

SuperPulsed thulium-fiber laser for lithotripsy: first clinical experience in percutaneous nephrolithotomy

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Objectives

The Ho:YAG laser is highly efficient in stone fragmentation and dusting, and recent modifications to Ho:YAG laser technology such as the Moses effect have further improved its efficacy. Despite the well-established clinical utility of the Ho:YAG laser, next-generation, fiber-based laser systems may prove to be even safer and more efficacious. Specifically, the thulium fiber laser (TFL) offers a higher laser energy absorption in water and has been reported to cause minimal stone retropulsion in-vitro.

Aim:

to evaluate the efficacy and safety of Thulium fiber laser (TFL) in laser lithotripsy during percutaneous nephrolithotomy (PCNL).

Materials and Methods

Patients with stones < 30 mm were prospectively recruited to undergo PCNL using SuperPulse TFL (av. power 50 W, peak power 500 W, wavelength 1.94 μ m NTO IRE-Polus, Russia). Stone size, stone density, operative time, and "laser on" time (LOT) were recorded. Stone free rate and residual fragments were determined on postoperative computer tomography. Complications were classified using the Clavien-Dindo grade. Stone retropulsion and endoscopic visibility were assessed based on surgeons' feedback using a questionnaire.

Conclusions:

 **TFL is a safe and effective modality for lithotripsy during PCNL**

Results

A total of 137 patients were included in the study with a mean age of 52 (± 1.8) years; of these 77 (56%) were males. Mean stone size was 12.5 (± 8.8) mm with a mean density of 1019 (± 375) HU (Tab. 1). Mean operative time was 27.8 (± 26.0) min and mean LOT was 6.5 (± 8.8) min. Most used settings were of 0.15 J / 30 W / 200 Hz and 0.5 J / 15 W / 30W (dusting) and 0.8 J / 25-30 W / 31-38 Hz (fragmentation). The mean total energy for stone ablation was 5.7 (± 9.9) kJ (Tab. 2).

Overall stone-free rate was 85%. The overall complication rate was 17%. Most postoperative complications were Clavien grade I-II, and none were determined to be related to the laser lithotripsy. Surgeons reported stone retropulsion that interfered with surgery in 2 (1.4%) cases insignificant retropulsion was noted in 16 (11.7%) cases. Poor visualization was reported in 7 (5.1%) cases and minor difficulties with visibility in 13 (9.5%) cases (Tab. 3, 4).

	All patients (n=120)	Retropulsion	Patients, n	Stone density, HU	Stone size, mm	Operative time, min	Lower on time, min	Total energy for stone ablation, kJ	Visibility	Patients, n	Stone density, HU	Stone size, mm	Operative time, min	Lower on time, min	Total energy for stone ablation, kJ
Age, years	22.81 (18-40)	No retropulsion (0)	105 (87.5)	1037 ± 394 (150-2100)	11.4 ± 8.0 (5.0-30)	21.4 ± 15.1 (7.0-20)	4.8 ± 5.1 (1.0-15)	3.3 ± 3.9 (1.0-19)	Clear visibility (0)	113 (94.2)	1020 ± 411 (150-2100)	10.7 ± 6.1 (5.0-30)	23.4 ± 17.9 (7.0-20)	4.8 ± 4.9 (1.0-15)	3.5 ± 3.1 (1.0-23)
Kidney (right/left)	56/81	Minimal retropulsion (1)	13 (10.8)	943 ± 304 (290-1494)	14.4 ± 8.8 (5.0-30)	25.4 ± 10.7 (7.0-20)	10.9 ± 4.4 (5.0-20)	15.8 ± 5.6 (5.0-23)	Minor difficulties (1)	4 (3.3)	973 ± 305 (493-1360)	14.0 ± 11.7 (5.0-30)	39.3 ± 17.9 (28-60)	12.3 ± 4.7 (5.0-20)	8.5 ± 1.9 (7.0-10)
Stone size, mm	12.5 ± 8.8 (5-30)	Extensive retropulsion (2)	2 (1.7)	1236 ± 231 (1072-1408)	6.8 ± 1.1 (6.0-9.0)	75.5 ± 17.7 (63-83)	26.0 ± 15.5 (15-37)	14.5 ± 4.7 (9-20)	Poor visualization (2)	3 (2.5)	1104 ± 330 (590-1500)	13.1 ± 4.9 (5.0-30)	43.0 ± 26.1 (17-75)	11.5 ± 1.4 (7-17)	6.3 ± 1.7 (6.0-10)
Stone density, HU	1019 ± 375 (150-2100)	p		0.228	0.098	0.015*	p<0.001*	0.007*	p		0.629	0.063	0.074	0.079	0.47*

Data presented as mean \pm SD (range). Comparison of outcomes in patients grouped by retropulsion (0=no retropulsion, to 2=high retropulsion that interferes with stone ablation) and interference with visibility (0=clear visibility, to 2=poor visibility that interferes with the procedure). Categorical variables were compared using the Pearson's chi-square test. For comparison of the means, analysis of variance (ANOVA) was used. *Statistical significance.

Table 1. Patient characteristics.

Stone density group	All patients (n=120)	≥1000 HU (n=52)	<1000 HU (n=68)	$\frac{p}{\geq 1000 \text{ HU vs } <1000 \text{ HU}}$
Stone density, HU	1019 ±375 (150-2100)	1284 ±202 (1000-2100)	640 ±200 (150-990)	p<0.001
Stone size, mm	12.1 ±7.4 (5.0-30)	11.5 ±6.90 (5.0-30)	13.4 ±8.1 (5.0-30)	0.147
Operative time, min	23.4 ±17.9 (7.0-120)	23.6 ±17.8 (7.0-120)	22.8 ±18.4 (10.0-90)	0.780
Laser on time, min	5.0 ±5.7 (1.0-20)	6.1 ±6.0 (1.0-20)	3.9 ±5.8 (0.30-10)	0.081
Total energy for stone ablation, kJ	3.6 ±4.3 (1.0-23)	3.9 ±4.4 (1.0-23)	3.1 ±3.3 (1.0-11)	0.177

Data presented as mean±SD [range]. Categorical variables were compared using the Pearson's chi-square test. For comparison of the means, analysis of variance (ANOVA) was used. *Statistical significance.

Table 3.
Retropulsion and visibility.

Complications		Total (n=120)
CLAVIEN GRADE I	Fever	4 (3.3)
	Transient creatinine elevation	4 (3.3)
	Clot retention	6 (4.2)
CLAVIEN GRADE II	Transient urine leakage	2 (1.7)
	UTI	2 (1.7)
	Wound infection	1 (0.8)
CLAVIEN GRADE IIIA	Double J-stent placement for urine leakage	6 (5.0)

Table 4.
Postoperative complications.

Data presented as n (%).

 **TFL lithotripsy allows for minimal retropulsion**

Further comparative studies of TFL vs Ho:YAG laser lithotripsy are required