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Efficacy of Semirigid Ureteroscopy in the Management of Upper Ureteric Stones in a Resource-Limited Hospital: A Prospective Observational Study

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Abstract

Background

Upper ureteric stone disease is a prevalent urological condition that demands timely intervention. In resource-limited hospitals, access to flexible ureteroscopy (fURS) and holmium:yttrium-aluminum-garnet (Ho:YAG) laser systems is often unavailable due to prohibitive costs and fragility of equipment. Semirigid ureteroscopy (SR-URS) remains the most accessible and durable endoscopic modality in such settings. This study evaluates the efficacy and safety of SR-URS for the management of upper ureteric stones in a resource-limited hospital.

Methods

This prospective observational study was conducted at a resource-limited secondary-level hospital. A total of 185 consecutive patients with upper ureteric stones (size 1.2–2.0 cm) were enrolled between January 2022 and December 2024. All procedures were performed with a semirigid Karl Storz ureteroscope using pneumatic lithotripsy and/or holmium laser. The primary outcome was stone-free rate (SFR) at four weeks. Secondary outcomes included operative time, perioperative complications classified by the Clavien-Dindo system, and need for a second-look procedure.

Results

The mean patient age was 45.2 ± 14.6 years (range 20–76). Males constituted 56.2% (n = 104) of the cohort. Mean stone size was 1.66 ± 0.20 cm. The SFR at four weeks was 98.4% (182/185). Mean operative time was 23.3 ± 10.2 minutes. The overall complication rate was 24.9% (n = 46); all complications were Clavien-Dindo grade I–II. The most common complications were mucosal injury (18.9%), false passage (18.9%), and intraoperative bleeding (11.9%). Stone migration occurred in 2.7% of cases. Three patients (1.6%) required a second-look procedure. No ureteral perforations occurred.

Conclusions

Semirigid ureteroscopy achieves an excellent stone-free rate of 98.4% with an acceptable safety profile in a resource-limited hospital setting. SR-URS should be considered the standard first-line treatment for upper ureteric stones in institutions where flexible ureteroscopy is unavailable or unaffordable.

Background

Urolithiasis is a common condition affecting 1–20% of the global population, with prevalence increasing year by year [1, 2]. Proximal and upper ureteric stones in particular pose a significant clinical challenge; their tendency toward impaction, proximal migration, and obstruction of the upper urinary tract often

mandates active intervention [3]. The economic burden is substantial — in the United States alone, stone disease cost an estimated US$5.3 billion annually in 2014 [4].

Current treatment options include medical expulsive therapy (MET), extracorporeal shock wave lithotripsy (ESWL), semirigid ureteroscopy (SR-URS), flexible ureteroscopy (fURS), percutaneous nephrolithotomy (PCNL), laparoscopic ureterolithotomy (LU), and open surgery [5, 6]. European Association of Urology (EAU) guidelines recommend ureteroscopic laser lithotripsy or ESWL as first-line treatment for proximal ureteric stones [7], with increasing adoption of fURS combined with Ho:YAG laser in developed nations, achieving stone-free rates of 81–94% [8].

However, flexible ureteroscopes are fragile, expensive (US$15,000–30,000 per instrument), and require repairs costing US$3,000–8,000 per episode — rendering them inaccessible to the majority of hospitals in low- and middle-income countries [9]. In this context, SR-URS represents the most practical and cost-effective endoscopic option. Published data from comparable settings demonstrate stone-free rates of 75–97.5% for upper ureteric stones with SR-URS [10–15], yet most series originate from university hospitals rather than true resource-limited facilities.

A recent single-arm meta-analysis of 24 studies (n = 2,058 patients) by Li et al. (2024) found a pooled SFR of 78% (95% CI: 75–82%) for SR-URS combined with Ho:YAG laser for proximal ureteral stones, with a 16% complication rate and a mean operative time of 51 minutes [16]. This meta-analysis did not specifically focus on resource-limited settings and included primarily tertiary-center cohorts.

The present study was designed to fill this evidence gap by prospectively documenting the efficacy and safety of SR-URS as a standalone modality in a genuine resource-limited hospital — a secondary-level institution without routine access to flexible ureteroscopy. The findings are intended to inform clinical decision-making and resource allocation in similar institutions worldwide.

Methods

Study Design and Setting

This prospective observational study was conducted at a resource-limited secondary-level hospital between January 2022 and December 2024. The institution serves a predominantly rural population and is equipped with a mobile C-arm fluoroscope, semirigid ureteroscopes, and pneumatic lithotripsy with intermittent access to a holmium laser generator. Flexible ureteroscopes were not routinely available during the study period. Ethical approval was obtained from the Institutional Review Board (IRB), and written informed consent was obtained from all participants prior to enrolment.

Participants

Inclusion criteria were: (1) adult patients aged ≥ 18 years; (2) upper ureteric stone confirmed by computed tomography urinary tract (CTUT) or ultrasound; (3) stone size 1.0–2.0 cm; (4) sterile urine culture or adequately treated urinary tract infection (UTI); and (5) willingness to undergo SR-URS as primary treatment.

Exclusion criteria were: active untreated urinary sepsis; pregnancy; solitary or transplanted kidney; congenital ureteral anomalies; pre-existing ureteral stent or nephrostomy tube; severe coagulopathy; or patient refusal.

Preoperative Assessment

All patients underwent a standardised preoperative assessment including complete blood count, serum creatinine and urea, urine analysis, mid-stream urine culture and sensitivity, plain kidney-ureter-bladder (KUB) X-ray, and CTUT without contrast for stone size measurement, density (Hounsfield units), and localisation. Patients with positive urine cultures received culture-directed antibiotic therapy until urinary sterility was confirmed before scheduling.

Surgical Technique

All procedures were performed under general or spinal anaesthesia in the dorsal lithotomy position. A mobile C-arm fluoroscope was used throughout with appropriate radiation protection. After cystoscopy and ureteral orifice identification, a 0.035-inch hydrophilic guidewire (Terumo-type) was inserted under fluoroscopic guidance. Ureteroscopy was performed using a 6.4/8.0 Fr or 8/9.8 Fr semirigid Karl Storz® ureteroscope (Karl Storz, Tuttlingen, Germany). The intramural ureter was dilated to 12 Fr using a Nottingham dilator when required. Saline irrigation was maintained at gravity flow to minimise retropulsion.

Stone fragmentation was performed using a pneumatic lithoclast (Swiss LithoClast® Master, EMS, Nyon, Switzerland) or a holmium:YAG laser (20–35W generator) depending on availability at the time of surgery. Laser energy settings were 0.8–1.5 J at 8–15 Hz via a 200–365 µm fibre, adjusted according to stone hardness. Stone baskets were used for fragment retrieval where available. Stone anti-retropulsion devices (stone cones) were not routinely available at the study centre.

A 6 Fr double-J (DJ) ureteral stent was inserted postoperatively when indicated: mucosal oedema, stone impaction, significant false passage, anticipated residual fragments, or failed primary access. Stents were removed at 2–4 weeks under local anaesthesia in the outpatient setting. All patients admitted through the emergency department were discharged within 24 hours; elective cases were managed as day-surgery procedures.

Outcome Measures

The primary outcome was stone-free rate (SFR) at four weeks postoperatively, defined as the absence of residual stone or fragments greater than 4 mm on KUB X-ray and/or ultrasound. Secondary outcomes were: mean operative time (from ureteroscope insertion to removal); perioperative and postoperative complications classified by the modified Clavien-Dindo grading system; stone migration rate; and need for a second-look (repeat) procedure.

Statistical Analysis

Data were analysed using SPSS version 23.0 (IBM Corporation, Armonk, NY, USA). Continuous variables are expressed as mean ± standard deviation (SD) and range. Categorical variables are expressed as frequencies and percentages. Subgroup comparisons used the independent-samples t-test for continuous variables and the Chi-square or Fisher's exact test for categorical variables, as appropriate. A two-sided p-value of < 0.05 was considered statistically significant.

Results

Demographic and Preoperative Characteristics

A total of 185 patients met the inclusion criteria and were enrolled. Baseline demographic and preoperative characteristics are summarised in Table 1. The mean age was 45.2 ± 14.6 years (range 20–76 years), with the 40–49 year group being the most represented (n = 47, 25.4%). Males constituted 56.2% (n = 104) and females 43.8% (n = 81), yielding a male-to-female ratio of 1.28:1 (Fig. 1A–B).

The majority of stones were located in the upper ureter (n = 182, 98.4%), with two in the mid-ureter (1.1%) and one in the lower ureter (0.5%). Mean stone size was 1.66 ± 0.20 cm (range 1.2–2.0 cm).

Table 1
Demographic and preoperative characteristics of the study population (n = 185)

Characteristic	n or Mean ± SD	Percentage (%) or Range
Total patients	185	100
Male	104	56.2
Female	81	43.8
Age — mean ± SD (years)	45.2 ± 14.6	—
Age range (years)	20–76	—
Upper ureter stone	182	98.4
Mid-ureter stone	2	1.1
Lower ureter stone	1	0.5
Mean stone size ± SD (cm)	1.66 ± 0.20	—
Stone size range (cm)	1.2–2.0	—

Stone Size Distribution

The distribution of stone sizes across the cohort is displayed in Table 2 and Fig. 2. The most frequent stone sizes were 1.6 cm (n = 37, 20.0%), 1.7 cm (n = 34, 18.4%), and 1.5 cm (n = 29, 15.7%). Stones ≥ 1.8 cm accounted for 32.9% of the cohort (n = 61).

Table 2
Distribution of stone sizes (n = 185)

Stone Size (cm)	Number of Patients (n)	Percentage (%)
1.2	4	2.2
1.3	13	7.0
1.4	7	3.8
1.5	29	15.7
1.6	37	20.0
1.7	34	18.4
1.8	26	14.1
1.9	17	9.2
2.0	18	9.7
Total	185	100.0

Operative Outcomes

All 185 procedures were successfully initiated. The mean operative time was 23.3 ± 10.2 minutes (range 10–55 minutes), substantially shorter than the meta-analytic pooled estimate of 51.03 minutes reported by Li et al. [16]. A DJ stent was inserted postoperatively in 54 patients (29.2%). The stone-free rate at four weeks was 98.4% (182/185). The operative time distribution and SFR are illustrated in Fig. 4A–B. Three patients (1.6%) required a second-look procedure: two for residual fragments confirmed on follow-up computed tomography (CT), and one for incomplete fragmentation attributed to high stone density.

Complications

The complication profile is summarised in Table 3 and Fig. 3. Any perioperative or postoperative complication was recorded in 46 of 185 patients (24.9%). All complications were classified as Clavien-Dindo grade I or II; no Clavien grade ≥ 3 complications occurred, with the exception of one ureteral avulsion (0.5%), which was managed successfully by immediate open ureterolithotomy (Clavien grade IIIb). The most common complications were mucosal injury (n = 35, 18.9%) and false passage (n = 35, 18.9%), which co-occurred in the majority of affected cases. Intraoperative bleeding not requiring transfusion was observed in 22 patients (11.9%). Stone migration occurred in five patients (2.7%). Ureteral perforation was not observed in any patient. Two patients (1.1%) had impossible stone access due to ureteral stricture and were managed with DJ stent insertion for passive dilation.

Table 3
Perioperative and postoperative complications classified by Clavien-Dindo grade (n = 185)

Complication	n	%	Clavien-Dindo Grade
Mucosal injury	35	18.9	I
False passage	35	18.9	I
Intraoperative bleeding	22	11.9	I–II
Stone migration	5	2.7	II–IIIb
Ureteral avulsion	1	0.5	IIIb
Failed access (ureteral stricture)	2	1.1	II
Ureteral perforation	0	0.0	—
Second-look procedure required	3	1.6	IIIb
Any complication	46	24.9	—

Discussion

This prospective observational study demonstrates that semirigid ureteroscopy achieves a stone-free rate of 98.4% for upper ureteric stones (size 1.2–2.0 cm) in a resource-limited hospital setting where flexible ureteroscopy was not routinely available. This outcome substantially exceeds the pooled SFR of 78% (95% CI: 75–82%) reported in the meta-analysis by Li et al. (2024) across 24 studies and 2,058 patients using semirigid URS with Ho:YAG laser [16], and compares favourably with all individual study comparators examined (Fig. 5).

The 97.5% SFR reported by Taha et al. (2020) using semirigid URS with holmium laser at Al-Azhar University Hospital, Egypt — the closest comparable figure in the literature — was achieved in a university setting with access to fluoroscopy, stone cones, and post-procedural flexible URS for migration cases [15]. Our rate of 98.4% was obtained in a secondary-level institution without stone cones and with only intermittent laser access, suggesting that careful patient selection, efficient operative technique, and moderate stone burden collectively compensate for equipment limitations.

Bangash et al. (2020) reported an SFR of 83.5% using pneumatic lithotripsy without anti-migration devices in 103 patients with proximal ureteric stones ≥ 10 mm at a resource-comparable institution [10]. The difference between their result and ours may reflect our cohort's moderate stone sizes, the structured use of gravity-flow irrigation to reduce retropulsion, and the availability of holmium laser in a substantial proportion of our cases. Importantly, stone size was the only significant predictor of failure in Bangash et al.'s analysis ($p = 0.01$), consistent with the observation that our mean stone size of 1.66 cm — lower than their mean of 13.33 mm — favours higher success rates [10].

The mean operative time of 23.3 minutes in our series is notably shorter than the 40–51 minutes reported in comparable series [15, 16, 17]. Shorter operative time is clinically significant: Bangash et al. demonstrated that operative time was independently associated with complication risk (mean 49.36 minutes in patients with complications versus 38.63 minutes without, $p < 0.01$) [10]. Our efficient procedural times likely reflect the accumulated experience of the operative team and may partly explain our low complication severity.

The overall complication rate of 24.9% is consistent with the 24.9–28.4% reported in comparable series [10, 17] and the meta-analytic estimate of 16% [16] — the latter being somewhat lower, possibly reflecting the inclusion of primarily tertiary-centre series in the meta-analysis. Critically, all complications in our series were minor (Clavien grade I–II) with the exception of a single ureteral avulsion (0.5%). This catastrophic but rare complication occurred in the context of dense stone impaction and was managed successfully by open surgery — consistent with the < 0.1% avulsion rate cited in the broader literature [17].

The mucosal injury rate of 18.9%, while appearing high, reflects the technical demands of proximal ureteral access with a semirigid instrument in the presence of moderate-to-large stones (mean 1.66 cm) and, in some cases, mucosal oedema from prolonged obstruction. These were Clavien grade I events managed with DJ stenting, consistent with the literature [14]. Similarly, the false passage rate of 18.9% is within the range reported for proximal ureteral procedures and must be interpreted within the context of the instrument rigidity and ureteral angulation inherent to this anatomical region.

Stone migration occurred in 2.7% of our patients — lower than the 12.3% reported by Batra et al. [17] and 16.7% by Yencilek et al., and comparable to the 2.5% of Taha et al. [15]. This may reflect the judicious use of low-pressure gravity irrigation, the impacted nature of many stones in our cohort (impacted stones migrate less readily), and the use of stone baskets for fragment containment. Notably, anti-migration devices were absent from our setup, yet migration rates remained low, suggesting that technique modification may partially compensate for their absence.

Okçelik et al. (2021) identified stone-to-UPJ distance as a novel predictor of SR-URS success ($p = 0.006$), with stones closer to the UPJ at higher risk of retropulsion [14]. While we did not formally measure this parameter, it informs future protocols at our institution. Similarly, Turkan et al. (2016) demonstrated that male sex and hydronephrosis were independent predictors of the need for flexible URS conversion [9], findings that support our exclusion of complex hydronephrotic patients and prioritisation of relatively straightforward cases.

The resource-limited context of this study merits explicit reflection. Our institution operated without flexible ureteroscopes as a backup — a scenario increasingly common across sub-Saharan Africa, South Asia, and Southeast Asia. Kassogue et al. (2025) from Kati University Hospital, Mali — reporting the first holmium laser URS series from a sub-Saharan centre — achieved an SFR of 84.1% with 90.2% of patients discharged in one day [20], confirming the feasibility of day-surgery endourology in resource-constrained environments. Our 98.4% SFR with a similar patient turnover model extends this evidence base.

Several limitations of this study should be acknowledged. First, the absence of a comparator arm (ESWL, PCNL, or fURS) limits comparative effectiveness conclusions. Second, stone composition analysis was not performed in all patients, precluding lithological subgroup analysis. Third, the single-centre design and the experience level of the operative team may limit generalisability to less-established endourology programmes. Fourth, follow-up was limited to four weeks; long-term stone recurrence and renal functional outcomes were not assessed. Fifth, the heterogeneity in lithotripsy energy (pneumatic versus laser, depending on availability) represents an acknowledged but uncontrolled variable. Future multicentre prospective studies across resource-limited settings, incorporating standardised outcome measures and cost-effectiveness analyses, are needed to confirm these findings.

Conclusions

Semirigid ureteroscopy achieves a stone-free rate of 98.4% with an acceptable complication profile (24.9%, all Clavien grade I–II) for upper ureteric stones in a resource-limited hospital setting, establishing it as a highly effective first-line treatment modality in this context. The short operative time (mean 23.3 minutes) and predominantly day-surgery hospitalization confirm the procedural efficiency and practicality of SR-URS in secondary-level facilities. In settings where flexible ureteroscopy is inaccessible, SR-URS performed by an experienced urologist achieves outcomes comparable to or exceeding those reported in well-resourced institutional series. Investment in SR-URS training programmes, instrument maintenance, and entry-level lithotripsy technology represents the highest-yield, cost-effective strategy for improving upper ureteric stone outcomes in resource-limited healthcare systems globally.

Abbreviations

CT
Computed Tomography
CTUT
Computed Tomography Urinary Tract
DJ
Double-J (ureteral stent)
EAU
European Association of Urology
ESWL
Extracorporeal Shock Wave Lithotripsy
Fr
French (unit of catheter/instrument diameter)
fURS
Flexible Ureteroscopy
Ho
YAG:Holmium:Yttrium-Aluminum-Garnet (laser)

IRB
Institutional Review Board
KUB
Kidney-Ureter-Bladder (plain X-ray)
LU
Laparoscopic Ureterolithotomy
MET
Medical Expulsive Therapy
PCNL
Percutaneous Nephrolithotomy
SD
Standard Deviation
SFR
Stone-Free Rate
SR-URS
Semirigid Ureteroscopy
UPJ
Ureteropelvic Junction
URS
Ureteroscopy
UTI
Urinary Tract Infection

Declarations

Ethics Approval and Consent to Participate

This study was approved by the Institutional Review Board of the Resource-Limited Hospital (IRB reference: [to be inserted]). All procedures were conducted in accordance with the ethical standards of the institutional research committee and the 1964 Declaration of Helsinki and its later amendments. Written informed consent was obtained from all individual participants included in the study.

Consent for Publication

Not applicable. This manuscript does not contain any individual person's data in any form (including individual details, images, or videos).

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This study received no external funding. All procedures were conducted as part of standard clinical care at the study institution.

Author Contribution

A.I. conceived and designed the study, performed the surgical procedures, supervised data collection, and drafted the manuscript. M.A. and M.H. contributed to study design, performed surgical procedures, and critically revised the manuscript. T.H. and Y.E. conducted preoperative patient assessment, collected clinical data, and contributed to data interpretation. A.H. and H.H. performed the statistical analysis and prepared Figures 1–5. A.S. and W.A. contributed to data acquisition, literature review, and manuscript preparation. All authors read and approved the final manuscript.

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Figures

Figure 1. Patient Demographics

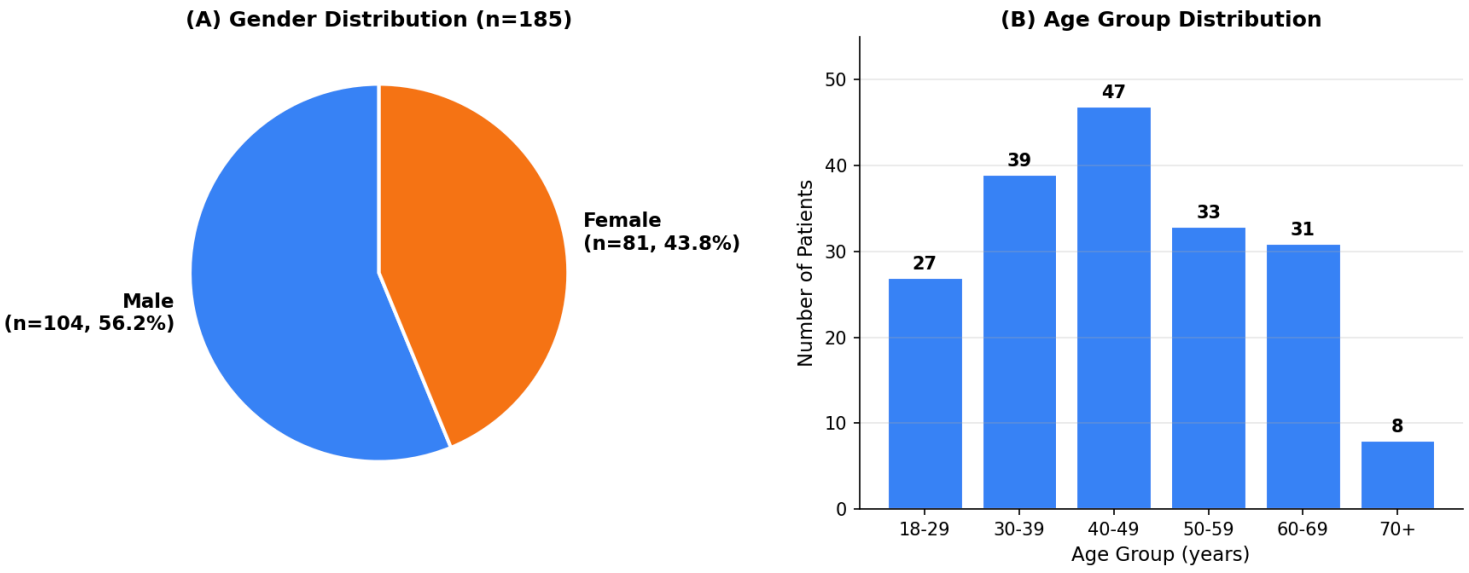


Figure 1

Patient demographics: (A) gender distribution; (B) age group distribution.

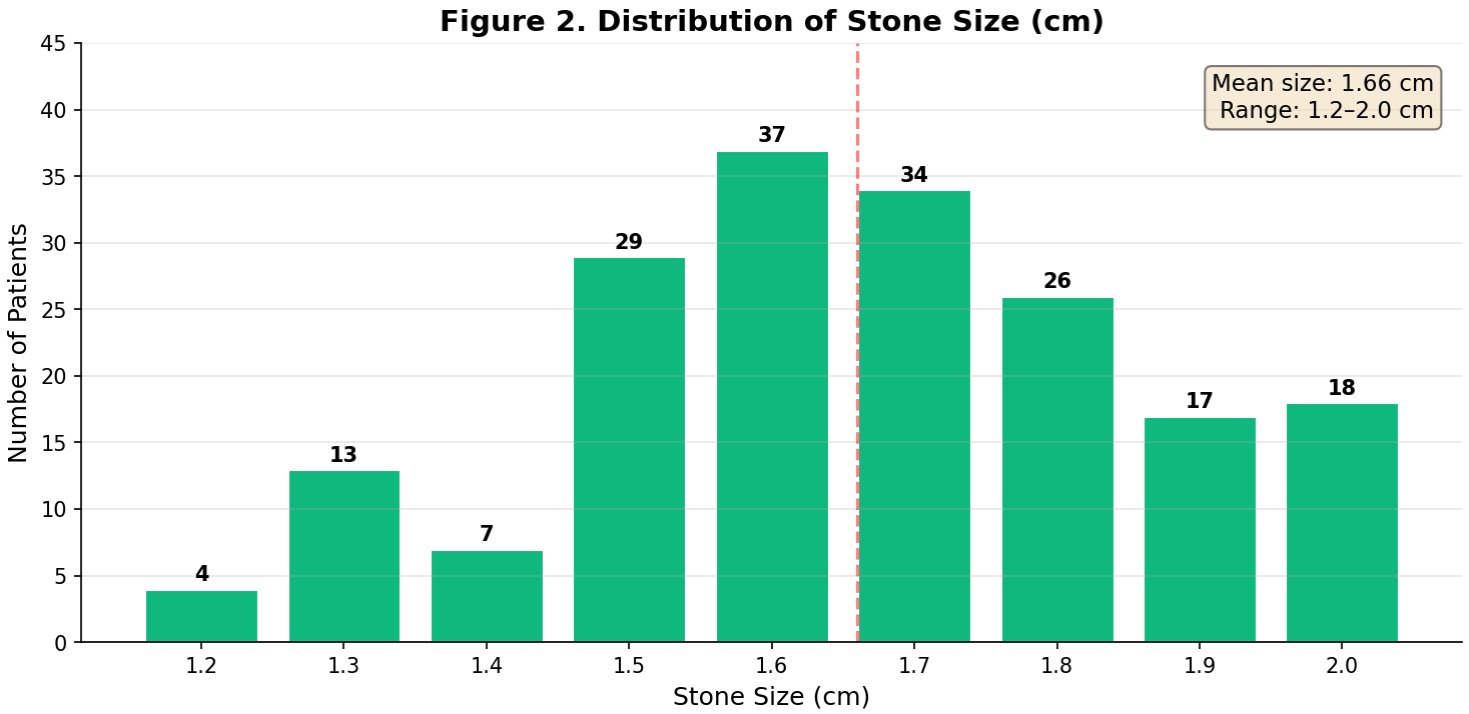


Figure 2

Distribution of stone sizes across the study cohort.

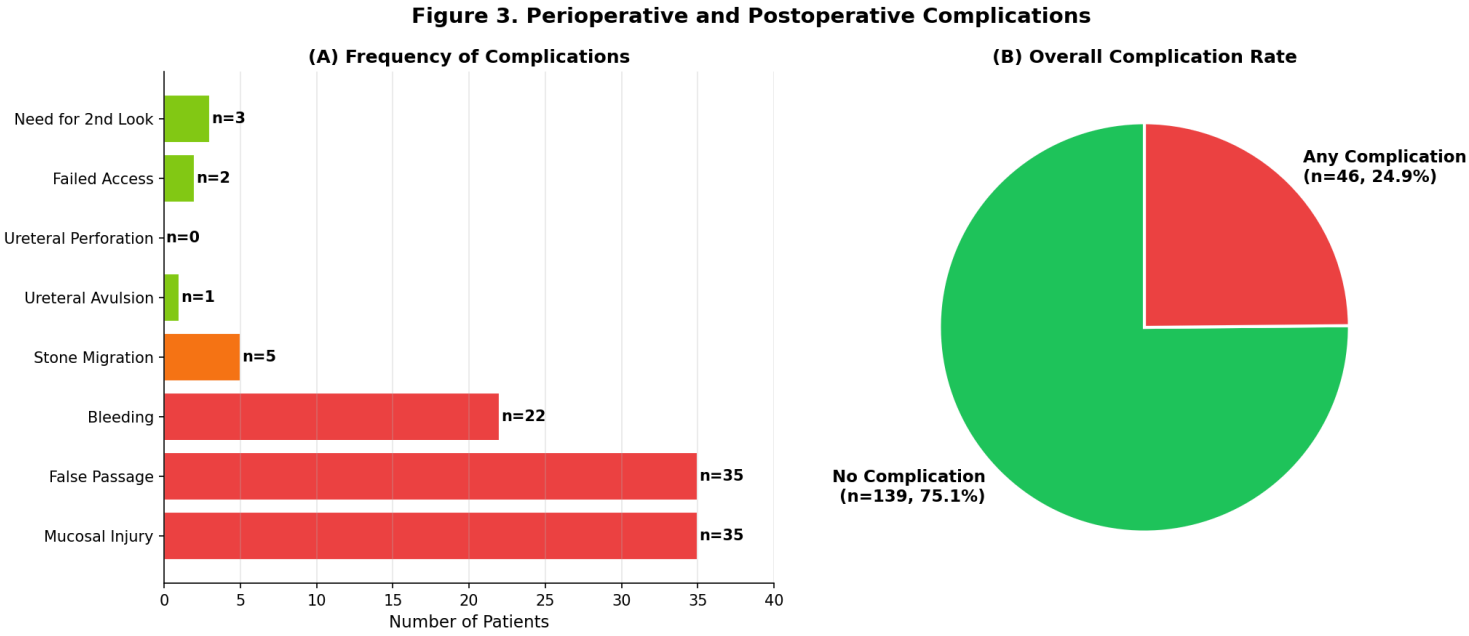


Figure 3

Complication profile: (A) frequency of individual complications; (B) overall complication rate.

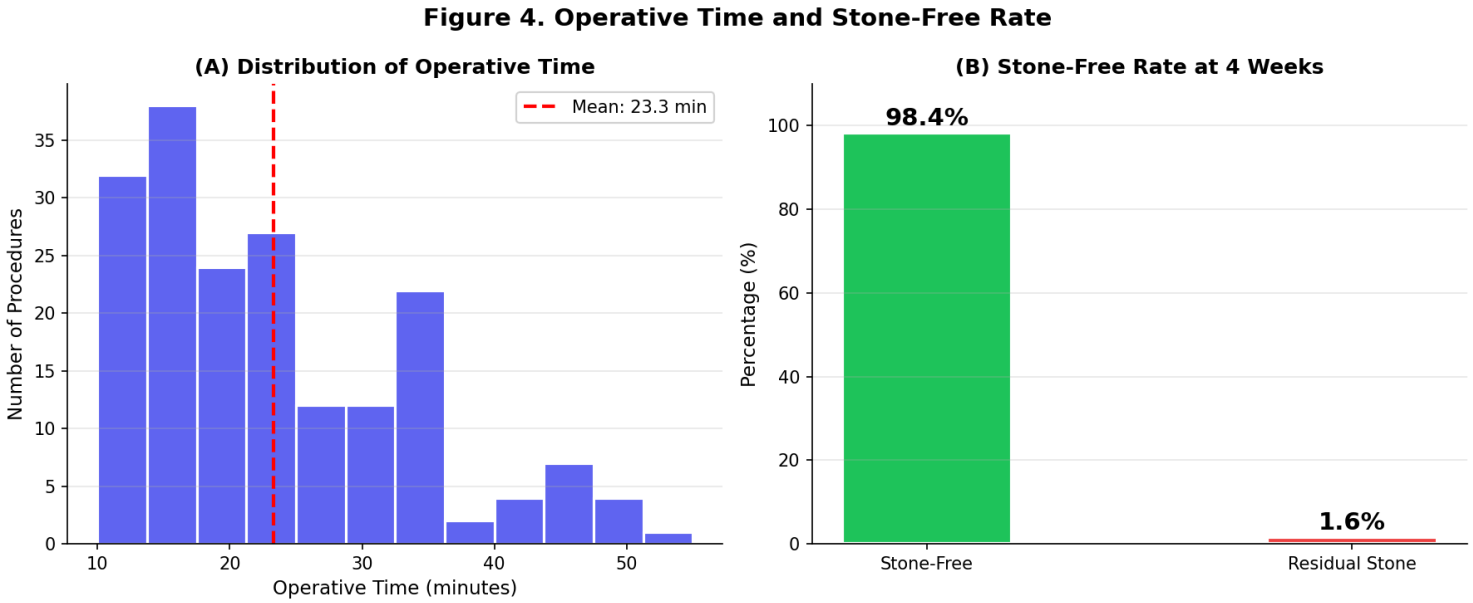


Figure 4

Operative outcomes: (A) distribution of operative times; (B) stone-free rate at four weeks.

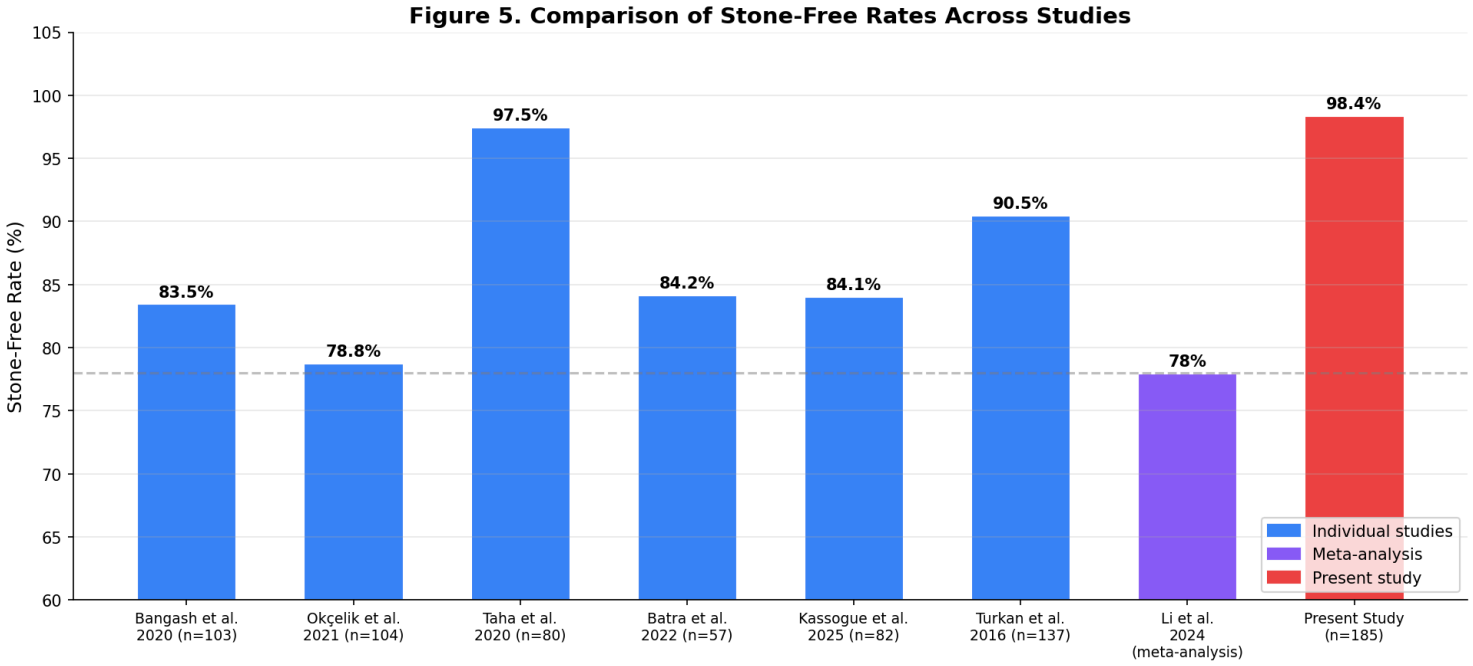


Figure 5

Comparison of stone-free rates between the present study and previously published series.