

# Comparative evaluation of the efficacy and safety of antegrade minimally percutaneous nephrolithotomy (mPCNL) and retrograde intrarenal surgery (RIRS) in the treatment of upper ureteral impacted stones: A retrospective cohort study

Kequan Cheng<sup>1,2\*</sup>, Xuwei Hong<sup>1\*</sup>, Gang Wang<sup>1,2</sup>, Zepai Chi<sup>1</sup>, Kemal Sarica<sup>3,4</sup>, Guoyuan Liu<sup>1</sup>, Yonghai Zhang<sup>1</sup>

<sup>1</sup> Department of Urology, Shantou Central Hospital, Shantou, Guangdong, P.R. China;

<sup>2</sup> Department of Urology, Sun Yat-Sen Memorial Hospital, Sun Yat-Sen University, Guangzhou, Guangdong, P.R. China;

<sup>3</sup> Department of Urology, Health Sciences University, Prof. Dr. Ilhan Varank Education and Training Hospital, Istanbul, Turkey;

<sup>4</sup> Department of Urology, Biruni University, Medical School, Istanbul, Turkey.

\* These authors contributed equally to this work.

## Summary

**Objective:** To compare the safety and efficacy of retrograde intrarenal surgery (RIRS)

versus minimally invasive percutaneous nephrolithotomy (mPCNL) in the minimal invasive management of impacted upper ureteral stones along with the evaluation of predictive radiological parameters.

**Patients and methods:** A retrospective analysis was done in 124 patients, undergoing RIRS (n:61) and mPCNL (n:63) for the management of impacted upper ureteral stones. Both operative (success and complication rates, operative time, postoperative hospital stay) and radiological (ureteral wall thickness (UWT), stone volume (SV), and stone density (Hounsfield unit, HU) factors were all evaluated and recorded. Comparative evaluation of stone free status in both groups was done following 72 hours and 4-weeks after the procedures to calculate the primary stone-free as well as final stone clearance rates. Additionally, the outcomes of RIRS group were categorized based on the intraoperative findings (presence or absence of stone encasement by a polyp) and preoperative radiological parameters. All data were well analyzed for statistical significance. A significance level of  $P < 0.05$  was considered statistically significant.

**Results:** Baseline patient and stone related characteristics were similar in two groups. The success rates after a single session for RIRS and mPCNL were 73.77% and 93.65%, respectively ( $p = 0.003$ ), indicating a significantly higher success rate for mPCNL. However the final stone clearance rates were 96.72% and 100.00%, respectively ( $p = 0.147$ ), with no significant difference observed among the groups. The RIRS group demonstrated higher rate of need for auxiliary treatments ( $p < 0.001$ ), shorter hospital stay ( $p < 0.001$ ) and lower incidence of bleeding ( $p < 0.001$ ). Radiological evaluation showed no significant differences in stone volume, HU and UWT values between patients with and without residual stones after RIRS ( $P_{\text{stone volume}} = 0.151$ ,  $PHU = 0.451$ ,  $PUWT = 0.083$ ). Similarly, no significant differences were observed with respect to these values also in mPCNL patients, ( $P_{\text{stone volume}} = 0.532$ ,  $PHU = 0.455$ ,  $PUWT = 0.658$ ). However, a significant difference has been noted regarding the mean value of UWT between the stones surround-

ed by a polypoid alterations and the ones without such changes with values  $5.23 \pm 0.65$  mm, to  $4.10 \pm 0.82$  mm respectively ( $p = 0.001$ ).

**Conclusions:** Our results demonstrated that antegrade mPCNL achieves faster stone clearance and a lower re-treatment rate without serious complications in impacted upper ureteric stones. However, RIRS could be a valuable and safe alternative with comparable success rates particularly in cases with contraindications to or unwillingness for mPCNL. Preoperative assessment of ureteral wall thickness (UWT) value may be a good predictor for the possible tissue changes in ureteral wall at stone site to guide the decision making of the most appropriate surgical approach.

**KEY WORDS:** Percutaneous nephrolithotomy; Retrograde intrarenal surgery; Ureteral impacted stones; Retrospective study.

Submitted 4 November 2024; Accepted 28 November 2024

## INTRODUCTION

Around 5-10% of the general population suffer from urolithiasis (1, 2). Majority of the cases presenting with obstructive ureteral calculi require a prompt management to preserve functional and structural status of the involved kidneys which may cause some irreversible changes if not removed on time (3-5).

Regarding the management of such cases, ureteroscopy (URS) with laser lithotripsy and percutaneous nephrolithotomy (PNL) are the available options applied in the management of obstructing large ureteral calculi (6). Antegrade percutaneous approach is being applied in a certain per cent of the cases with the complete removal of all stone(s) in a single session. However, this procedure is more invasive than other endourological approaches for the risk of certain severe complications (bleeding, perforation, infection, etc) even in experienced hands. In the

light of the risk for such complications endourologists began to use smaller instruments in an attempt to limit both the extent of renal injury and also the risk of above mentioned complications (7, 8). Miniaturized PCNL techniques are being utilized with higher success and limited complications in the majority of cases presenting with large upper tract stones (9).

On the other hand, based on its less invasive nature and successful outcomes compared with PCNL, flexible ureteroscopic management gained more popularity in the last 2-3 decades as a result of the evident advances in instrument technology. Based on these improvements and acceptable outcomes obtained the joint clinical guidelines of the AUA and the EAU Nephrolithiasis Panel on the Management of Ureteral Calculi recommend URS in patients with proximal ureteral stones smaller than 2 cm (10). Additionally, the most recent EAU and AUA guidelines also recommend URS as the primary modality for stones > 10 mm (1, 11).

This modality may serve as a viable alternative treatment particularly in patients with contraindications to PCNL or whom do not prefer to undergo such a more invasive intervention (12). However, accumulated data have shown that despite its evident minimally invasive nature, ureteroscopic manipulation may be associated with certain complications such as ureteral injuries and subsequent ureteral stricture formation (13).

Additionally, relatively lower *stone-free rates* (SFR) and the need for additional auxiliary procedures (14, 15) remain significant challenges for this technique when particularly dealing with large stones. Some stone related parameters have been identified and used to predict the outcomes of *Retrograde Intrarenal Surgery* (RIRS) in the management of large, impacted ureteral stones causing certain degree of obstruction. Related with this issue in addition to the size, volume, density and chemical composition of the stones treated, the thickness of the ureteric wall surrounding the impacted stone(s) have been used with great success to predict both the success as well as complications of RIRS in such cases (16).

Taking the advantages and disadvantages of both modalities into account, in this study we aimed to compare the clinical results of RIRS and mPCNL in the management of single impacted upper ureteral stones less than 2 cm in diameter. Also, the potential value of some radiological parameters in the prediction of success after RIRS were evaluated to select the most appropriate surgical method in these stones.

## PATIENTS AND METHODS

A retrospective analysis was conducted in 124 patients with upper ureteral impacted stones (< 2 cm) admitted to our urology department from April 2020 to December 2023. Based on the type of intervention applied, patients were divided into two groups: Group 1 (n:61) including patients undergoing RIRS with laser lithotripsy and Group 2 (n:63) including patients undergoing mPCNL. An informed consent was obtained in all cases undergoing both interventions.

Inclusion criteria were unilateral single upper ureteral stones (< 2 cm) confirmed by *non-contrast computed tomog-*

*raphy* (NCCT). Exclusion criteria included patients with active urinary tract infections, previous renal-ureteral interventions, renal functional deterioration and anatomical abnormalities contraindicating surgery. In addition to a detailed history and through urogenital examination, blood/urine analyses were done in all patients. Patients with urinary tract infections were previously treated according to the outcomes of culture-sensitivity tests. Radiological evaluation consisted of *kidney-ureter-bladder* (KUB) film, sonography and NCCT in all cases. An intravenous urography was performed in cases requiring further anatomical information for making a proper decision. Demographic data, including age and sex, medical history, and stone side, size, and location, were recorded (see Table 1). Surgical duration, length of hospital stays, perioperative complications, and treatment outcomes were evaluated and compared between groups. Additionally, *Hounsfield units* (HU) value of the stone, *ureteral wall thickness* (UWT) and maximum transverse and longitudinal diameter of the stones were measured on NCCT and noted. KUB X-ray was obtained within 72 hours of post-operative period to confirm the correct placement of double-J stents and to assess residual stone status. Surgical success was defined as the absence of fragment or presence of residual stone fragments smaller than 3 mm following the procedures. Residual stones were treated with *extracorporeal shock wave lithotripsy* (ESWL) or *external physical vibration lithotripsy* (EPVL). DJ stents were removed after two weeks, and all patients were followed up one month postoperatively in the outpatient or inpatient department to outline the status of final stone clearance.

## Definitions of outcome measures

*Surgical efficacy*: Assessed the results of 72-hour and one-month follow-up, including technical success rate and stone-free rate. *Operative Time*: For RIRS, timing commenced with the placement of the flexible ureteroscope sheath, or the guidewire passing the stone and concluded with the successful placement of the ureteral stent. For mPCNL, timing began with the percutaneous puncture and ended with the successful placement of the nephrostomy tube.

*Postoperative Hospital duration*: The duration from the day of surgery until discharge. *Postoperative Auxiliary Treatment Rate*: Number of cases requiring ESWL and EPVL based on follow-up KUB results. *Postoperative Complications*: Postoperative Complications were classified according to the Clavien-Dindo system, including the number of cases requiring hemostatic agents, those with postoperative fever, and those needing pain medication within 24 hours of surgery.

## Surgical procedure

*RIRS*: The procedure was performed in the lithotomy position under general or combined spinal-epidural anesthesia. A 0.035-inch Wolf guidewire was passed into the ureter through the rigid Fr 8.0 to 9.8 Wolf ureteroscope and stone localization was confirmed by using low-pressure irrigation. Fragmentation of the stone was performed with the help of either holmium laser or pneumatic ballistic lithotrip-

sy. The holmium laser settings were arranged with a frequency value of 10 Hz, energy value of 800 J, and pressure value of 14 kPa. While larger fragments were extracted with the help of stone forceps, dust and smaller fragments were flushed out. The procedure was finished with the routine placement of a 5-Fr double-J stent in the affected ureter. A urethral catheter was left in place for 1 to 2 days.

**mPCNL:** Following the placement of a 5Fr open end ureteral catheter during cystoscopic evaluation in lithotomy position under general anesthesia, later the patient was turned into prone position and renal puncture was performed with a 18-gauge puncture needle under ultrasound guidance. Upon achieving puncture to the dependant calyx, a 0.035-inch guidewire was inserted into the collecting system whit following a 1 cm skin incision, fascial dilation and placement of a 18-Fr working sheath. A 17-Fr nephroscope was introduced through the working sheath for stone fragmentation. Stones were disintegrated using either a holmium laser or pneumatic ballistic lithotripsy and all fragments were removed. A nephrostomy tube was inserted if necessary. Following the removal of all stone fragments a 5-French double-J stent was placed antegradely into the affected ureter. A urethral catheter was placed and retained for 1 to 2 days as needed.

### Radiologic evaluation of the stones and relevant parameters

NCCT images were analyzed by two radiologists to measure the *ureteral wall thickness* (UWT) at the stone location by taking the maximum value from cross-sectional images. *Hounsfield unit* (HU) value of the stone was measured at the stone's central region, avoiding the boundary with surrounding soft tissue. Maximum longitudinal and transverse diameter of the stones were measured in coronal and transverse planes. Stone surface area (SA) and volume (V) were estimated using the following formulas based on EAU guidelines (10):

$$SA \text{ (mm}^2\text{)} = l \times w \times \pi \times 0.25 \text{ (Formula 3-1)}$$

$$V \text{ (mm}^3\text{)} = 0.6 \times SA \times l \text{ (Formula 3-2)}$$

(l = maximum longitudinal diameter, w = maximum transverse diameter)

Degree of hydronephrosis was classified based on preoperative ultrasound or CT measurements of renal pelvis separation as mild, moderate, or severe.

### Statistical analysis

Data were analyzed using SPSS 26.0 software. For quantitative data, independent samples t-tests were used for normally distributed data, and Wilcoxon rank-sum tests for non-normally distributed data. Categorical data were analyzed using chi-square tests. Statistical significance was set at  $p < 0.05$ .

## RESULTS

### Comparative evaluation of the efficacy rates

A total of 124 adult patients were included in the study. There were no statistically significant differences between the two groups in terms of demographic characteristics such as sex, age, medical history, stone side, location, and size (Table 1).

**Table 1.** Preoperative baseline characteristics of patients in the MPCNL and RIRS groups.

	RIRS (n = 61)	MPCNL (n = 63)	$\chi^2/t$	P
Sex/cases (%)				
Female	25 (40.98)	22 (34.92)	0.48	0.487
Male	36 (59.02)	41 (65.08)		
Age (mean SD)	53.82 (14.61)	54.68 (13.05)	-0.35	0.729
Side of the stone/cases (%)				
Left	38 (62.29)	32 (50.79)	1.67	0.197
Right	23 (37.71)	31 (49.21)		
Medical history/cases (%)				
Diabetes	6 (9.84)	12 (19.05)	2.12	0.145
Coronary heart disease	4 (6.56)	1 (1.59)	1.98	0.160
Hypertension	19 (31.15)	19 (30.16)	0.01	0.905
COPD <sup>1</sup>	0 (0.00)	1 (1.59)	0.98	0.323
BPH <sup>2</sup>	9 (14.75)	7 (11.11)	0.37	0.545
Operational history/cases (%)				
ESWL	7 (11.48)	3 (4.76)	1.88	0.170
RIRS	4 (6.56)	1 (1.59)	1.98	0.160
PCNL	0 (0.00)	1 (1.59)	0.98	0.323
Imaging characteristics (mean SD)				
UWT/mm	4.23 (0.88)	4.02 (0.90)	1.30	0.196
HU	1150.38 (258.18)	1158.81 (263.38)	-0.18	0.857
Transverse diameter/mm	11.25 (2.37)	10.81 (1.82)	1.16	0.247
Longitudinal diameter/mm	14.45 (3.80)	14.48 (3.21)	-0.04	0.966
Hydronephrosis/cases (%)				
Mild	26 (42.62)	20 (31.75)	3.95	0.139
Moderate	20 (32.79)	17 (26.98)		
Severe	15 (24.59)	26 (41.27)		

Mean SD: Mean Standard Deviation;  
<sup>1</sup> Chronic obstructive pulmonary disease; <sup>2</sup> Benign prostatic hyperplasia.

Comparative evaluation of the peri- and postoperative parameters are given in Table 2. Although there was a significant difference in the operative success rates between the two groups ( $p < 0.05$ ), no significant difference could be noted in the stone-free rates of two groups. Of the 61 cases in RIRS group, 14 required additional procedures (ESWL or EPVL) to achieve a complete stone-free status. The auxiliary treatment rate was higher in the RIRS group compared to the mPCNL group ( $p < 0.05$ ).

**Table 2.** Postoperative efficacy and safety outcomes of RIRS and MPCNL.

	RIRS (n = 61)	MPCNL (n = 63)	$\chi^2/t$	P
Operation success rate (%)	45 (73.77)	59 (93.65)	9.05	0.003
Stone clearance rate (%)	59 (96.72)	63 (100.00)	2.10	0.147
Postoperative adjunctive therapy (%)	14 (22.95)	1 (1.59)	13.30	< 0.001
Operation time/min (mean $\pm$ SD)	69.41 (36.11)	72.33 (29.93)	-0.49	0.624
Hospital stay/days (mean $\pm$ SD)	2.98 (1.58)	4.76 (2.32)	-5.01	< 0.001
Infection case (%)	8 (13.11)	3 (4.76)	2.67	0.102
Bleeding/case (%)	1 (1.63)	19 (30.16)	18.63	< 0.001
Analgesic use/case (%)	49 (80.33)	50 (79.37)	0.02	0.894

Mean (SD) indicates the mean (standard deviation).

Complications were classified by using the Clavien-Dindo grading system and no Grade IV complication was noted in any case of this study. There was no statistically significant difference regarding the postoperative pain between the two groups. However, use of the hemostatic drugs was more frequent (30.16%) in the mPCNL group where one patient received blood transfusion and one underwent interventional treatment for bleeding demonstrating a statistically significant difference ( $p < 0.05$ ) between two groups with respect to this complication. There was no significant difference between the two techniques regarding the postoperative need for pain medication within 24 hours and infective complication rates. Last but not least, the average hospital stay was  $2.98 \pm 1.58$  days in the RIRS group and  $4.76 \pm 2.32$  days for the mPCNL group respectively, indicating a relatively longer recovery time observed in the mPCNL group ( $p < 0.05$ ).

### Evaluation of the radiological parameters

Comparative analysis of the possible relationship between treatment outcomes and mean stone related parameters (volume and HU) as well as mean UWT values revealed no statistically significant differences between two group of cases (PRIRS-stone volume =  $0.151 > 0.05$ , PRIRS-HU =  $0.451 > 0.05$ , PRIRS-UWT =  $0.083 > 0.05$ ; PmPCNL-stone volume =  $0.532 > 0.05$ , PmPCNL-HU =  $0.455 > 0.05$ , PmPCNL-UWT =  $0.658 > 0.05$ ) (Tables 3, 4).

A retrospective analysis of our data revealed that the RIRS group had a lower success rates in a single session compared to the mPCNL group, often requiring additional ESWL or EPVL. Further analysis of success rates in RIRS group demonstrated that stone free rates were significantly affected by the changes in the ureteral wall characteristics (Table 5).

While 36 out of 61 cases in this group had inflammatory

**Table 5.**

Comparison of imaging data for cases with and without polyp encapsulation in RIRS group.

	Stone without polyp encapsulation (n = 54)	Stone with polyp encapsulation (n = 7)	t-value	P-value
Stone volume/mm <sup>3</sup> (mean SD)	102.51 (53.45)	86.61 (20.52)	0.78	0.441
HU (mean SD)	1154.83 (266.86)	1116.00 (189.54)	0.37	0.711
Ureteral wall thickness/mm	4.10 (0.82)	5.23 (0.65)	-3.48	0.001

*HU stands for Hounsfield Units, a measure used in CT scans; UWT stands for ureteral wall thickness; Mean SD indicates the mean standard deviation.*

polyps noted during the procedure, 6 had strictures and 7 had stones encased by polyps, which could complicate guidewire placement, increase the risk of intraoperative bleeding, and necessitate multiple ureteroscopy manipulations causing additional trauma. Based on this fact, further detailed analysis on the preoperative imaging findings and the presence of intraoperative polyps encasing stones was conducted, as demonstrated in Table 5.

The mean preoperative UWT value detected in NCCT imaging was significantly higher in cases with stones encased by polyps ( $5.23 \pm 0.65$  mm), ( $P_{UWT} = 0.001$ ). In contrast, there was no statistically significant difference in the mean stone volume and mean HU values ( $P_{stone\ volume} = 0.441$ ,  $P_{HU} = 0.711$ ).

## DISCUSSION

Currently both antegrade PCNL and RIRS are acceptable options for the minimal invasive management of impacted proximal ureteral stones with varying rates of success and complications in different series (17). Each modality has its own advantage and disadvantages and accumulated experience so far demonstrated that despite its higher stone free rates in a single session, even mini-PCNL could be associated with severe complications (18-20). On the other hand, with the use new generation flexible scopes with Ho-YAG laser technology, RIRS was found to reveal comparable stone free rates with limited rate of complications particularly in risk group of cases for PCNL (21).

Taking all these facts into account, in this present study we aimed to evaluate the efficacy and safety of both modalities in the management of impacted upper ureteral stones causing obstruction. Additionally, we evaluated the some certain radiological parameters in an attempt to predict the outcomes of RIRS in such stones and their possible role in the preoperative decision making phase to outline the best modality.

Evaluation of our obtained data revealed the following findings.

### Evaluation of success rates and the need for auxiliary treatment

Our results demonstrated a significant difference between success rates in terms of stone free status during short term evaluation between the two modalities where RIRS approach seemed to be less effective. Additionally,

**Table 3.**

Comparison of imaging data of residual stones after RIRS surgery.

	No residual stones (n = 59)	Residual stones (n = 4)	t	P
Stone volume/mm <sup>3</sup> (mean $\pm$ SD)	92.30 (30.19)	124.27 (83.00)	-2.23	0.151
HU (mean $\pm$ SD)	1135.38 (279.19)	1192.56 (188.15)	-0.76	0.451
UWT/mm (mean SD)	4.12 (0.84)	4.56 (0.94)	-1.76	0.083

*HU stands for Hounsfield Units, a measure used in CT scans; UWT stands for ureteral wall thickness; Mean SD indicates the mean standard deviation.*

**Table 4.**

Comparison of imaging data of residual stones after MPCNL surgery.

	No residual stones (n = 45)	Residual stones (n = 16)	t	P
Stone volume/mm <sup>3</sup> (mean $\pm$ SD)	93.33 (29.36)	118.96 (72.48)	-0.70	0.532
HU (mean $\pm$ SD)	1152.29 (265.82)	1255.00 (233.13)	-0.75	0.455
UWT/mm (mean SD)	4.01 (0.90)	4.22 (0.94)	-0.04	0.658

*HU stands for Hounsfield Units, a measure used in CT scans; UWT stands for ureteral wall thickness; Mean SD indicates the mean standard deviation.*

patients undergoing RIRS procedure required higher need for adjunctive treatments to achieve outcomes similar to mPCNL. As a certain advantage, mPCNL was associated with the advantage of effective fragmentation of the stones from above enabling rapid expulsion of residual fragments under high-pressure irrigation coupled with the enhanced clarity. Despite marked advances in RIRS technology, such as improved irrigation systems and larger working channels, flexible ureteroscopy technique remains less effective in stone fragmentation compared to mPCNL (22).

Related with this issue, *Faruk et al.*, found that flexible ureteroscopic management is effective for upper ureteral stones (average size of 1.24 cm), with a 96.4% single-session success rate (23). However, flexible ureteroscopic stone management was found to exhibit promising results in challenging cases such as obese and pediatric patients. In their original study *Best et al.* were able to demonstrate a single-session success rate of 91% obese patients undergoing flexible ureteroscopic lithotripsy (24). Regarding the disadvantages of RIRS compared to mini-PCNL, the complex nature of the procedure with its high equipment costs and maintenance expenses seemed to limit the widespread use of RIRS (25). Stone fragmentation and removal may also be less practical and effective during RIRS compared to mPCNL where dust forming during the procedure can cause blurred vision making the identification of small fragments hard for the surgeon. However, recent technological advancements with the introduction of new effective laser types and suction device will certainly help to improve the success rates of RIRS, as in studies indicating good results for relatively larger stones (26). In fact *Mulțescu et al.* and *Cho et al.* were able to demonstrate that stones larger than 1 cm could be well pulverized in a successful manner with flexible ureteroscopic approach (27).

#### **Evaluation of the procedure related complications**

Complications with mPCNL are primarily linked to puncture and stone fragmentation, including severe risks like bleeding, upper urinary tract perforation, renal function deterioration and injury to adjacent organs.(28, 29) In the retrospective study of 10.413 cases of F-URL treatment patients by *Xu et al.* (30) the incidence rate of complications with electronic ureteroscopy soft mirrors did not exceed 1%.

In our study, 8 patients in the RIRS group experienced postoperative infective problems, which were well treated with appropriate antibiotic treatment. Among these, 3 cases experienced fever possibly due to bacteremia from stone fragmentation. Regarding the bleeding complication while postoperative hematuria generally improved well within one day after the procedure in RIRS cases, cases in mPCNL group required more hemostatic drugs, with one case requiring interventional treatment for severe bleeding. Thus, mPCNL generally involves more postoperative complications and higher management demands.

#### **Evaluation of ureteral wall thickness value on the outcomes of RIRS**

Mean *ureteral wall thickness* (UWT) values did not show any statistically significant difference between the two

groups with or without residual stones for either specific technique. Possible reasons include: 1) UWT measurements can be influenced by factors such as the surgeon's experience, scan thickness, and CT image quality; (31) 2) Large stones are frequently associated with ureteral anomalies, which can lead to measurement errors. In this study, 5 cases in the RIRS group exhibited significant ureteral tortuosity, necessitating image aggregation from three planes to achieve more accurate UWT values.

Subgroup analysis revealed that stones encased by polyps in the RIRS group had significantly mean higher UWT values, indicating that preoperative measurement of UWT may be an effective predictor for the presence of polyps encasing stones. Elevated UWT was found to be associated with ureteral inflammatory proliferation.(16) Our results indicate that measurement of UWT value may help to predict stone related ureteral changes and guide urologists in decision making phase to choose the most appropriate option for a successful and complication free procedure. Mini PCNL approach could be a reasonable alternative in such cases by avoiding RIRS for polyp-encased stones to minimize the risk of procedure related complications.

#### **Limitations**

Our study is not free of limitations. First of all the retrospective, single-center nature of the study design could be stated as the main limitations. Additionally, relatively small size of the sample along with a shorter follow-up period (one month) are additional limitations. We believe that further randomized controlled trials would further support the validity of these findings. Clinical observations indicate that impacted stones are often accompanied by varying degrees of ureteral tortuosity, which may introduce measurement errors. Additionally, inflammatory reactions leading to congestion and edema can cause the ureteral wall to have a density similar to surrounding soft tissues, resulting in measurement bias. Utilizing imaging techniques to accurately measure *ureteral wall area* (UWA) and extract imaging features could provide new insights for developing individualized treatment plans for patients with upper ureteral impacted stones (32).

#### **CONCLUSIONS**

Our findings demonstrated that mini-PCNL could provide higher stone free rates and lower need for auxiliary treatments compared to RIRS in the management of impacted upper ureteral stones. However, RIRS was found to be safer with limited rate of complications associated with faster postoperative recovery. Our findings did also point out the predictive role of UWT value on the presence and severity of polypoid formation surrounding the stones. Thus, this radiological parameter may be helpful for the endourologists during decision making phase to choose the appropriate modality for the management of such stones to limit procedure related complications and increase the stone free rates.

#### **REFERENCES**

1. Türk C, Petrik A, Sarica K, et al. EAU Guidelines on interventional treatment for urolithiasis. *Eur Urol.* 2016; 69:475-82.

2. Knoll T, Wezel F, Michel MS, et al. Do patients benefit from miniaturized tubeless percutaneous nephrolithotomy? A comparative prospective study. *J Endourol.* 2010; 24:1075-9.
3. Sunaryo PL, May PC, Holt SK, et al. Ureteral strictures following ureteroscopy for kidney stone disease: a population-based assessment. *The JPN J Urol.* 2022; 208:1268-75.
4. May PC, Hsi RS, Tran H, et al. The morbidity of ureteral strictures in patients with prior ureteroscopic stone surgery: multi-institutional outcomes. *J Endourol.* 2018; 32:309-14.
5. Sammon JD, Ghani KR, Karakiewicz PI, et al. Temporal trends, practice patterns, and treatment outcomes for infected upper urinary tract stones in the united states. *Eur Urol.* 2013; 64:85-92.
6. Schuster TG, Hollenbeck BK, Faerber GJ, et al. Complications of ureteroscopy: analysis of predictive factors. *JPN J Urol.* 2001; 166:538-40.
7. Ruhayel Y, Tepeler A, Dabestani S, et al. Tract Sizes in miniaturized percutaneous nephrolithotomy: a systematic review from the european association of urology urolithiasis guidelines panel. *Eur Urol.* 2017; 72:220-35.
8. Clayman R. From knife to needle to nothing: The waning of the wound. *Int Braz J Urol.* 2001; 27.
9. Ghani KR, Andonian S, Bultitude M, et al. Percutaneous nephrolithotomy: update, trends, and future directions. *Eur Urol.* 2016; 70:382-96.
10. Preminger GM, Tiselius HG, Assimos DG, et al. 2007 Guideline for the management of ureteral calculi. *Eur Urol.* 2007; 52:1610-31.
11. Assimos D, Krambeck A, Miller NL, et al. Surgical management of stones: american urological association/endourological society guideline, part I. *JPN J Urol.* 2016; 196:1153-60.
12. Aboumarzouk OM, Somani BK, Monga M. Flexible ureteroscopy and holmium:YAG laser lithotripsy for stone disease in patients with bleeding diathesis: a systematic review of the literature. *Int Braz J Urol.* 2012; 38:298-305; discussion 6.
13. Roberts WW, Cadeddu JA, Micali S, et al. Ureteral stricture formation after removal of impacted calculi. *JPN J Urol.* 1998; 159:723-6.
14. Soderberg L, Ergun O, Ding M, et al. Percutaneous nephrolithotomy versus retrograde intrarenal surgery for treatment of renal stones in adults. *Cochrane DB Syst Rev.* 2023; 11: Cd013445.
15. Akman T, Binbay M, Ozgor F, et al. Comparison of percutaneous nephrolithotomy and retrograde flexible nephrolithotripsy for the management of 2-4 cm stones: a matched-pair analysis. *BJU Int.* 2012; 109:1384-9.
16. Dean NS, Millan B, Uy M, et al. Ureteral wall thickness is an effective predictor of ureteral stone impaction and management outcomes: a systematic review and meta-analysis. *JPN J Urol.* 2023; 210:430-7.
17. Lai S, Jiao B, Diao T, et al. Optimal management of large proximal ureteral stones (>10 mm): A systematic review and meta-analysis of 12 randomized controlled trials. *Int J Surg.* 2020; 80:205-17.
18. Wu C, Hua LX, Zhang JZ, et al. Comparison of renal pelvic pressure and postoperative fever incidence between standard- and mini-tract percutaneous nephrolithotomy. *Kaohsiung J Med Sci.* 2017; 33:36-43.
19. Yang Z, Song L, Xie D, et al. Comparative study of outcome in treating upper ureteral impacted stones using minimally invasive percutaneous nephrolithotomy with aid of patented system or transurethral ureteroscopy. *Urology.* 2012; 80:1192-7.
20. Sakr A, Salem E, Kamel M, et al. Minimally invasive percutaneous nephrolithotomy vs standard PCNL for management of renal stones in the flank-free modified supine position: single-center experience. *Urolithiasis.* 2017; 45:585-9.
21. Gökce M, Akpınar Ç, Obaid K, et al. Comparison of retrograde ureterorenoscopy (URS) and percutaneous antegrade ureteroscopy for removal of impacted upper ureteral stones >10 mm in the elderly population. *Int Braz J Urol.* 2021; 47:64-70.
22. Goodman TM. Ureteroscopy with pediatric cystoscope in adults. *Urology.* 1977; 9:394.
23. Yencilek F, Canguven O, Albayrak S, et al. A comparison of shock wave lithotripsy, semirigid and flexible ureteroscopy in the management of proximal ureteral calculi. *Türk J Urol.* 2009; 35:101-107.
24. Best SL, Nakada SY. Flexible ureteroscopy is effective for proximal ureteral stones in both obese and nonobese patients: a two-year, single-surgeon experience. *Urology.* 2011; 77:36-9.
25. Lildal SK, Andreassen KH, Baard J, et al. Consultation on kidney stones, Copenhagen 2019: aspects of intracorporeal lithotripsy in flexible ureterorenoscopy. *World J Urol.* 2021; 39:1673-82.
26. Prabhakar M. Retrograde ureteroscopic intrarenal surgery for large (1.6-3.5 cm) upper ureteric/renal calculus. *Indian J Urol.* 2010; 26:46-9.
27. Multescu R, Geavlete B, Georgescu D, et al. Holmium laser intrarenal lithotripsy in pyelocaliceal lithiasis treatment: to dust or to extractable fragments? *Chirurgia-Bucharest.* 2014; 109:95-8.
28. Sun H, Zhang Z, Yuan J, et al. Safety and efficacy of minimally invasive percutaneous nephrolithotomy in the treatment of patients with medullary sponge kidney. *Urolithiasis.* 2016; 44:421-6.
29. de la Rosette JJ, Opondo D, Daels FP, et al. Categorisation of

## DECLARATIONS

**Ethical approval:** The study was approved by the Institutional Review Board of Shantou Central Hospital.

**Availability of data and material:** The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request.

**Competing interests:** These authors declare that they have no conflict of interest.

**Funding:** This study was supported by the Special Fund Project for Science and Technology Innovation Strategy of Guangdong Province (Grant No. STKJ202209068).

**Authors' contributions:** Conception and design: YZ, KS and GL; Data analysis and interpretation: KC and GW; Data acquisition: XH and ZC; Critical revision of the manuscript: YZ, KS and GL; Drafting the manuscript: KC and XH; Statistical analysis: KC, XH; Supervision: YZ. All authors read and approved the final version of the manuscript.

**Acknowledgments:** Not applicable.

**Consent for publication:** Not applicable.

complications and validation of the Clavien score for percutaneous nephrolithotomy. *Eur Urol.* 2012; 62:246-55.

30. Xu G-b, Li X-z, He Y-z, et al. Ten years experience in treatment of upper urinary calculi with RIRS: clinical analysis of 10 413 cases in single center. *Chin J Endosc.* 2020; 26:64-8.

31. Popiolek M, Lidén M, Georgouleas P, et al. Radiological signs of

stone impaction add no value in predicting spontaneous stone passage. *Urolithiasis.* 2024; 52:114.

32. Yamashita S, Kohjimoto Y, Iguchi T, et al. Ureteral wall volume at ureteral stone site is a critical predictor for shock wave lithotripsy outcomes: comparison with ureteral wall thickness and area. *Urolithiasis.* 2020; 48:361-8.

---

### Correspondence

Kequan Cheng, MD  
chengkq2021@163.com

Xuwei Hong, MD  
hong\_xuwei@sina.cn

Gang Wang, MD  
1031020787@qq.com

Zepai Chi, MD  
zepaichist@126.com

Guoyuan Liu, MD  
liuguoyuan91@sohu.com

Department of Urology, Shantou Central Hospital, Shantou, Guangdong, P.R. China

Kemal Sarica, MD  
saricakemal@gmail.com

Department of Urology, Health Sciences University, Prof. Dr. İlhan Varank Education and Training Hospital, Istanbul, Turkey

Yonghai Zhang, MD (Corresponding Author)  
zhang\_yonghai@126.com

Department of Urology, Shantou Central Hospital  
114th Waima Road, Shantou, Guangdong, P.R. China