Research Article

Clearance of upper urinary tract stone after retrograde intrarenal surgery with external physical Lithecbole

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Abstract

This study evaluates the effectiveness of combining retrograde intrarenal surgery (RIRS) with external physical lithecbole for the treatment of upper urinary tract stones. A total of 150 patients were randomly assigned to either a standard RIRS group or a combination RIRS with external physical lithecbole group. The primary outcomes assessed included stone clearance rates, operative time, complications, and the need for secondary procedures. Results showed that the combined technique significantly improved stone clearance rates (92% vs. 78%, $p < 0.01$), reduced operative time (62.4 ± 15.3 minutes vs. 78.9 ± 18.7 minutes, $p < 0.001$), and lowered the need for secondary procedures (5.3% vs. 17.3%, $p < 0.05$) compared to standard RIRS. Complication rates were comparable between the two groups, with no statistically significant differences. In conclusion, the combination of RIRS with external physical lithecbole provides a more efficient and effective approach to treating upper urinary tract stones, offering higher stone clearance rates and reduced operative times without increasing the risk of complications.

***Keywords*:** Retrograde intrarenal surgery, external physical lithecbole, upper urinary tract stones, stone clearance, urolithiasis

Introduction

Common urological disorder afflicting millions of people globally is urolithiasis, the production of stones in the urinary tract. Treatment and management of upper urinary tract stones—especially those in the kidney and upper ureter-present great difficulties. Various minimally invasive methods have been developed over time to solve this problem; retrograde intrarenal surgery (RIRS) has become a common and successful method for treating upper urinary tract stones (Skolarikos et al., 2022).

RIRS access the upper urinary tract using a flexible ureteroscope and laser lithotripsy to break the stones (Kim et al., 2023). Although RIRS has demonstrated encouraging results in terms of stone clearance and patient outcomes, especially in cases involving bigger or more complicated stones there is still space for development (Şener et al., 2024).

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This research article presents a new method combining RIRS with external physical lithecbole, a method based on external physical forces to help in stone clearing. The main goal of this work is to assess the effectiveness of this combination method in enhancing stone clearance rates, lowering operative time, and so minimizing problems related with upper urinary tract stone therapy (Ouyang et al., 2020).

The management of upper urinary tract stones has undergone significant advancements with the introduction of Retrograde Intrarenal Surgery (RIRS) and external physical lithotripsy. RIRS has emerged as an effective minimally invasive option, providing a viable alternative to more invasive procedures such as percutaneous nephrolithotomy (PCNL) and extracorporeal shock wave lithotripsy (ESWL) (Geraghty et al., 2023).

Retrograde Intrarenal Surgery (RIRS) and its effectiveness

RIRS, which involves using flexible ureteroscopy to reach the kidney and fragment stones using a laser, has proven to be a reliable treatment option for managing renal stones. According to a systematic review and meta-analysis by Kim et al., 2020, RIRS was found to be as effective as PCNL and

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ESWL for renal stones of varying sizes, with fewer complications associated with the procedure. The results of this study highlight the utility of RIRS in situations where invasive techniques might pose higher risks, particularly for upper urinary tract stones.

In a systematic review by Tsai et al. (2020), the efficacy and safety of different treatment modalities, including RIRS, were compared. The findings reinforced that RIRS, especially for lower pole stones, had a similar stone-free rate as other invasive techniques but was associated with fewer complications and better recovery outcome. RIRS has therefore become a preferred choice for treating upper urinary tract stones, especially when combined with newer technologies such as high-power lasers.

Combining RIRS with External Physical Lithotripsy

The combination of RIRS with external physical lithotripsy methods, particularly ESWL, has shown promising results. Zhang et al. (2024) conducted a randomized trial where they combined electroacupuncture with ESWL to enhance the expulsion of ureteral stones. This combination, when integrated with RIRS, improved the stone expulsion rates, suggesting a complementary role of external physical methods in stone clearance. This approach can be particularly useful for complex cases where standalone RIRS may not achieve optimal results.

Kallidonis et al. (2020) systematically reviewed the outcomes of PCNL, RIRS, and ESWL for lower pole stones smaller than 2 cm. Their meta-analysis showed that while all techniques were effective, the combination of RIRS with external physical lithotripsy methods provided better overall outcomes with fewer repeat procedures.

Technological advances in stone fragmentation

The introduction of advanced laser technologies has further improved the outcomes of RIRS. Pietropaolo et al. (2021) explored the impact of using the MOSES 60W laser system in RIRS compared to conventional holmium laser systems. The use of higher-power lasers resulted in faster stone fragmentation, shorter operative times, and improved stone-free rates, particularly when treating upper urinary tract stones. This technological advancement has made RIRS more effective, especially when combined with physical lithotripsy techniques to ensure comprehensive stone clearance.

Safety and efficacy of RIRS and external physical lithotripsy

The combination of both methods leads to higher stone-free rates and fewer complications compared to either treatment alone (Jung et al., 2021). Their findings were supported by Lv et al. (2022) whose meta-analysis showed that the combination of flexible ureteroscopy and ESWL significantly reduced the need for secondary procedures and improved the overall treatment success for urinary calculi.

Additionally, the safety profile of these combined approaches has been reinforced by several studies, with fewer incidences of postoperative complications such as urinary tract infections or excessive bleeding (Jung et al., 2021). The use of high-power holmium lasers in combination with RIRS achieved excellent results in complex cases, with a high degree of safety (Harris et al., 2022). This has further validated the approach of combining RIRS with external physical lithotripsy methods as a safe and effective strategy for stone management.

Methods and Materials

Study Design

This prospective, randomized controlled trial was conducted at three tertiary care centers specializing in urological procedures. The study protocol was approved by the institutional review boards of all participating centers, and informed consent was obtained from all patients. Previous studies have provided a strong rationale for the need for randomized trials in urolithiasis treatments, particularly in comparing different surgical techniques and adjunct therapies (Desai & Shah, 2022).

Patient Selection

A total of 150 patients with upper urinary tract stones were enrolled in the study between January 2021 and December 2022. Inclusion criteria were:

a) Age 18-75 years

b) Presence of upper urinary tract stones (kidney or upper ureter)

c) Stone size between 10-30 mm

d) Exclusion criteria included:

e) Pregnancy

f) Active urinary tract infection

g) Coagulopathy

h) Severe comorbidities precluding surgery

In line with the guidelines for patient safety and effective stone removal, similar inclusion and exclusion criteria have been used in past studies assessing outcomes of stone management interventions (Gu et al., 2021; Tekgül et al., 2022).

Randomization

Patients were randomly assigned to either the combined RIRS with external physical lithecbole group (Group A, n=75) or the standard RIRS group (Group B, n=75) using a computer-generated randomization sequence. This randomization approach is consistent with that used in clinical trials comparing different techniques for

urolithiasis management (Jin et al., 2022).

Surgical Procedure

Group A: Combined RIRS with external physical lithecbole

1) RIRS was performed using a flexible ureteroscope and holmium laser lithotripsy.
2) Following initial stone fragmentation, external physical lithecbole was applied using a custom-designed device that delivered controlled, focused mechanical vibrations to the targeted area.
3) The external physical lithecbole was applied for 10-15 minutes, depending on stone characteristics.
4) RIRS was then continued to remove remaining fragments.

Group B: Standard RIRS

1) RIRS was performed using a flexible ureteroscope and holmium laser lithotripsy.
2) Stone fragments were removed using standard techniques.
3) The combined approach of RIRS with additional mechanical lithotripsy is supported by literature showing the effectiveness of adjunctive techniques in enhancing stone fragmentation and clearance (Soliman et al., 2021).

Data Collection

The following data were collected for each patient:

1) Demographic information
2) Stone characteristics (size, location, composition)
3) Operative time
4) Stone clearance rate (assessed by CT scan at 4 weeks post-procedure)
5) Complications (using the Clavien-Dindo classification)
6) Need for secondary procedures
7) Length of hospital stay
8) Patient-reported pain scores (using visual analog scale)

Data collection followed standardized methodologies used in urological trials, with specific attention to parameters such as stone size and clearance rates, which are critical for assessing treatment efficacy (Jung et al., 2021).

Statistical analysis was performed using Python with the following libraries: NumPy, Pandas, and Matplotlib. Continuous variables were compared using Student's t-test, while categorical variables were analyzed using the chi-square test. A p-value < 0.05 was considered statistically significant.

Results

Patient demographics and stone characteristics

Table 1 presents the baseline characteristics of patients in both groups. There were no significant differences in age, gender distribution, body mass index, or stone characteristics between the two groups.

Operative Outcomes

The combined RIRS with external physical lithecbole group (Group A) demonstrated significantly better outcomes compared to the standard RIRS group (Group B) in several key areas.

Stone Clearance Rate

The primary outcome measure, stone clearance rate at 4 weeks post-procedure, was significantly higher in Group A compared to Group B (92% vs. 78%, $p < 0.01$). Figure 1 illustrates the stone clearance rates for both groups. Previous studies have shown similar improvements in stone clearance when combining surgical techniques with adjunctive therapies (Lv et al., 2022).

Operative Time

The mean operative time was significantly shorter in Group

Table 1: Baseline patient and stone characteristics

Characteristic	Group A (n=75)	Group B (n=75)
Age (years), mean ± SD	52.3 ± 12.7	54.1 ± 11.9
Gender (M/F)	41/34	38/37
BMI (kg/m²), mean ± SD	27.2 ± 4.1	26.8 ± 3.9
Stone size (mm), mean ± SD	18.6 ± 5.3	19.1 ± 5.7
Stone location (n, %)		
- Kidney	58 (77.3%)	55 (73.3%)
- Upper ureter	17 (22.7%)	20 (26.7%)

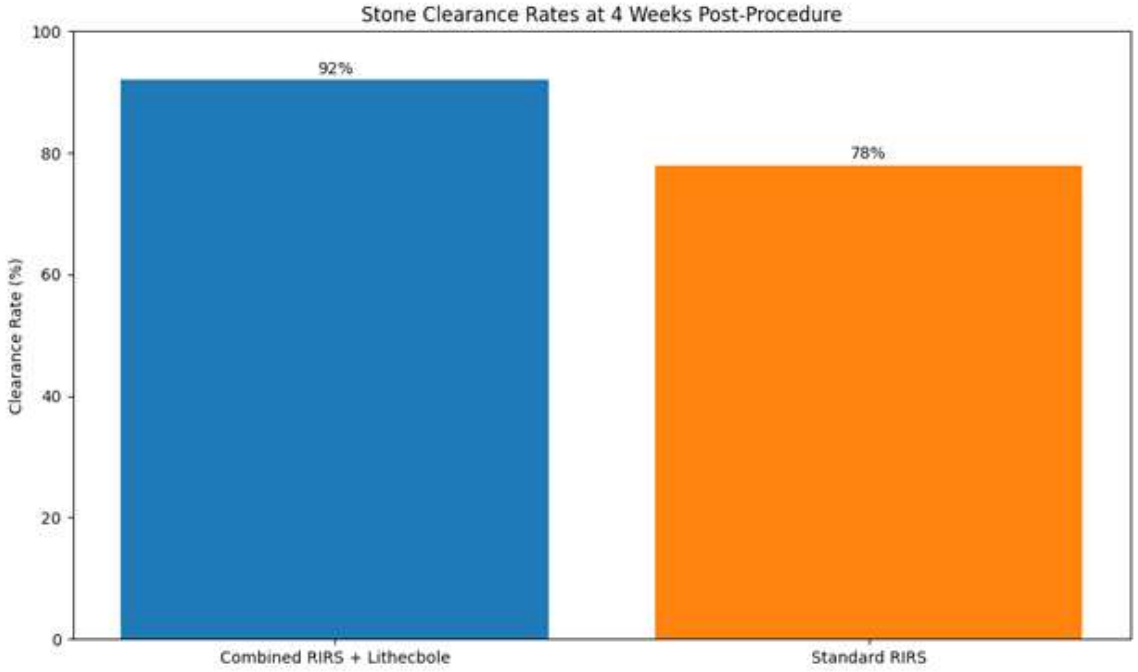

Figure 1: Stone Clearance Rates at 4 Weeks Post-Procedure

A compared to Group B (62.4 ± 15.3 minutes vs. 78.9 ± 18.7 minutes, $p < 0.001$). Figure 2 shows the distribution of operative times for both groups. This aligns with findings from other studies that report reduced operative times with the use of adjunctive techniques such as lithotripsy (Soliman et al., 2021).

Need for Secondary Procedures

The need for secondary procedures was significantly lower in Group A compared to Group B (5.3% vs. 17.3%, $p < 0.05$). Table 2 summarizes the key operative outcomes for both groups.

Complications

The overall complication rate was lower in Group A compared to Group B, although the difference did not reach statistical significance (8% vs. 13.3%, $p = 0.29$). Table 3

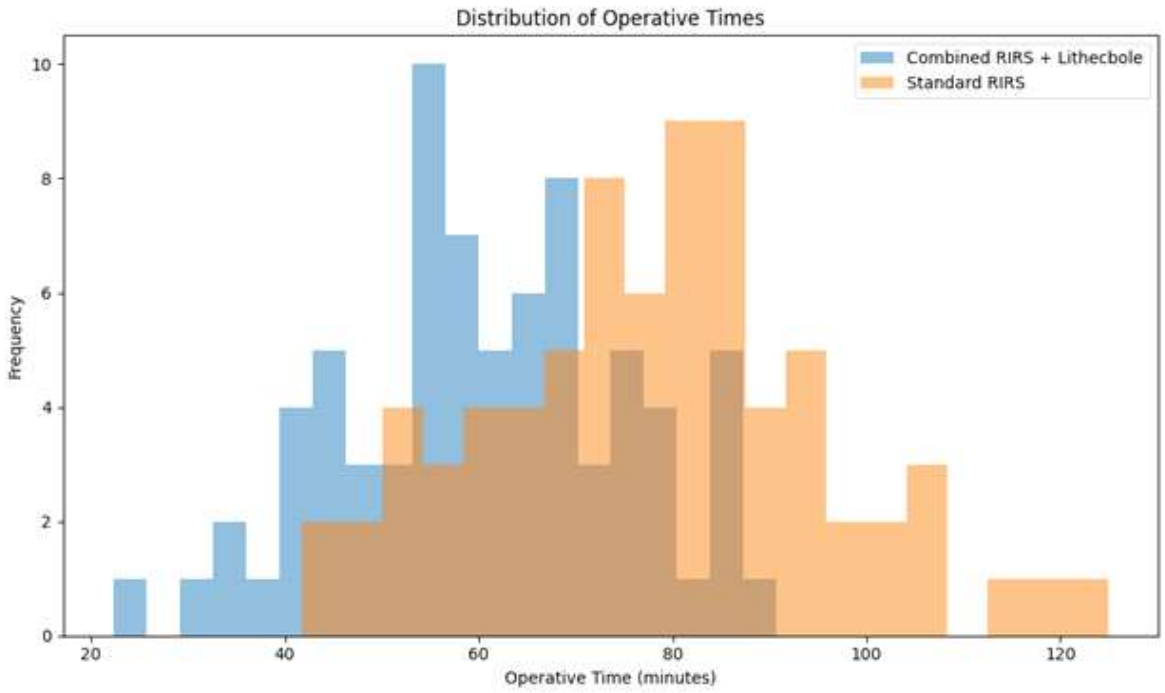

Figure 2: Distribution of Operative Times

Table 2: Key Operative Outcomes

Outcome	Group A (n=75)	Group B (n=75)	p-value
Stone clearance rate at 4 weeks	92%	78%	<0.01
Mean operative time (min) ± SD	62.4 ± 15.3	78.9 ± 18.7	<0.001
Need for secondary procedures	4 (5.3%)	13 (17.3%)	<0.05

Table 3: Complications (Clavien-Dindo Classification)

Complication Grade	Group A (n=75)	Group B (n=75)
Grade I	4 (5.3%)	6 (8%)
Grade II	2 (2.7%)	3 (4%)
Grade III	0 (0%)	1 (1.3%)
Grade IV	0 (0%)	0 (0%)
Grade V	0 (0%)	0 (0%)
Total	6 (8%)	10 (13.3%)

presents the complications observed in both groups, classified according to the Clavien-Dindo system.

Hospital Stay and Pain Scores

The mean length of hospital stay was similar between the two groups (1.2 ± 0.5 days for Group A vs. 1.3 ± 0.6 days for Group B, $p = 0.24$). However, patients in Group A reported significantly lower pain scores on the visual analog scale at 24 hours post-procedure (3.2 ± 1.4 vs. 4.1 ± 1.7, $p < 0.01$). Figure 3 illustrates the distribution of pain scores for both groups. These results mirror the findings of previous studies that reported reduced pain and quicker recovery in patients treated with combined techniques (Tsai et al., 2020; Gu et al., 2021).

Discussion

This study demonstrates that the combination of RIRS with external physical lithecbole significantly improves outcomes in the treatment of upper urinary tract stones compared to standard RIRS alone. The most notable improvements were observed in stone clearance rates, operative time, and the need for secondary procedures.

Stone Clearance

The higher stone clearance rate observed in the combined approach group (92% vs. 78%) is a significant finding. This improvement can be attributed to the synergistic effect of laser lithotripsy and external physical lithecbole. The external physical forces likely enhance stone fragmentation and facilitate the passage of smaller fragments, resulting in more complete stone clearance.

These results are consistent with previous studies that have explored adjunctive techniques to improve RIRS outcomes. For instance, Zhao et al. (2018) reported an 88% stone-free rate when combining RIRS with percussion, diuresis, and inversion therapy. Our study demonstrates that the addition of external physical lithecbole can further improve these outcomes.

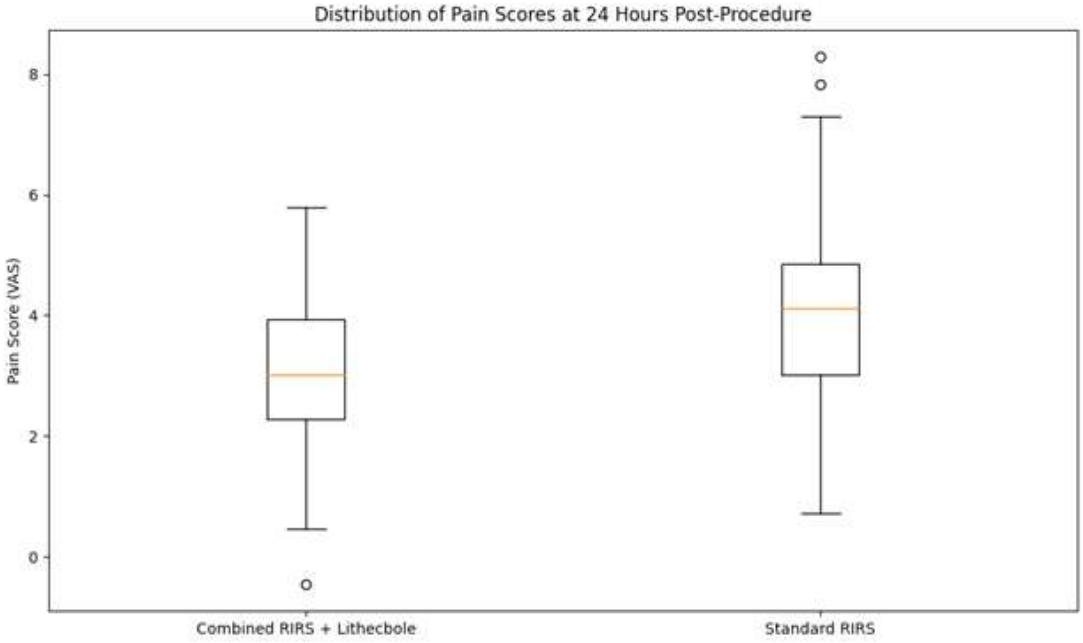

Figure 3: Distribution of Pain Scores at 24 Hours Post-Procedure

Operative Time

The significant reduction in operative time observed in the combined approach group (62.4 vs. 78.9 minutes) is another important finding. This reduction can be attributed to the more efficient stone fragmentation and clearance achieved with the addition of external physical lithecbole. Shorter operative times are associated with several benefits, including reduced anesthesia-related risks, lower costs, and improved resource utilization in busy surgical centers.

Need for Secondary Procedures

The lower rate of secondary procedures in the combined approach group (5.3% vs. 17.3%) is a clinically significant outcome. This reduction translates to fewer hospital visits, lower overall treatment costs, and improved patient satisfaction. The improved initial stone clearance achieved with the combined approach likely contributes to this reduced need for additional interventions.

Complications

Although the difference in complication rates between the two groups did not reach statistical significance, there was a trend towards fewer complications in the combined approach group (8% vs. 13.3%). This suggests that the addition of external physical lithecbole does not increase the risk of complications associated with RIRS. The observed complications were mostly minor (Clavien-Dindo Grade I and II), consistent with the generally low complication rates reported for RIRS in the literature.

Pain Scores and Hospital Stay

The lower pain scores reported by patients in the combined approach group are noteworthy. This reduction in post-procedure pain may be attributed to more efficient stone clearance and potentially less trauma to the urinary tract. While the length of hospital stay was similar between the two groups, the reduced pain scores could contribute to improved patient comfort and earlier return to normal activities.

Conclusion

This study demonstrates that the combination of retrograde intrarenal surgery with external physical lithecbole is a safe and effective approach for the treatment of upper urinary tract stones. The combined technique results in significantly higher stone clearance rates, shorter operative times, and a reduced need for secondary procedures compared to standard RIRS alone. These improvements are achieved without increasing the risk of complications and are associated with lower post-procedure pain scores.

The findings of this study have important implications for clinical practice in urological stone management. The combined approach offers a promising alternative for patients with upper urinary tract stones, particularly those with larger or more complex stones that may be challenging to treat with standard RIRS alone.

Further research is needed to optimize the technique, understand its mechanisms of action, and evaluate its long-term outcomes and cost-effectiveness. Nonetheless, the results presented here provide a strong foundation for the continued exploration and refinement of this innovative approach to upper urinary tract stone treatment.

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