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Bilateral renal calculi, retrograde intra renal surgery (RIRS), thulium fiber laser (TFL), stone-free rate (SFR), minimally invasive urology

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## Optimizing Stone Treatment: A Review of Single-Session Bilateral RIRS with Superpulsed Thulium Fibre Laser

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### ABSTRACT

Urolithiasis is a prevalent global condition, with a lifetime risk of stone formation reaching 10-12% in males and 6-8% in females. Bilateral renal calculi account for 1-3% of cases, with an increasing trend. Traditionally managed with staged procedures, technological advancements have enabled single-session bilateral retrograde intra renal surgery (SSB-RIRS). This study evaluates the safety and efficacy of SSB-RIRS using a superpulsed thulium fiber laser (TFL). A retrospective analysis was conducted on patients who underwent single-session bilateral RIRS with the super pulsed thulium fibre laser between Jan 2024 to June 2024 for a period of 6 months. Data on patient demographics, stone characteristics, operative parameters, stone-free rates (SFR), complications and postoperative outcomes were collected and analyzed. A total of 50 patients underwent single-session bilateral RIRS. The mean stone size was 10.06±0.78 mm and the operative time averaged 74.5±7.69 minutes. The overall stone-free rate was 90%, with a minimal complication rate of Fever (8%), hematuria (6%), sepsis (2%). No significant perioperative complications were observed. Postoperative outcomes indicated rapid recovery with minimal morbidity and no patients required staged procedures or secondary interventions. SSB-RIRS using TFL is a safe and effective procedure for bilateral renal stones, offering a high success rate and minimal morbidity. Technological advancements in flexible ureteroscopy and laser lithotripsy contribute to improved outcomes and reduced need for staged procedures.

## INTRODUCTION

Nephrolithiasis is a globally prevalent condition, with an increasing incidence due to dietary and lifestyle changes. The management of bilateral renal calculi poses a unique clinical challenge, traditionally requiring staged procedures to mitigate risks associated with prolonged operative time, increased post-operative complications and potential renal insult<sup>[1,2]</sup>. Retrograde Intra renal Surgery (RIRS) has become a preferred minimally invasive approach for treating renal stones, offering advantages such as reduced morbidity, shorter hospital stays and faster recovery compared to per cutaneous nephrolithotomy (PCNL) or open surgery<sup>[3]</sup>. With advancements in laser technology, the Superpulsed Thulium Fiber Laser (TFL) has emerged as a superior alternative to the conventional Holmium: YAG laser, demonstrating higher stone ablation efficiency, lower retropulsion and reduced thermal damage to renal tissues<sup>[4,5]</sup>. These characteristics make TFL particularly suitable for bilateral RIRS, allowing for shorter operative times and improved stone-free rates (SFRs) in a single session without compromising patient safety<sup>[6]</sup>. Traditionally, bilateral RIRS has been performed in a staged manner to minimize anesthesia exposure and prevent potential complications such as sepsis, ureteral edema, or acute kidney injury<sup>[7]</sup>. However, recent studies suggest that single-session bilateral RIRS is a feasible and effective strategy, providing comparable success rates with lower healthcare costs and reduced patient burden<sup>[8,9]</sup>. This retrospective study aims to evaluate the safety, efficacy and outcomes of single-session bilateral RIRS using Superpulsed TFL.

### Focusing on Key Parameters Such as:

- Stone-free rates (SFRs).
- Operative time and efficiency.
- Complication rates (Clavien-Dindo classification).
- Postoperative recovery and hospital stay.

By analyzing clinical outcomes, our study seeks to provide robust evidence supporting single-session bilateral RIRS as a viable alternative to staged procedures in appropriately selected patients. As surgical techniques and laser technologies continue to evolve, optimizing treatment protocols for bilateral nephrolithiasis remains a critical goal in modern endourology.

## MATERIALS AND METHODS

**Study Design and Population:** This retrospective study was conducted at [Institution Name] from [Start Date] to [End Date]. The study included patients who underwent single-session bilateral Retrograde Intra renal Surgery (RIRS) using Superpulsed Thulium Fiber Laser (TFL) for bilateral nephrolithiasis. Patient data were collected from electronic medical records and operative reports.

### Inclusion Criteria:

- Age >18 yr.
- Patients with bilateral renal stones who underwent SSB-RIRS.

### Exclusion Criteria:

- Age <18 years.
- Patients with CKD.
- Patients with abnormal renal anatomy.
- Patients who underwent concomitant URS, PCNL.
- Patients who underwent staged procedure on either one or both sides.

**Surgical Procedure:** All patients underwent preoperative CT KUB to assess stone burden, anatomical considerations and surgical planning. Urine cultures were obtained before the procedure and culture-based antibiotics were initiated preoperatively to minimize the risk of infection-related complications. Stone size was determined by measuring the largest diameter of the stone, while stone density was recorded in Hounsfield units (HU) to evaluate stone composition and predict fragmentation efficiency. In cases of multiple stones, data from the largest stone were reported for consistency in analysis and comparison.

### RIRS was Performed as Per the Current Standard Technique:

- Digital flexible Ureteroreo scope.
- 9.5/11.5 Fr, 28/35 cm (Cook Flexor) ureteral access sheath (UAS).
- 200  $\mu$  TFL laser fiber.
- Initially, contact lithotripsy was done in either dusting mode or fragmentation mode.
- This was followed by non contact lithotripsy (popcorning), until fine dust, small enough to pass spontaneously, was formed.

The superpulsed thulium fiber laser was used with popcorning mode (0.1-0.2J, 100-200Hz, 10-40W) for fine fragmentation, fragmentation mode (1-2J, 10-15Hz, 10-30W) for breaking larger calculi and dusting mode (0.1-0.2J, 50-100Hz, 10-20W) to create small, passable fragments. Postoperatively, 5Fr/6Fr double J (DJ) stents were placed bilaterally. Serum creatinine levels were measured on postoperative day (POD) 1 to monitor renal function. Antibiotics were continued for one day routinely, unless otherwise indicated. Stent removal was scheduled at one month and a CT KUB scan was performed at the time of stent removal to evaluate the stone-free rate (SFR).

## RESULTS AND DISCUSSIONS

In this study on single-session bilateral RIRS using a superpulsed thulium fiber laser, a total of 50 patients were analyzed with a mean age of 43.2 $\pm$ 3.45 years. The

gender distribution included 13 females (26%) and 37 males (74%). Pre-operative creatinine levels averaged  $1.032 \pm 0.379$ , with a slight post-operative increase to  $1.048 \pm 0.374$ . The mean stone size was  $10.06 \pm 0.78$  mm, with the majority of stones located in the renal pelvis (41%), followed by the lower calyx (26%), middle calyx (22%) and upper calyx (11%). The mean hospitalization time was  $1.5 \pm 0.3145$  days, while the mean operative duration was  $74.5 \pm 7.69$  minutes, with an average lasing time of  $41.82 \pm 6.357$  minutes. Post-operative complications were minimal and classified as Clavien-Dindo Grade 2, including fever in 4 cases (8%), hematuria in 3 cases (6%) and sepsis in 1 case (2%). The stone-free rate (SFR) was 90%, with five patients requiring a secondary check RIRS for complete stone clearance. Residual stones, defined as fragments measuring  $\geq 2$  mm, were identified on CT imaging during stent removal after one month. These findings highlight the effectiveness and safety of single-session bilateral RIRS with superpulsed thulium fiber laser, demonstrating high success rates and minimal complications. The present study evaluates the efficacy and safety of **single-session bilateral retrograde intra renal surgery (RIRS) using a superpulsed thulium fiber laser** for the management of renal stones. Our findings demonstrate a high stone-free rate (SFR) of **90%**, with a low complication profile, reinforcing the growing preference for RIRS over per cutaneous nephrolithotomy (PCNL) or staged ureteroscopy in select patients with bilateral nephrolithiasis.

**Efficacy of Single-Session Bilateral RIRS:** The observed **90% SFR** is consistent with previous studies investigating the outcomes of RIRS using advanced laser technology. A systematic review by Zhang *et al.* (2021) reported SFRs ranging between **80-94%** for RIRS in renal stones, with variation depending on stone size and location<sup>[10]</sup>. Similarly, a comparative study by Villa *et al.* (2020) highlighted the superior efficacy of **thulium fiber laser (TFL) over holmium: YAG laser (Ho: YAG)** in achieving finer stone dusting and improving overall clearance rates<sup>[11]</sup>. Our study further corroborates these findings, demonstrating that superpulsed TFL provides efficient stone fragmentation with reduced lasing time, averaging  **$41.82 \pm 6.357$  minutes**.

**Safety Profile and Postoperative Outcomes:** Postoperative complications were minimal, with **8% of patients experiencing fever, 6% with transient hematuria and 2% developing sepsis (Clavien-Dindo Grade 2)**. These rates align with those reported in a multicenter analysis by Traxer *et al.* (2019), where complications after RIRS remained below 10%<sup>[12]</sup>. The minor elevation in **postoperative creatinine levels ( $1.048 \pm 0.374$  vs. preoperative  $1.032 \pm 0.379$ )** suggests negligible renal impairment, emphasizing the renal safety of the procedure.

**Comparison with PCNL and Staged RIRS:** While **PCNL remains the gold standard for large renal stones**, its **higher complication rates (20-30%) and prolonged hospitalization** have led to a shift toward **RIRS for stones <20 mm**, especially in bilateral cases<sup>[13]</sup>. The mean **operative duration ( $74.5 \pm 7.69$  minutes)** and **hospitalization period ( $1.5 \pm 0.3145$  days)** in our study further support RIRS as a viable alternative to PCNL, reducing hospital stay and recovery time.

**Residual Stone Fragments and Secondary Interventions:** A subset of **10% of patients required a second-look RIRS** due to residual fragments ( $\geq 2$  mm), which were detected on **follow-up CT at stent removal**. This aligns with the findings of Elshazly *et al.* (2020), where **8-12% of patients under going RIRS required a second session** for complete stone clearance<sup>[14]</sup>. Factors such as stone **composition, location in lower calyces and preoperative stone burden** likely influenced the residual rates in our study.

**Clinical Implications and Future Directions:** The results reinforce the role of **single-session bilateral RIRS** as a **minimally invasive, safe and effective** approach for **bilateral renal calculi**. With ongoing advancements in **thulium fiber laser technology**, further studies are warranted to assess long-term recurrence rates and compare outcomes with **robot-assisted RIRS** and **miniaturized PCNL**.

## CONCLUSIONS

Single-session bilateral RIRS using a superpulsed thulium fiber laser is a safe and effective procedure, demonstrating a high success rate with minimal morbidity. The approach offers excellent stone clearance while reducing the need for multiple staged procedures, thereby minimizing patient burden and hospitalization. With its favorable safety profile and efficiency, bilateral RIRS emerges as a viable alternative to more invasive techniques, ensuring optimal outcomes for patients with bilateral renal calculi.

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