) can be used [23]. Minimal noise is produced. The TFL has a near single mode beam profile [13]. The PE can be set as low as 0.025 J, which allows energy density to be adjusted to compensate for the smaller fibre. It can therefore produce very fine dust particles. Given the higher range in frequency settings, operative time is not impaired. However, it is worth noting that no study to date has reported use of frequency settings >500 Hz [24].

Current Evidence

Pre-Clinical Studies: Key Findings

Since the first description in 2005, many pre-clinical studies have ensued, which have investigated TFL in the context of stone lithotripsy [25].

Blackmon *et al.* [26] compared vaporisation rates between the TFL (70 mJ × 3 Hz) and holmium laser (70 mJ × 10 Hz) on human calcium oxalate monohydrate and uric acid stones (*ex vivo*). Vaporisation rates with TFL were 5–10-times faster and the ablation crater was 4–10-times deeper. More recent experimental studies have shown that when using fragmentation settings, the TFL was twice as fast and up to five-times faster when a dusting regimen is applied [27]. Hardy *et al.* [28] recorded particle sizes as small as 0.2 mm in a similar study using the TFL ('micro-dusting'). Keller *et al.* [29] recently confirmed the capability of the TFL to dust stones of all composition types. The authors confirmed feasibility to collect sufficient sample amounts for morpho-constitutional analysis after dusting. Several studies have also explored additional modifications that can be made to the TFL. This includes methods to reduce 'burn-back' given this is known to be accelerated as fibre diameter decreases [30]. Earlier efforts experimented with use of a hollow steel sheath; however, these were shown to worsen retropulsion [31]. More recently, a model using a 'muzzle brake' has been trialled [23]. Hutchens *et al.* [30] demonstrated this technology also serves to reduce retropulsion (−25%), as it can better control the vapour bubble expansion.

Clinical Studies: Ureteroscopy (URS)

There is currently a lack clinical data available on the TFL and evidence is largely limited to Russian studies as the technology became available there first in 2018; however, not all of these are available in the English language (Tables 1 and 2). Notably, only one comparative study on the TFL has been published [32]. In 2018, Martov *et al.* [33] reported the first clinical experience with the TFL. This study included 44 patients with stones in the upper urinary tract (size range 0.6–1.8 cm), as well as 12 cases with bladder stones (size range 1.1–3.5 cm). The mean overall disintegration time was 19.2 min and only one case was not found to be stone free at the 6-week follow-up. Pyelonephritis was reported in 15.9% of cases. In 2020, Enikeev *et al.* [34] reported outcomes of TFL in a prospective sample of 40 patients with renal stones. The mean stone size and density was 16.5 mm and 880 Hounsfield units (HU), respectively. Two laser regimens were used throughout the study: 0.5 J × 30 Hz and 0.15 J × 200 Hz. Settings >200 Hz for dusting resulted in high efficacy, but at this point the 'snowstorm' effect of the fine particles negatively affected surgeon visibility. The final SFR was 92.5% at the 3-month follow-up. In a separate study, the same group then recorded outcomes from 149 patients undergoing URS with the TFL for solitary ureteric stones (distal ureter: 45.6%, mid ureter: 28.2%, proximal ureter: 26.2%) [35]. Stone size ranged from 4 to 21 mm (mean density 985 HU). The final SFR at 3 months was 90% and a complication rate of 5.4% was recorded, including only two major complications (Clavien–Dindo Grade ≥III). A postoperative JJ stent was inserted in all cases and removed on day 7–10. The authors reported the seven most commonly applied settings: (i) 0.8 J × 10 Hz, (ii) 0.8 J × 12 Hz, (iii) 0.5 J × 12 Hz, (iv) 0.5 J × 30 Hz, (v) 0.2 J × 60 Hz, (vi) 0.15 J × 100 Hz, and (vii) 0.15 J × 200 Hz. A positive correlation was determined between retropulsion and PE ($r = 0.5$, $P < 0.001$). For this reason, the upper limit of PE recommended was 0.8 J. In 2020, Rapoport *et al.* [36] published outcomes from a retrospective series of 15 patients undergoing URS with the TFL for solitary lower pole stones (size range 4–17 mm, density range 350–1459 HU). The stone could be reached in every case and the mean (range) lithotripsy time and hospital stay was 12 (3–30) min and 1.1 days, respectively. The final SFR was 86.6% assessed using CT at the 1-month follow-up. The complication rate was 6.6% and no serious adverse events (Clavien–Dindo Grade ≥III) were recorded. More recently, Ulvik *et al.* [37] reported the first European experience (SOLTIVE™ SuperPulsed) in 18 cases performed at our institution, Haukeland University Hospital, Bergen, Norway. While this was only a single surgeon series, the technology successfully cleared stones up to 3.2 cm in size. Application of 0.6–0.8 J at 30 Hz (18–24 W) resulted in faster fragmentation and still produced adequate dust when compared with dusting using a regimen of 0.1–0.2 J × 200–240 Hz (20–48 W), although finer dust particles were produced with the latter set up. The former combination of parameters was demonstrated to successfully clear a stone burden of 1 cm in <20 min. Minimal micro-bleeding was observed and improved visibility meant that no irrigation pump was required. In 2021, Martov *et al.* [32] published the first randomised trial comparing the TFL and holmium laser for ureteric stone management ($n = 174$). The same fixed settings were applied for both laser systems (1 J × 10 Hz, 10 W). The TFL caused retropulsion in only 4% of cases (4% vs 69%, $P < 0.05$). All the TFL cases were stone free at follow-up compared to 94% in holmium group.

Table 1 Baseline demographics for published TFL clinical studies.

Reference	Year	Country	Study type	Sample size, *n*	Age, years, mean	Stone size, cm, mean	Laser settings	Manufacturer	Study limitations
URS									
Martov *et al.* [33]	2018	Russia	Cohort	56	NA	0.6–1.8	NA	IRE-Polyus	Full version not available in English Retrospective
Enikeev *et al.* [34]	2020	Russia	Cohort	40	56	1.65	1) 0.5 J × 30 Hz 2) 0.15 J × 200 Hz	IRE-Polyus	No control group Likert scales to assess retropulsion and visibility
Enikeev *et al.* [35]	2020	Russia	Cohort	149	NR	0.4–2.1	0.1–1 J × 7.5–300 Hz	IRE-Polyus	Use of non-validated questionnaires.
Rapoport *et al.* [36]	2020	Russia	Case series	15	NA	0.4–1.7	0.1–4 J × 7–300 Hz	IRE-Polyus	Retrospective Full version not available in English
Ulvik [37]	2020	Norway	Case series	18	NR	Up to 3.2	1) 0.6–0.8 J × 30 Hz 2) 0.1–0.2 J × 200–240 Hz	SOLTIVE™	Single surgeon series Full breakdown of data not published
Martov *et al.* [32]	2021	Russia	RCT	174	48.1	1.22	1 J × 10 Hz	IRE-Polyus	Only one laser setting studied No cost analysis Single centre
Carrera *et al.* [38]	2021	USA	Cohort	76	60.9	1.02	0.2 J × 228.9 Hz (mean)	SOLTIVE™	No criteria for UAS use
Corrales *et al.* [39]	2021	France	Cohort	50	Ureteric, 66 Renal, 55	Ureteric, 486 mm^3 Renal, 1800 mm^3	Ureteric, 0.2–0.4 J × 20–55 Hz Renal, 0.2–0.6 J × 50–180 Hz	SOLTIVE™	No long term follow up No control group
Mini-PCNL (<18 F)									
Enikeev *et al.* [40,41]	2020	Russia	Cohort	120	52	1.25	0.1–4 J × 7–300 Hz	IRE-Polyus	Use of non-validated questionnaires
Niu *et al.* [44]	2020	USA	Case series	2	NR	1.5–3	1) 1 J × 30 Hz 2) 0.3 J × 50 Hz	SOLTIVE™	Small sample Full breakdown of data not published
Shah *et al.* [45]	2020	India	Cohort	54	40.42	1.82	0.1–1 J × 100–300 Hz	IRE-Polyus	Limited data on laser settings

HF, high frequency (20–49 Hz); HRF, higher frequency (50–200 Hz); LF, low frequency (4–19 Hz); NA, not available (non-English language); NR, not reported; RCT, randomised control trial.

Table 2 Clinical outcomes for published TFL clinical studies.

Reference	LOT, min, mean	Operation time, min, mean	Length of stay, days	Final SFR, %	Complications: Minor (Clavien–Dindo I–II)	Complications: Major (Clavien–Dindo III–IV)
URS						
Martov *et al.* [33]	19	NA	2.4	97.7	Pyelonephritis ($n = 9$)	Nil
Enikeev *et al.* [34]	4	NR	NR	92.5	Fever ($n = 2$), transient creatinine elevation ($n = 1$), UTI ($n = 2$)	Nil
Enikeev *et al.* [35]	NR	<60	NR	90	UTI/pain ($n = 6$)	Nil
Rapoport *et al.* [36]	1.3	NS	1.1	86.6	$N = 1$ (NA)	Nil
Ulvik [37]	NR	NR	Day case	NR	Nil	Nil
Martov *et al.* [32]	8.4	24.7	2.4	100	Fever ($n = 8$) Haematuria ($n = 1$)	Sepsis ($n = 1$)
Corrales *et al.* [39]	Ureteric, 9.3 Renal, 23	Ureteric, NR Renal, NR	Ureteric, NR Renal, NR	Ureteric, NR Renal, NR	Ureteric, $n = 1$ (NR) Renal, $n = 2$ (NR)	Ureteric, nil Renal, nil
Carrera *et al.* [38]	10.8	59.4	0.5	66.7	Postoperative bleeding ($n = 1$), fever ($n = 1$), pain ($n = 2$), sepsis ($n = 3$), stent loss ($n = 1$)	Sepsis ($n = 3$)
Mini-PCNL (<18 F)						
Enikeev *et al.* [40,41]	5	23.4*	NR	85	Fever ($n = 4$), transient creatinine elevation ($n = 4$), clot retention ($n = 6$), UTI ($n = 2$), wound infection ($n = 1$)	Extravasation ($n = 6$)
Niu *et al.* [44]	28	NR	NR	NR	Nil	Nil
Shah *et al.* [45]	10.1	39.85	NR	100	UTI ($n = 3$)	Nil

*NA, not available (non-English language); NR, not reported. *Excludes puncture time.*

The TFL was associated with significantly shorter 'laser on' time (LOT; 8.4 vs 15.9 min, $P < 0.05$), operating time (24.7 vs 32.4 min, $P < 0.05$), and hospital stay (2.4 vs 3.2 days, $P < 0.05$). Fewer complications were observed in the TFL group (nine vs 16). A limitation of this study was that only a single laser setting was applied throughout the study. Also, no cost analysis was performed to compare the two laser modalities. Corrales *et al.* [39] reported outcomes in a sample of 50 patients from France. The median PE and frequency settings were 0.4 J × 40 Hz and 0.3 J × 100 Hz for ureteric and renal stones, respectively. The overall complication rate was 6% (Clavien–Dindo Grade I–II) and the authors concluded ablation speed for renal stones (1.16 mm^3/s) was twice as fast as the average speed reported with the holmium laser. Carrera *et al.* [38] recorded the first results from the first North American study on the TFL ($n = 76$). While this was performed in a multicentre setting, there was no control group. The mean (SD) settings were 0.2 (0.3) J × 228.9 (299.3) Hz. There were no reports of thermal injuries to the ureter, but one case had bleeding in the collecting system, which was managed with laser coagulation settings (1 J × 20 Hz). The SFR was 78.9% at the 12-week follow-up. A limitation of this study was that no criteria for usage of UAS was reported.

Clinical Studies: Miniaturised PCNL (mini-PCNL)

In 2020, Enikeev *et al.* [40] reported the first use of the TFL in mini-PCNL (16.5–17.5 F) in a sample of 120 patients, mostly using the settings 0.8 J × 31–38 Hz (25–30 W) for fragmentation [41]. However, there was no control group in this study. The mean LOT and SFR were 5.1 min and 85%, respectively. The same group has also described use of the TFL in the setting of ultra-mini-PCNL (10–12-F sheath) and micro-PCNL [42,43]. Niu *et al.* [44], reported their experience of using the TFL in the setting of mini-PCNL (15/16-F sheath). The authors reported optimal fragmentation and dusting was performed using 0.1 J × 30 Hz and 0.3 J × 50 Hz, respectively. However, the authors did not report a full breakdown of results and it was a very small series. Later in 2020, Shah *et al.* [45] recorded findings from a prospective cohort of 54 patients undergoing mini-PCNL (18-F sheath) using dusting with suction via the nephrostomy sheath. The initial settings of 0.2 J × 125–200 Hz were determined to be the most satisfactory for simultaneous dusting and aspiration (mean LOT 10.08 min). The final SFR was 100% at the 1-month follow-up. Three patients had UTIs and there were no major complications (Clavien–Dindo Grade ≥III) recorded.

Advantages of TFL

As a result of these features, the TFL offers numerous advantages (Table 3). While PCNL is recommended for first-line treatment of large stones, the TFL may offer URS greater

Table 3 Advantages and disadvantages of TFL.

Advantages	Disadvantages
• Simple cooling system • Smaller fibre diameter • Improved irrigation and visibility • Reduced retropulsion • Increased absorption in water • Can treat all stone types • Potential for large stones • Higher frequency • Low PE possible • Minimal collateral tissue damage • Shorter lithotripsy times	• Lack of clinical studies • Cost efficiency not known • Optimal settings not established

potential to effectively treat stones in this category. The need for staged procedures may also be reduced as a result. Given the inner diameter of a standard ureteroscope is 1.2 mm, a smaller size fibre (ultra-small fibre 50 μm also available) allows for improved irrigation and therefore visibility as a result. Improved irrigation may reduce stone migration and complications associated with pressured pumps. Flexibility of the scope is also improved due to small fibre size, which may improve outcomes in scenarios such as lower pole stones with an acute infundibulopelvic angle (IPA) where extreme deflection may be needed. It also offers up the possibility of miniaturisation of ureteroscopes similar to PCNL [46]. The ablation properties of the TFL are anticipated to reduce bleeding as a result of collateral tissue damage. As well as the larger, less practical size of holmium generators, they also need to be handled with extra care because their internal mirror arrangement can be easily damaged. In contrast, the TFL generator is portable and can be used with a standard power outlet with reduced electrical hazard risks accordingly. Modifications to the laser fibre tip will help preserve against degradation and combined with the longer life span of laser diodes compared to flash lamps, the durability of the TFL appears to be favourable.

Disadvantages of TFL

Despite these clear advantages, there remain questions and possible disadvantages associated with the TFL (Table 3). Multiple new laser technologies have been previously introduced to rival the holmium laser yet failed. The holmium laser has a large body of published data to support its efficiency, which at present, the TFL lacks. An important consideration will be the cost profile, which will impact largely on its uptake. Optimal settings for the TFL are yet to be established [47]. While frequency of values of >2000 Hz are possible in theory, the reality is such limits are highly unlikely to be adopted in clinical practice. Hardy *et al.* [48] investigated temperature changes at different frequency settings, measured at 3 mm away from the laser fibre tip using an *in vitro* ureter model. No change in temperature (33°C) was recorded up to and until 300 Hz (35 mJ). However, beyond this value, the temperature began to rise (500 Hz = 39°C). The authors recommended limiting frequency to a maximum of 300 Hz accordingly. The safety implications of this would suggest its real-world use will adopt much lower values on a day-to-day basis. Lower frequencies should also be maintained in the ureter [39,49].

Our Experience with TFL

Settings

When starting up with the TFL in clinical practice, consider use of low settings, e.g. 0.4 J and 6 Hz. These low energy settings allow for direct comparison to what is commonly used with the holmium laser. Application of low settings ensures that proper vision is maintained throughout the procedure and retropulsion is minimised. Stone fragmentation is considered to be effective even when using these low settings due to the laser's wavelength being close to the water absorption peak, its shorter penetration depth, and lower ablation threshold (compared to the holmium laser). Very low energy settings are possible with the TFL. However, the authors have found that compensating with high frequency (e.g. >100 Hz) typically results in impaired vision due to a pronounced 'snowstorm effect'. This forces the surgeon to remove their foot from the laser activation pedal in order to regain adequate vision. The result of this appears to be less effective dusting, although the dust is very fine. The TFL can be effectively applied for use with bladder stones and this scenario can provide an opportunity for the surgeon to experiment with the wide range of possible settings, while reducing risk of heat damage to surrounding structures.

Fibre Selection

Consideration should be given for use of 150- or 200-μm fibre when performing URS, as these small fibres enable space inside the working-channel for proper irrigation. The latter is important to maintain temperature control in the renal pelvis and reduce the risk of overheating due to laser activation. Proper irrigational flow is also important to maintain temperature control in the renal pelvis and reduce the risk of overheating due to laser activation. In our practice, the 200-μm fibre appears more preferable, as it is both easier to handle and insert through the endoscope compared to the thinner 150-μm fibre, which is also more easily damaged. The 150-μm fibre may on the other hand be valuable in situations where extreme scope deflection is needed. In addition, the vibration effect on the fibre tip during laser activation is less pronounced when a 200-μm fibre is used compared to the 150-μm fibre.

Dust Analysis

When using the TFL, we have been able to aspirate the dust produced and send it for biochemical analysis. This is a more labour-intensive process in the laboratory compared to standard analysis of fragments; however, our initial findings reveal accurate results.

Limitations and Future Research

Evaluation of the TFL for use in clinical practice is hindered by the paucity of studies including only one randomised study [32]. Numerous studies are also only available in languages other than English. Future studies are therefore required to provide much need ratification of the aforementioned, impressive pre-clinical findings. These should ideally be randomised trials, which provide direct (head-to-head) comparison with the holmium laser and a sufficient follow-up duration. A study of this kind is now under way at our institution and will be an additional step towards addressing this evidence gap (NCT04668586). Similarly, a randomised trial comparing the TFL vs holmium laser for lower pole stones is currently ongoing in Russia (NCT04346485).

Conclusion

The TFL is a novel technology in the setting of stone lithotripsy. It offers the properties of a small fibre coupled with option of low PE yet high frequency, which allows for potentially improved stone clearance. These key features amongst others give it the potential to become the next ‘gold standard’. However, further clinical data are warranted in order for its formal position in stone lithotripsy to be delineated.

Conflict of Interest

Øyvind Ulvik is a consultant for Olympus but they were not involved in the writing of the manuscript. Patrick Jones and Christian Beisland have nothing to declare.

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Abbreviations: HU, Hounsfield units; laser, Light Amplification by the Stimulated Emission of Radiation; LOT, 'laser on' time; (mini-)PCNL, (miniaturised) percutaneous nephrolithotomy; PE, pulse energy; SFR, stone-free rate; TFL, thulium fibre laser; UAS, ureteric access sheath; URS, ureteroscopy; YAG, yttrium-aluminium-garnet.