Efficacy and Safety of Thulium Fiber Laser for Renal Stone: A Cross Sectional Study

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ABSTRACT

Introduction: Renal stone disease is a common urological condition associated with increasing morbidity and healthcare burden worldwide. Retrograde intrarenal surgery using laser lithotripsy has become an established minimally invasive treatment option for renal calculi. Recently, Thulium fiber laser has emerged as a promising laser technique because of its superior stone ablation efficiency, reduced retropulsion, finer stone dusting, and minimal tissue penetration. **Aims:** To evaluate the efficacy and safety of Thulium Fiber lithotripsy in patients undergoing retrograde intrarenal surgery for renal stones. **Methods:** This prospective cross-sectional study was conducted in the Department of Urology, Nepalgunj Medical College, from February 2026 to April 2026. A total of 38 patients with renal stones measuring 10-20 mm were included. All patients underwent retrograde intrarenal surgery with thulium fiber laser. Operative outcomes, stone clearance, and postoperative complications were recorded and analyzed. **Results:** Among 38 patients, 22 (57.9%) were females and 16 (42.1%) were males. The mean stone size was 15.3 ± 2.9 mm. The mean operative time was 60.6 ± 22.4 minutes, and the mean hospital stay was 2.5 ± 1.0 days. Stone-free status was achieved in 36 patients (94.7%). Postoperative complications included fever in 13.2%, hematuria in 7.9%, and urinary tract infection in 5.3% of patients. No major complications or mortality were observed. **Conclusion:** Thulium fiber laser lithotripsy is a safe and effective minimally invasive treatment modality for renal stones, demonstrating high stone clearance rates with acceptable operative outcomes and minimal complications.

***Keywords**:* Lithotripsy; Retrograde Intrarenal Surgery; Renal Stone; Thulium Fiber Laser

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INTRODUCTION

Stone disease is a common cause of acute flank pain and is associated with increasing prevalence and healthcare costs worldwide.[1,2] The management of renal stones depends on stone size, location, and composition, and includes extracorporeal shock wave lithotripsy (ESWL), percutaneous nephrolithotomy (PCNL), and retrograde intrarenal surgery (RIRS) with laser lithotripsy.[3,4] For the last two decades, the Holmium:Yttrium Aluminum Garnet (Ho:YAG) laser has been considered the gold standard for laser lithotripsy. The advantages of Ho:YAG laser include its ability to fragment all types of urinary stones, compatibility with thin and flexible laser fibers, minimal energy loss, and limited tissue penetration due to high absorption of its wavelength in water.[4,5] Recently, Thulium Fiber Laser (TFL) has emerged as a promising alternative to Ho:YAG laser. Introduced into urological practice in 2018, TFL operates at a wavelength of 1940 nm, which is closer to the peak water absorption spectrum.[6] Compared with Ho:YAG laser, TFL has approximately four times greater water absorption coefficient, allowing more efficient stone ablation with lower pulse energy and higher frequencies. Experimental studies have shown that TFL provides faster stone ablation, finer stone dusting, reduced retropulsion, improved hemostatic properties, and less fiber burn-back.[7,8] Both in-vitro and in-vivo studies have demonstrated superior stone fragmentation efficiency and minimal tissue penetration with TFL compared with Ho:YAG laser systems.[9-11] Its wide range of pulse energy and frequency settings allows effective stone dusting as well as fragmentation. Therefore, the present study aimed to evaluate the efficacy and safety of TFL lithotripsy in patients undergoing RIRS for renal stones.

METHODS

This prospective cross-sectional study was conducted at the Department of Urology, Nepalgunj Medical College, from

February 2026 to April 2026. A total of 38 patients diagnosed with renal stones measuring 10–20 mm were included in the study. Ethical clearance was obtained from the Institutional Review Committee, and informed consent was taken from all participants prior to enrollment. Patients with active urinary tract infection, abnormal renal function, coagulopathy, spinal deformity, and pregnancy were excluded from the study.

All patients underwent preoperative evaluation including urine culture, ultrasonography of abdomen and pelvis, and non-contrast computed tomography of kidney, ureter, and bladder (NCCT-KUB). Baseline laboratory investigations including hemoglobin, total leukocyte count, blood urea, and serum creatinine were recorded. The procedure was performed under general anesthesia with the patient in lithotomy position. Following placement of a 0.035-inch guidewire, a 9.5/11.5 Fr ureteric access sheath was inserted under fluoroscopic guidance. Flexible ureteroscopy was performed using a 7.5 Fr flexible ureteroscope, and the renal collecting system was systematically inspected to identify the stone.

Lithotripsy was performed using Urolase™ Thulium Fiber Laser with a 200-µm laser fiber. Initial laser settings were 0.3 J and 28 Hz, which were adjusted according to stone characteristics within a range of 0.2–1 J and 15–40 Hz. Following satisfactory stone clearance, a 5 Fr, 26 cm double-J stent was placed under fluoroscopic guidance. Operative findings, stone clearance, and post-operative complications were recorded. Post-operative complications were classified according to the modified Clavien–Dindo classification system. USG abdomen and pelvis and X-ray KUB were done in 4th postoperative week to see stone clearance. The stone-free rate was defined as no radio-opaque shadow visible on plain X –ray film of kidney, ureter and bladder (KUB) and no hyperechoic foci with posterior acoustic shadow on ultrasonography of abdomen and pelvis.

RESULTS

A total of 38 patients were included in the study, among whom 22 (57.9%) were females and 16 (42.1%) were males. Most patients were aged above 40 years (52.6%).

1. Sex

Sex	Frequency (n)	Percentage (%)
Female	22	57.9
Male	16	42.1
Total	38	100

2. Age

Age Group (years)	Frequency (n)	Percentage (%)
< 20	0	0
20–40	18	47.4
> 40	20	52.6
Total	38	100

Stone Characteristics

The most common stone location was the renal pelvis in 12 patients (31.6%), followed by lower calyx stones in 7 patients (18.4%).

The mean stone size was 15.3 ± 2.9 mm with a range of 10–20 mm. The mean stone density was 1062 ± 83 Hounsfield units.

3. Stone Location Distribution

Sex	Frequency (n)	Percentage (%)
Renal pelvis	12	31.6
Middle calyx	6	15.8
PUJ	5	13.2
Lower calyx	7	18.4
Upper ureter	5	13.2
Upper calyx	2	5.3
Others	1	2.6

Operative Outcomes

The mean operative time was 60.6 ± 22.4 minutes, ranging from 28 to 92 minutes. The mean hospital stay was 2.5 ± 1.0 days. Stone-free status was achieved in 36 patients (94.7%), while residual stones were present in only 2 patients (5.3%).

Postoperative Complications

Postoperative fever occurred in 5 patients (13.2%), hematuria in 3 patients (7.9%), and urinary tract infection in 2 patients (5.3%). No patient experienced major bleeding, hemoglobin drop, blood transfusion, or mortality. According to the modified Clavien–Dindo classification, 32 patients (84.2%) had no complications, 4 patients (10.5%) had Grade I complications, and 2 patients (5.3%) had Grade II complications. No Grade III–V complications were observed.

4. Post-operative complications

Complication	Number (n)	Percentage (%)
Fever	5	13.2
UTI (Urinary Tract Infection)	2	5.3
Hematuria	3	7.9

5. Modified Clavien-Dindo classification

Grade	Description	Number (n)	Percentage (%)
Grade 0	No complication	32	84.2
Grade 1	Minor complication (no intervention)	4	10.5
Grade 2	Requiring pharmacological treatment (e.g., DJ stent removal)	2	5.3

Grade 3	Requiring surgical/radiological intervention	0	0
Grade 4	Life-threatening complication	0	0
Grade 5	Death	0	0

DISCUSSION

Thulium Fiber Laser lithotripsy has emerged as a significant advancement in endourological stone management because of its superior stone ablation efficiency, reduced retropulsion, and minimal tissue penetration. The present study evaluated the efficacy and safety of TFL-assisted RIRS in patients with renal stones measuring 10–20 mm. The stone-free rate observed in our study was 94.7%, which is comparable with previously published literature. Vaddi et al reported a stone clearance rate of 93.6%, while Taratkin et al demonstrated a stone-free rate of 92.5% following TFL-assisted RIRS.[15,16] The high stone clearance observed in the present study may be attributed to the superior dusting capability and efficient fragmentation associated with TFL technology.

The mean operative time in the present study was 60.6 ± 22.4 minutes, while the mean hospital stay was 2.5 ± 1.0 days. Similar findings have been reported by Enikeev et al, who demonstrated improved stone ablation efficiency and shorter lasing time with TFL compared with conventional Ho:YAG systems.[17] Ulvik et al also reported superior dusting ability and reduced retropulsion with TFL, resulting in improved visualization and operative efficiency during RIRS.[18]

Postoperative complications in the present study were predominantly minor and manageable. Fever, hematuria, and urinary tract infection were the most common complications observed. According to the modified Clavien–Dindo classification, the majority of patients had no postoperative complications, and only low-grade complications were encountered. No major complications, ureteric injuries, blood transfusions, or mortality occurred.

These findings are consistent with previous studies. Vaddi et al reported postoperative complications in 16.6% of patients.[15] Martov et al observed an overall complication rate of 15.9%, with most complications being minor and conservatively managed.[19] Taratkin et al also reported excellent safety outcomes with low complication rates following TFL-assisted RIRS.[16]

Overall, the findings of this study support the growing evidence that TFL-assisted RIRS is an effective and safe minimally invasive modality for the management of renal stones less than 2 cm.

LIMITATION

It was a single center study with relatively small sample size.

CONCLUSION

Retrograde intrarenal surgery using Thulium Fiber Laser is a safe and effective minimally invasive treatment modality for renal stones measuring 10–20 mm. TFL demonstrated a high stone-free rate with acceptable operative time, short hospital stay, and predominantly minor postoperative complications.

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