

## Risk Factors, Complications, and Outcomes in Flexible Ureteroscopy: A Retrospective Study from Riyadh, Saudi Arabia (2022–2024)

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### ABSTRACT

**Objective:** This study evaluates the risk factors, complications, and outcomes associated with flexible ureteroscopy (FURS) for the treatment of renal and proximal ureteral stones at Imam Abdulrahman Al-Faisal Hospital, Riyadh, Saudi Arabia.

**Methods:** A retrospective analysis was conducted on 175 patients who underwent FURS between June 2022 and January 2024. Data collected included demographics, comorbidities, operative details, and postoperative complications. Statistical analyses were performed to identify associations between patient characteristics and complications, with significance set at  $p < 0.05$ .

**Results:** The cohort had a mean age of 41.31 years, with 81.14% male patients. Common comorbidities included diabetes mellitus (21.71%) and hypertension (17.71%). The most frequent complications were residual stones (5.14%), hematuria (5.71%), and ureteral injuries (6.29%). Diabetes was significantly associated with infections ( $p < 0.001$ ) and urosepsis ( $p = 0.001$ ), while hypertension was linked to infections ( $p < 0.05$ ). No significant associations were found between operative duration and complications. Overall, 97.14% of patients achieved clinical improvement, with a 0.57% mortality rate due to urosepsis.

**Conclusion:** FURS is a safe and effective procedure with a high success rate and manageable complications. Diabetes and hypertension are significant risk factors for postoperative infections, underscoring the need for preoperative risk assessment and targeted interventions. Future studies should validate these findings across multicenter settings and explore advancements in technology to further improve patient outcomes.

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### Introduction

Flexible ureteroscopy is a procedure used to diagnosed and treat with problems and infection in urinary tract particularly those with kidney problems. Flexible ureteroscopy (URS) has emerged as a significant option for addressing proximal ureteral and renal stones, thanks to ongoing technological advancements. Retrograde intrarenal surgery, in particular, has seen notable improvements. According to the 2020 European Association of Urology Urolithiasis Guidelines, innovations such as smaller endoscope designs, enhanced deflection systems, superior optical capabilities, advanced tools, and the introduction of disposable equipment have significantly increased the utilization of URS in managing stones in both the ureter and kidney [1].

Since the world is in technological advances, those with problems in uterus, kidney or in any internal organs can easily diagnose and treat through flexible ureteroscopy procedures using flexible ureterorenoscopy. This procedure, set up patient correct positioning for gaining access, insertion and proper handling of ureterorenoscopy. With the high definition of digital imaging, the target image was captured with high definition and image quality that provides more valid and reliable outcomes and help

medical experts to identify problems that can immediately treat and provide at least minimum first aid treatment. Thus, the flexible ureterorenoscopy has technology advances it allows more complex procedures into more flexible and easier to use.

The 2016 guidelines from the American Urological Association highlight that flexible URS is highly effective for proximal ureteral stones less than 2 cm in size, offering favorable outcomes with minimal risks and complications. Conversely, semi-rigid URS tends to have higher rates of treatment failure and retreatment for stones in the proximal ureter, underscoring the importance of access to flexible URS for such cases [2].

Additionally, recent studies confirm that URS, when performed by experienced professionals, achieves excellent outcomes with a strong safety profile. It has demonstrated better stone clearance rates and efficiency than shock wave lithotripsy, particularly for large ureteral stones and non-staghorn renal stones [3]. This study aims to delve into the complications associated with URS, identify the factors contributing to these risks, and recommend strategies to minimize their occurrence and enhance patient safety.

Risk Factors for Bleeding after Flexible Ureteroscopic Lithotripsy Bleeding, infection, and ureteral injury are three main complications after semi-rigid and flexible URS. A study reported that 11 patients

(0.4%) developed a subcapsular renal hematoma after semi-rigid URS using a holmium: Yttrium-aluminum-garnet (Ho: YAG) laser. Patients who developed a perirenal hematoma had larger stones, more severe hydronephrosis, longer operation duration (41 vs. 33 min,  $P < 0.001$ ), and higher perfusion pressure for hydraulic irrigation ( $P < 0.001$ ) than patients who did not develop a perirenal hematoma [4]. While another study identified that 4 (0.36%) of 1114 patients were diagnosed with subcapsular hematoma after URS [4]. All four patients had the triad of loin pain, fever, and a significant hemoglobin drop necessitating a blood transfusion. Large obstructive proximal ureteral stones and thin renal cortex were risk factors of postoperative perirenal hematoma [5].

Retrospectively analyzed 45 patients undergoing flexible URS and found that 4 (8.9%) patients with lower body mass index, chronic kidney disease, and a thinner renal cortex had a higher risk of developing a perirenal hematoma [6]. They proposed that during flexible URS, the high irrigation pressure, to maintain adequate vision may be associated with postoperative bleeding. Another report showed the incidence of bleeding after flexible URS was 25 (1.59%) among 1571 procedures [7].

The five patients receiving anticoagulant treatments, and six patients with bleeding diathesis have no bleeding complication. Also, the patients with and without anticoagulation had similar hemorrhagic or thromboembolic adverse events [8].

Thus, flexible URS remains the only potential surgical alternative for renal stones in patients on anticoagulant therapy, which is a contraindication to other minimally invasive treatment options (e.g., percutaneous nephrolithotomy or extracorporeal shock wave lithotripsy).

## Methods

### Study Design and Setting

This retrospective study was conducted at Imam Abdulrahman Al-Faisal Hospital, evaluating patients who underwent flexible ureteroscopic lithotripsy (FURS) with a holmium laser from June 2022 to January 2024. The study adhered to the ethical guidelines and principles of medical research, ensuring patient confidentiality and data integrity.

### Patient Population

The study included a total of 175 patients diagnosed with renal or proximal ureteral stones. Inclusion criteria were patients who underwent FURS for the treatment of stones, regardless of gender or age. Exclusion criteria included patients with incomplete medical records or those who underwent procedures other than FURS.

### Data Collection

Patient Data were Retrospectively Reviewed from Hospital Records. Key Variables Collected Included:

- Demographic information: Age and gender.
- Medical history: Presence of diabetes mellitus, hypertension, and renal insufficiency.
- Surgical history: Previous history of stone-related surgeries.
- Clinical parameters: Stone size, operative duration, residual stones, and complications.
- Outcomes: Postoperative complications and overall patient recovery.

## Procedure

All procedures were performed by experienced urologists following standard protocols for FURS. Patients were placed in the lithotomy position, and a semi-rigid ureteroscope was initially used for diagnostic purposes. Subsequently, a flexible ureteroscope was inserted, aided by a hydrophilic guidewire and an access sheath. Stones were fragmented using a holmium laser with adjustable power and pulse settings. At the end of the procedure, the ureter and kidney were inspected for residual stones and possible injuries. A double J ureteral stent was placed for 1 to 3 months based on the degree of ureteral injury and residual stone burden.

## Outcomes Measured

The Primary Outcomes Measured Were

- Risk factors: Association between demographic/clinical variables and complications.
- Complications: Rates of infection, urosepsis, ureteral injuries, and subcapsular hematoma.
- Stone-free rate: Percentage of patients without residual stones postoperatively.

## Ethical Considerations

All procedures and treatment were done by all experts and were based to the medical history and records of the hospitals. And all data/information of participants-patients were securely protected.

## Statistical Analysis

To evaluate the association between medical history variables (diabetes mellitus and hypertension) and complications following flexible ureteroscopy, contingency table analyses were performed. Categorical variables representing medical history and complications were cross-tabulated, and statistical tests were conducted to assess significance and the strength of associations. Statistical significance was defined as a p-value of less than 0.05. For complications with low expected frequencies in contingency tables, Fisher's exact test was performed as an alternative to the Chi-squared test to ensure the robustness of statistical conclusions, given the smaller number of the investigated sample size. For the indicated significant association, the strength of associations was quantified using Cramer's V, where values were interpreted as negligible ( $< 0.1$ ), small (0.1–0.3), moderate (0.3–0.5), and strong ( $> 0.5$ ).

## Result

A total of 175 patients who underwent flexible ureteroscopy were included in this study. Their demographic data, medical history, operative details, and postoperative complications are summarized in Table 1. The mean age of the cohort was 41.31 years ( $\pm 11.06$ ), with males representing the majority (81.14%,  $n=142$ ) and females comprising 18.86% ( $n=33$ ). The most prevalent comorbidities were diabetes mellitus (21.71%,  $n=38$ ) and hypertension (17.71%,  $n=31$ ), followed by prior stone surgery (3.43%,  $n=6$ ) and renal insufficiency (2.29%,  $n=4$ ).

## Operative Data and Postoperative Complications

The mean duration of the procedure was 51.15 minutes ( $\pm 24.53$ ). Postoperative complications occurred in a subset of patients (Table 1):

**Table 1: Subjects' Characteristics and Complications Frequencies**

N	175	
Age (SD)	41.31	(±11.06)
<b>Sex</b>		
Male	142	81.14%
Female	33	18.86%
<b>Medical history</b>		
Diabetes	38	21.71%
Hypertension	31	17.71%
Renal Insufficiency	4	2.29%
Stone Surgery	6	3.43%
<b>Operation</b>		
Duration (SD) in minutes	51.15	(±24.53)
Residual Stones	9	5.14%
<b>Post Operation</b>		
Infections	5	2.86%
Urosepsis	3	1.71%
Ureteral Injury	11	6.29%
Ureteral Perforation	3	1.71%
Ureteral Avulsion	0	0.00%
Contrast Extravasation	9	5.14%
Hematuria	10	5.71%
Post Obstructive Diuresis	4	2.29%
Stent Migration	3	1.71%
Subcapsular Hematoma	1	0.57%
ICU Admission	4	2.29%
<b>Outcomes</b>		
Improved	170	97.14%
Need Further Management	4	2.29%
Deceased	1	0.57%

Data on subjects who underwent Flexible Ureteroscopy, including demographic characteristics and complications, are presented as mean ± standard deviation for continuous variables and as frequency and percentage for categorical variables

**Postoperative Complications:** The most frequently reported complications were residual stones (5.14%, n=9), hematuria (5.71%, n=10), and ureteral injuries (6.29%, n=11). Less common but clinically significant complications included infections (2.86%, n=5), contrast extravasation (5.14%, n=9), and urosepsis (1.71%, n=3). Rare complications such as subcapsular hematoma (0.57%, n=1) and post-obstructive diuresis (2.29%, n=4) were also documented. ICU admissions were necessary for 2.29% of patients (n=4), reflecting the severity of certain complications. Importantly, no cases of ureteral avulsion were observed.

**Clinical Outcomes:** The majority of patients (97.14%, n=170) achieved clinical improvement following the procedure. A small proportion (2.29%, n=4) required further management, and one mortality (0.57%, n=1) was recorded (Table 1).

### Association Between Medical History and Complications

The associations between medical history and postoperative complications are detailed in Table 2:

**Table 2: Association of Medical History and Flexible Ureteroscopy Complications**

Medical history				
Complications	Diabetes	p-value	Hypertension	p-value
Residual Stones	3	0.41	1	1
Infections	5	<0.001	3	<0.05
Urosepsis	3	0.001	1	0.45
Ureteral Injury	2	1	3	0.41
Ureteral Perforation	1	0.5	1	0.45
Contrast Extravasation	2	1	1	1
Hematuria	3	0.45	2	0.69
Post Obstructive Diuresis	1	1	2	0.15
Stent Migration	0	1	1	0.45
Subcapsular Hematoma	1	0.22	1	0.18
ICU Admission	3	1	2	1

Frequencies of complications following flexible ureteroscopy are presented. The association between medical history and the occurrence of complications after flexible ureteroscopy was assessed using Fisher's exact test. Statistical significance was defined as a p-value of less than 0.05

**Diabetes Mellitus:** Significant associations were identified between diabetes mellitus and postoperative infections (p < 0.001) as well as urosepsis (p = 0.001). Cramer's V analysis indicated a moderate strength of association for infections (V = 0.33) and a small to moderate association for urosepsis (V = 0.25). No statistically significant associations were observed between diabetes mellitus and other complications, such as residual stones, ureteral injuries, or hematuria.

**Hypertension:** Hypertension was significantly associated with postoperative infections (p < 0.05), with a small strength of association (Cramer's V = 0.19). However, hypertension did not demonstrate significant associations with other complications, including urosepsis, residual stones, or hematuria.

### Subgroup Analysis

Male patients constituted the majority of the cohort, but complication rates did not differ significantly between sexes (Table 1). Similarly, age did not appear to influence the frequency or type of complications observed.

### Duration of Procedure

The mean operative time of 51.15 minutes (±24.53) showed no direct correlation with the incidence of complications. This suggests that other factors, such as patient comorbidities or intraoperative challenges, may have a greater impact on the likelihood of adverse outcomes (Table 1).

### Clinical Implications

These findings underscore the importance of thorough preoperative evaluation, particularly for patients with diabetes

mellitus, who were shown to be at higher risk for infections and urosepsis. Implementation of strict infection control measures and enhanced postoperative surveillance may reduce the incidence of complications in these patients. While hypertension was also associated with infections, its impact appeared to be less pronounced (Table 2).

### Outcome Analysis

The high rate of clinical improvement (97.14%) highlights the efficacy of flexible ureteroscopy as a therapeutic intervention for urological conditions. This success may be attributed to advancements in surgical techniques, optimized perioperative care, and appropriate patient selection (Table 1).

### Discussion

Flexible ureteroscopic lithotripsy (FURS) has become a cornerstone in the management of renal and proximal ureteral stones, offering high success rates with a relatively low incidence of complications. However, as this study demonstrates, specific patient and procedural factors significantly influence the risk of postoperative complications, including infections, ureteral injuries, and, in rare cases, mortality. Understanding these risk factors is essential for improving patient outcomes and minimizing adverse events.

### Risk Factors for Infection

Infections remain a notable complication following FURS, with this study reporting an infection rate of 2.86%. This aligns with findings from a systematic review and meta-analysis of 12,357 patients, which identified several risk factors for infection, including female sex (OR = 1.82), diabetes mellitus (OR = 1.40), positive preoperative urine cultures (OR = 2.18), longer operation duration (OR = 1.03), and preoperative ureteric stent placement (OR = 1.91) [9].

In this study, diabetes mellitus was significantly associated with postoperative infections ( $p < 0.001$ ), with a moderate strength of association (Cramer's  $V = 0.33$ ). This finding is consistent with existing literature emphasizing the role of diabetes in impairing immune responses and increasing susceptibility to infections. Interestingly, no significant correlation was observed between operative time and infections in this study, contrary to some reports suggesting that procedures exceeding 60 minutes are associated with higher infection rates due to prolonged irrigation and bacterial migration [10,11]. This discrepancy underscores the importance of adhering to strict infection control protocols and optimizing intraoperative techniques to mitigate risks.

### Risk Factors for Ureteral Injury

Ureteral injuries were observed in 6.29% of patients in this study, which is higher than the rates reported in some prior studies. The Traxer ureteral injury scale provides a widely accepted classification system for grading ureteral injuries, ranging from minor mucosal petechiae (Grade 0) to severe complications like complete ureteral avulsion (Grade 3&4) [12].

Factors contributing to ureteral injuries include the use of ureteral access sheaths (UAS), high irrigation pressures, and the mechanical properties of the ureteroscope. While UAS is intended to reduce intrarenal pressure and facilitate multiple entries, improper placement or excessive pressure can result in significant ureteral trauma [11]. This study supports the use of UAS as a preventive measure, provided they are correctly sized and placed to avoid trauma. Advances in ureteroscope design,

including flexible and pressure-sensitive instruments, may further reduce the risk of injury [13,14].

### Risk Factors for Mortality

Mortality associated with FURS is rare but significant. This study reported one death (0.57%) due to urosepsis; a finding consistent with existing literature where urosepsis accounts for the majority of FURS-related fatalities [15]. Diabetes mellitus and hypertension were notable comorbidities associated with this case, underscoring their role as significant risk factors. Other contributing factors, such as large stone burden and prolonged operative time, have been documented as exacerbating risks. Preventive measures, such as ensuring sterile urine preoperatively, closely monitoring patients with multiple comorbidities, and maintaining strict perioperative protocols, are critical to reducing mortality risks.

### Prevention Strategies

This study highlights the importance of a multifaceted approach to preventing complications during FURS. Key strategies include:

**Preoperative Optimization:** Conducting thorough evaluations of comorbidities, particularly diabetes mellitus and hypertension, can guide perioperative planning.

**Intraoperative Measures:** The routine use of appropriately sized UAS, strict adherence to irrigation pressure guidelines, and maintaining continuous fluid outflow are essential to minimizing ureteral trauma and infection risks.

**Technological Innovations:** Advances such as suctioning UAS and robotic-assisted systems like the Avicenna Roboflex hold promise for improving safety and outcomes, particularly in complex cases [14,15].

### Clinical Implications and Future Directions

The findings emphasize the need for individualized risk assessments based on patient demographics, comorbidities, and stone characteristics. Incorporating evidence-based practices, such as infection prevention protocols and careful instrument handling, can reduce complication rates and improve outcomes. Simulation-based training for surgeons and the integration of advanced technologies, including robotic systems, may further enhance procedural safety and success.

### Conclusion

This study highlights flexible ureteroscopy (FURS) as a safe and effective treatment for renal and proximal ureteral stones, with a high stone-free rate and low complication incidence. Diabetes mellitus and hypertension were significant risk factors for postoperative infections and urosepsis, underscoring the need for thorough preoperative evaluation and targeted risk mitigation strategies. While rare complications such as ureteral injuries and subcapsular hematoma were observed, advancements in surgical techniques and infection control protocols continue to enhance patient outcomes.

Further research should validate these findings in multicenter studies, explore innovative technologies to minimize complications, and evaluate long-term outcomes and cost-effectiveness of FURS.

### Limitations

This study highlights flexible ureteroscopy (FURS) as safe and effective, with a high success rate and low complication rates. However, the study's single-center retrospective design and small

sample size limit the generalizability of its findings. Potential biases include the exclusion of patients with incomplete records and the absence of a control group for comparative analysis. Despite these limitations, the study provides valuable insights into the impact of patient comorbidities and procedural outcomes in FURS.

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