Flexible Ureterorenoscopy versus Shockwave Lithotripsy in Management of Residual Stone Fragments after Percutaneous Nephrolithotomy

Mansour Ali Aboubakr Omar*, Khaled Mohammed Abdalsamad,
Esam Abdelmohsen Mahmoud, Mahmoud Mohamed Malek
Department of Urology, Faculty of Medicine - Zagazig University, Egypt
***Corresponding author:** Mansour Ali Aboubakr Omar, **Mobile:** (+20) 01005624129, **E-Mail:** mansooooour85@gmail.com

ABSTRACT
Background: Shock wave lithotripsy (SWL) and flexible ureterorenoscopy (FURS) have been used to treat renal stones.
Objective: This study aimed to compare the results of FURS and SWL in managing post- percutaneous nephrolithotomy residual stone particles.
Subjects and Methods: This prospective randomized controlled study included 48 patients with renal residual stones. It was conducted at Urological Department, Zagazig University Hospitals to compare the outcomes of SWL and FURS for the treatment of residual stone fragments from ≥ 4 mm to ≤ 20 mm following percutaneous nephrolithotomy (PNL).
Results: The success rate, operating time, residual stones, and complications in the two groups were all significantly different. One month following surgery, the SFR was higher in the FURS group (91.7%) than in the SWL group (66.7%) ($p < 0.02$). Less time was spent operating on patients in the SWL group (37.6 ± 7.63) than FURS group (57.50 ± 8.84). Complication rate was 16.6% in the SWL group and 12.5% in the FURS group.
Conclusion: Treatment of 0.4–20 mm residual stone fragments following PNL using FURS, SWL, and other techniques was found to be safe and successful in all cases. Compared to SWL, the SFR of FURS was greater, and the retreatment rate was lower. The operating duration in the FURS group was the longest.
Keywords: Flexible ureterorenoscopy, Shockwave lithotripsy, Residual stone, Percutaneous nephrolithotomy.

INTRODUCTION

Renal stones are still one of the most frequent urological illnesses, affecting 2% to 3% of the general population. 80-90% of all urinary calculi with a high risk of recurrence were kidney stones. Malnutrition, metabolic disorders, environmental and nutritional variables were all linked to it. Small renal calculi are becoming more common in individuals. Pain, hematuria, infection, reduced renal function, and renal failure can result from a kidney stone. In most cases, treatment is necessary when these symptoms are present [(1)].

As a result of advances in minimally invasive surgical techniques, the standard of care for patients with kidney stones smaller than 20 millimeters has shifted away from open surgery to techniques such as extracorporeal shock wave lithotripsy (SWL), percutaneous nephrolithotomy (PNL), and flexible ureterorenoscopy (FURS) [(2)]**.** Patients with lower pole stones who are unable to have surgery because of anatomical reasons can consider PNL and FURS, according to European Association of Urology guidelines set to take effect in (2021) [(3)]**.** Various treatments are available for the removal of kidney stones in the lower caliceal region, including observation, shock wave lithotripsy, flexible ureterorenoscopy, and nephrolithotomy through the ureteral flange. The best way to deal with caliceal stones is still up for debate. Large kidney stones should be treated with PNL [(4)].

Increased stone-free rate (SFR) and lower complications can be attributed to technological advancements in PNL, such as ultrasound-guided percutaneous access, minimised tract size and flexible equipment. After PNL, however, some stone pieces may remain and must be dealt with to prevent re-growth or obstructions of ureters [(5)].

SWL was first used to treat kidney stones in the 1980s and swiftly rose to the top of the list. Non-invasive, low-risk outpatient procedures like SWL are popular with urologists and patients alike. However, the percentage of patients who are stone-free following SWL is inversely related to stone size [(6)]**.**

By the introduction of flexible ureterorenoscopy as a viable therapy option, **Grasso and Ficazzola** [(7)] employed a less invasive method called a tiny active tip. Renal stones can be treated with FURS and a laser. There was no correlation between lower calyx architecture and the SFRs, which ranged from 66% to 82%.

Because of the high stone clearance, reduced problems, and low re-treatment rate of the FURS method, interest in this operation is rising. With FURS, you have to use flexible lithotrite and baskets, which limits your ability to see the sample, and the fragments you remove are smaller because of this. Consequently, cost is the most significant impediment to the widespread use of FURS in developing nations [(8)]. Research in this study compared outcomes of FURS and SWL in managing stone pieces following a percutaneous nephrolithotomy.

SUBJECTS AND METHODS

At urological department, Faculty of Medicine at Zagazig University Hospitals, 48 patients with renal residual stones after PNL were included in the study.

Inclusion criteria: Patients who did PNL in last one month, age more than 18 years, and patients with residual stone fragments from ≥ 4 mm to ≤ 20 mm.
Exclusion criteria: Uncontrolled coagulopathy, patients with kidney malformations, patients with chronic disease (cardiac disease, liver cirrhosis), patients refuse to participate, and Hounsfield units more than 1000.

Received: 03/04/2022
Accepted: 30/05/2022

Treatment was assigned on a randomized basis according to a 1:1 ratio; the first group underwent FURS and the second group underwent SWL.

Group A: included 24 patients, flexible ureteroscope (FURS) was done.

Group B: included 24 patients, SWL was done

This was what all of the participants in this research had to go through:

- Full history taking including: Age, sex, education status, age at onset of stone disease, previous operations.
- Thorough clinical examination
- Biochemical assessment including liver function tests, complete blood count, kidney function tests, urine analysis and culture if needed.

Imaging: Plain X-ray (KUB), abdomino-Pelvic ultrasonography, and pelvi-abdominal CT without contrast in all patients.

Operative Technique:

Group A: The FURS group:

All cases were done by OTU® Wiscope Single-Use Digital Flexible Ureteroscope Image system resolution 160 K, length 670, Bidirectional 275-degree deflection, 9.5F outer diameter, 7.4F tip diameter, working distance 2-50mm, light source built into the handle through an 11/13F ureteral access sheath (OTU® Wiscope) (Figure 1) with an integrated camera head.

It was determined that the density and volume of the stone would determine the laser energy and frequency of pulsation used for the Holmium laser lithotripsy. A 1.9-Fr nitinol basket (OTU® Wiscope) (Figure 2) was used to collect the stone fragments. It was customary to insert a 5F double-J ureteral stent into the patient's kidney.

Figure (1): Uscope (OTU® Wiscope).

Figure (2): Image system (OTU® Wiscope).

- During general anaesthesia, the patient had a fluoro-endoscopic lithotomy. The renal pelvis was inserted with a hydrophilic guide wire.
- Saline 0.9 % was used for irrigation at height of 40-50 cm from the level of the operating table and positive pressure was used to augment the vision, for better delineation of the pelvicalyceal system and orientation of the calyces, we did pyelogram at first (Figure 4).

Figure (3): Deflection mechanism 275-degree, digital imaging.

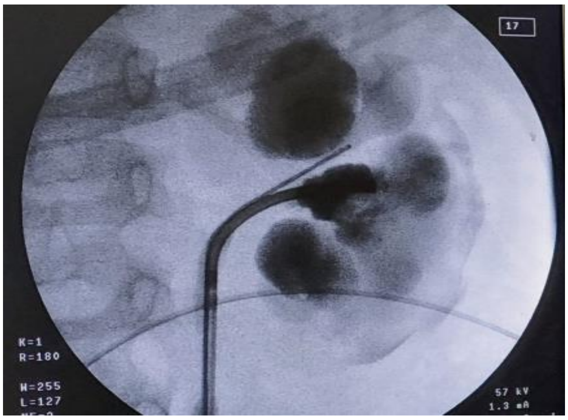

Figure (4): LT kidney Pyelogram.

- A ureteral access sheath was inserted over a (0.035) safety guidewire that was inserted into the renal pelvis for improved visibility (Figures 5 & 6). When the sheath is positioned immediately below the UPJ, the scope can be easily moved in and out of the system without causing an increase in intrapelvic pressure.

Figure (5): Ureteral access sheath 11/13 Fr.

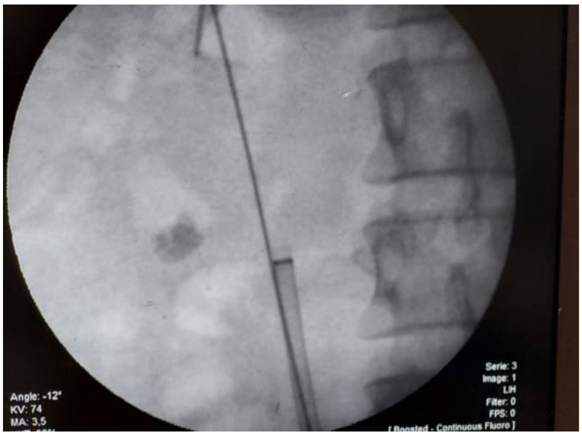

Figure (6): Ureteral access sheath introduction under fluoroscope to the renal pelvis.

- The flexible ureterorenoscope is introduced upward to the pelvis and under fluoroscopic guidance we direct the flexible end of the flexible ureterorenoscope toward the targeted calyx with main two movement of the endoscope, forward and backward of deflection mechanism (Figure 3), supination and pronation of operator's hand and to and from movement inside the ureteral access sheath till reaching the stone bearing calyx.
- Stones disintegrated using holmium laser either in situ or after moved to the renal pelvis by 1.9F. Zero-tip nitinol dormie basket, the laser fiber was back loaded while the scope is straight and then the scope is tilted toward the stone in the lower calyx (Figure 7).
- A holmium: Stone dusting was performed with a YAG laser (200m caliber fiber) rather than an additional, more expensive treatment.

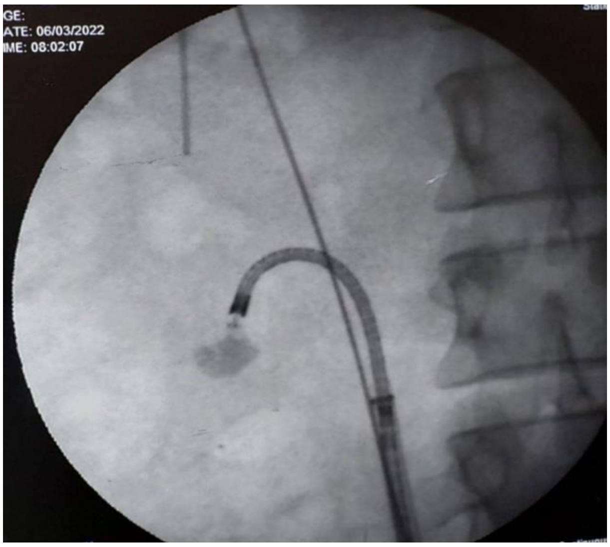

Figure (7): Direction to FURS toward the stone in lower calyx.

- Laser lithotripsy began with parameters of 0.8 J/15 Hz at the beginning. We altered these parameters at roughly 10 mm in order to avoid pneumatic effects from the laser, which can cause stones from different calyxes to migrate to each other.
- Time of operation in surgery has been defined as the moment it takes from the time the FURS is inserted into the kidney until the JJ stent is fully implanted.

All patients underwent postoperative DJ stent insertion.

Group B: The SWL group:

Preparation: (1) Fasting for 8 hours at least before the procedure. (2) Anti-flatulent drugs like disflatyl® chewable tablets or eucarbon® tablets for patients with a history of longstanding bowel symptoms.

The procedure:

All SWL procedures were performed in the supine position and under fluoroscopic guidance. In most cases the calculus could be visualized adequately in situ with the biplanar fluoroscopy. Surgeons employed a Dornier lithotripter to break up the stone, and a water cushion was adapted to suit the patient's body shape. Some patients were treated on outpatient basis with no needed general or spinal anesthesia.

The patients received analgesia before starting SWL session in form of nalbuphine 20mg intravenous diluted in 10 cc normal saline 0.9%, and ketorolac tromethamine 30 mg intramuscular. Every treatment session was begun at 0.1 charging unit which is equivalent to 9.5 kV. We began the treatment at this low energy level to minimize the “startle” response from the patient when the first shocks are administered thus preventing the movement of the stone away from the focus of SWs.

Then, we increase the power gradually by 1 unit every 100 shocks until the desired energy level is obtained according to the stone fragility and patient tolerance. SWs were given at fixed rate of 40/minute for all patients. Fluoroscopy and snapshot imaging were used to confirm the stone's location and track its fragmentation at intervals of 300-500 shocks. Fluoroscopy or 2600 shock waves, whichever came first, signaled the completion of the surgery. All treatment parameters, including operating time, fluoroscopy time, the quantity and energy of SWs used per session, and the number of sessions, were documented.

Follow up for both groups:

Stone-free status (SFR) if the one-month follow-up NCCT showed no residual pieces or fragments less than 4 mm, the procedure was considered successful.

At one week (for all patients): Ask about complications (fever, hematuria, renal colic), abdomen and pelvis ultrasound.

At two weeks (for all patients): Abdomen and pelvis ultrasound, kidney ureter bladder X-ray (KUB), and assessment of the pain by Visual Analogue Scale (VAS).

At 4 weeks (success end point): NCCT to assess SFR, ask about complications (fever, hematuria and renal colic), and JJ removal.

Ethical consent:

Research Ethics Council at Zagazig University approved the study (ZU-IRB#8673) as long as all participants provided informed consent forms. Ethics guidelines for human experimentation were adhered to the World Medical Association's Helsinki Declaration.

Statistical analysis

In order to analyze the data acquired, Statistical Package of Social Sciences version 20 was used to execute it on a computer (SPSS). In order to convey the findings, tables and graphs were employed. The quantitative data were presented in the form of the mean, median, standard deviation, and confidence intervals.

The information was presented using qualitative statistics such as frequency and percentage. The student's t test (T) is used to assess the data while dealing with quantitative independent variables. Pearson Chi-Square and Chi-Square for Linear Trend (X^2) were used to assess qualitatively independent data. The significance of a P value of 0.05 or less was determined.

RESULTS

Table (1) showed age was distributed as 39.62 ± 10.42 and 43.37 ± 9.92 respectively between SWL and FURS groups also there was no significant difference regarding sex distribution.

Table (1): Age and sex distribution between studied groups

			FURS	SWL	t/ X^2	P
Age			43.37 ± 9.92	39.62 ± 10.42	1.277	0.208
Sex	**Female**	**N**	9	8	0.09	0.76
		%	37.5%	33.3%		
	Male	**N**	15	16		
		%	62.5%	66.7%		
Total		**N**	24	24		
		%	100.0%	100.0%		

In terms of stone characters, there was no discernible difference between the groups (Table 2).

Table (2): Stone characters distribution between studied groups

			FURS	SWL	t/ X^2	P
Size of stone			9.87±3.02	9.83±3.52	0.044	0.965
HU			794.04±261.9	735.66±182.78	1.023	0.293
Side	**L**	**N**	16	13	0.78	0.37
		%	66.7%	54.2%		
	R	**N**	8	11		
		%	33.3%	45.8%		
Site of stone	**L**	**N**	13	9	2.48	0.47
		%	54.2%	37.5%		
	M	**N**	6	5		
		%	25.0%	20.8%		
	P	**N**	2	4		
		%	8.3%	16.7%		
	U	**N**	3	6		
		%	12.5%	25.0%		
Total		**N**	24	24		
		%	100.0%	100.0%		

Table (3) showed operation time was significantly longer in FURS group as it was distributed as 37.6 ± 7.63 and 57.50 ± 8.84 respectively between SWL and FURS groups.

Table (3): Operation time distribution between studied groups

	FURS	SWL	t	P
Operation time (min)	57.50±8.84	37.6±7.63	11.321	0.00**

Table (4) showed that VAS post-operatively was higher among SWL but not significantly.

Table (4): Pain characters distribution between studied groups

			FURS	SWL	t/ X^2	P
VAS post op			5.54±1.25	2.68±0.84	4.121	0.00**
Analgesia post OP	**Not**	**N**	3	2	1.25	0.25
		%	12.5%	8.3		
	Needed	**N**	21	22		
		%	87%	91.6%		
Total		**N**	24	24		
		%	100.0%	100.0%		

Success was significantly associated with FURS **(Table 5).**

Table (5): Success rate distribution between studied groups

			Type of operation		X^2	P
			FURS	SWL		
Stone free	**Not**	**N**	2	8	4.52	0.03*
	Yes	**N**	22	16		
	Rate		91.7%	66.7%		
Total		**N**	24	24		
		%	100.0%	100.0%		

Table (6) showed that in SWL group there was four complicated cases. First one had colicky pain, fever and UTI. The second patient had colicky pain, UTI and fever. The third patient had colicky pain and hematuria. The forth patient had colicky pain and hematuria. In FURS group there was three complicated cases, the first one had colicky pain, fever, UTI and hematuria. The second patient had fever, colicky pain and hematuria and third patient had fever and UTI.

Table (6): Complication distribution between studied groups

Modified Clavien score grades	complications			Type of operation FURS	SWL	X^2	P
I	Fever	No	N	21	22	0.35	0.55
			%	87.5%	91.6%		
		Yes	N	3	2		
			%	12.5%	8.33%		
II	Colicky pain	No	N	22	20	1.25	0.25
			%	91.6%	83.3%		
		Yes	N	2	4		
			%	8.33%	16.6%		
II	Hematuria	No	N	22	22	0.35	0.55
			%	91.6%	91.6%		
		Yes	N	2	2		
			%	8.33%	8.33%		
II	UTI	No	N	22	22	0.35	0.55
			%	91.6%	91.6%		
		Yes	N	2	2		
			%	8.33%	8.33%		

DISCUSSION

Many urologists favour SWL as an outpatient surgery since it is noninvasive and has a low morbidity rate. Stone size has an adverse effect on the stone-free rates (SFRs) after SWL. Remaining stones smaller than 20 mm in diameter are often treated with SWL. A single stone in the pelvis of the kidney or the ureteropelvic junction is the best way to remove it from the urinary tract. The lower the pole, the lower the clearance for remaining stones must be [9].

Flexible Ureterorenoscopy is another less invasive treatment option (FURS). In recent years, interest in FURS has grown due to its high stone clearance rate, reduced complications, and low re-treatment rate [5].

Dimensions such as opacity, size, and colour of the stone did not significantly differ between the two groups.

In our study, the mean stone diameter was 9.83 ± 3.52 mm and 9.87 ± 3.02 mm in group A and group B respectively. This is near to the stone diameter in the study done by **Bozkurt *et al.*** [10].

According to operating data and patient outcomes, the two groups were equivalent in terms of success rate, operative time, residual stones, and comorbidities.

The average operating time in FURS group (57.50 ± 8.84) was significantly longer than that in SWL group (37.6 ± 7.63) ($p < 0.05$), which is consistent with the results of previous study by **Chen *et al.*** [11] who reported a longer operating time for FURS (69.1 ± 23.6) when compared to SWL.

We defined success in our study with patient has residual stone less than 4 mm and no symptoms. The SFR data in our study is very consistent with the result of previous studies by **Bozkurt *et al.*** [10].

Within this range (66.7%), although much lower than (91.7%) the SFR followed SWL in this study. Our patients' decreased SFR for SWL was linked to stone disintegration failure. Many factors, including obesity and increased stone density, chemical composition, and skin-to-stone distance, were found to effect SWL stone fragmentation. On excretory urography, the inability to clear fragments was attributed to an acute angle between the axis of the renal pelvis and the lower pole calyx, as well as the width and length of the lower pole infundibulum [12,13]. In their study, **Chen *et al.*** [11] reported that the stone-free rate was comparable in both groups of SWL and FURS. In meta-analysis of fourteen studies comparing SWL versus FURS demonstrated that SFR of SWL was lower than that of FURS and complications were similar between SWL and FURS [14].

About the location of residual stones, **our study** recorded that the most common site was the lower calyx in our series. Lower caliceal residual stones were 45.8%, middle caliceal were 22.91%, upper caliceal were 18.75% and renal pelvis were 12.5%. These data confirm the data of **Lovegrove *et al.*** [15] as they found that the location of the residual stones was 47% lower, 32% middle, 24% upper pole, and 18% renal pelvis/ureter. It agrees with **Ganpule and De Sai** [16] who found that 57.7% of the residual stones were in lower calyx, 10.2% were in middle calyx, 1.1% were in upper calyx, 26.2% were in renal pelvis, 2.7% were in upper ureter, and 2.1% were multiple. It is more common at lower calyx [17, 18, 19].

There were 16.6% of complications in the SWL group and 12.5% in the FURS group, and all cases that were difficult were classified as Grade III or lower by Clavien-Dindo. Hence, our study shows better result than study of **Danilovic *et al.*** [(20)] which show minor complications (Clavien-Dindo < III) occurred in 11/36 (30.6%) patients submitted to FURS and in 2/33 (6.1%) patients submitted to SWL group (p=0.025). Two patients (6.1%) of the SWL group had Clavien-Dindo IIIb complication due to steinstrasse and were submitted to ureteroscopy. I think the steinstrasse is happened as the patients of SWL had no double J fixation. Both groups had the same number of emergency room visits (6.1% vs. 8.3%, p=1.0) Due to steinstrasse-induced pain, two SWL patients sought medical attention at the ER and were ultimately readmitted for ureteroscopy. Urine infection, lumbar discomfort, and urinary infection with lumbar pain each brought three FURS patients to the emergency room [(14, 21)].

Regarding fever > 38°C in current study, 3 patients in FURS (12.5%) and 2 patients in SWL (8.3%) reported to have fever > 38°C after operation, other studies reported incidence of postoperative fever where **Yi *et al.*** [(13)] reported 4 patients in FURS (6.06 %) and 1 patient in SWL group (1.47 %).

In our study colicky pain was noted in both groups (12.5%). While **Al-Tunrende *et al.*** [(18)] found that 26.4% of the patients had symptomatic episode in the form of renal colic pain that need medical therapy. **Salem** [(22)] stated that the most common post-surgical consequence following SWL is haemorrhage (32%), which happens because of the procedure's direct influence on renal tissue. It typically disappears within several days. In study done by **Ozgor *et al.*** [(21)], they reported that the rate of hematuria post-FURS was 1.59% and it had mild-to-moderate transient hematuria.

Our study found that 8.33% of patients who underwent SWL had a UTI, which was higher than the 0.5 to 2.5% reported in prior series [(23,24)]**.** Also 8.33% of all FURS patients were found to have UTIs, which is in line with prior studies that revealed rates of 7.4 to 7.7% [(13, 25)]. This shows the need of preoperative urine cultures, which should be carried out many days before to the operation. FURS patients should be given perioperative antibiotics regardless of whether or not they have an infectious stone or bacteriuria, according to the EAU recommendations [(9)].

CONCLUSION

In conclusion, most 0.4–20 mm remaining stone fragments after PNL were successfully treated with FURS and SWL, respectively. The SFR of FURS was greater and the retreatment rate was lower than that of SWL, and the operating duration in the FURS group was the longest. FURS had a complication rate that was equivalent with SWL.

Conflict of interest: The authors declared no conflict of interest.

Sources of funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Author contribution: Authors contributed equally in the study.

REFERENCES

1. **Srisubat A, Potisat S, Lojanapiwat B *et al.* (2014):** Extracorporeal shock wave lithotripsy (ESWL) versus percutaneous nephrolithotomy (PCNL) or retrograde intrarenal surgery (RIRS) for kidney stones. Cochrane Database of Systematic Reviews, 11: 1-5.
2. **Geavlete P, Multescu R, Geavlete B (2008):** Influence of pyelocaliceal anatomy on the success of flexible ureteroscopic approach. Journal of Endourology, 22 (10): 2235-2240.
3. **White W, Elizabeth B, Zite N *et al.* (2013):** Predictive value of current imaging modalities for the detection of urolithiasis during pregnancy: a multicenter, longitudinal study. J Urol., 189: 931-36.
4. **McClinton S, Starr K, Thomas R *et al.* (2020):** The clinical and cost effectiveness of surgical interventions for stones in the lower pole of the kidney: the percutaneous nephrolithotomy, flexible ureterorenoscopy and extracorporeal shockwave lithotripsy for lower pole kidney stones randomised controlled trial (PUrE RCT) protocol. Trials, 21 (1): 1-15.
5. **Ruhayel Y, Tepeler A, Dabestani S *et al.* (2017):** Tract sizes in miniaturized percutaneous nephrolithotomy: a systematic review from the European Association of Urology Urolithiasis Guidelines Panel. European Urology, 72 (2): 220-235.
6. **El-Nahas A, Ibrahim H, Youssef R *et al.* (2012): Flexible** ureterorenoscopy versus extracorporeal shock wave lithotripsy for treatment of lower pole stones of 10–20 mm. BJU International, 110 (6): 898-902.
7. **Grasso M, Ficazzola M (1999):** Retrograde ureteropyeloscopy for lower pole caliceal calculi. The Journal of Urology, 162 (6): 1904-1908.
8. **Hussain M, Acher P, Penev B *et al.* (2011):** Redefining the limits of flexible ureterorenoscopy. Journal of Endourology, 25 (1): 45-49.
9. **Quhal F, Seitz C (2021):** Guideline of the guidelines: urolithiasis. Current Opinion in Urology, 31 (2): 125-129.
10. **Bozkurt I, Degirmenci T, Celik S *et al.* (2019):** Does leaving residual fragments after percutaneous nephrolithotomy in patients with positive stone culture and/or renal pelvic urine culture increase the risk of infectious complications?. Urolithiasis, 47 (4): 371-375.
11. **Chen L, Sha M, Li D *et al.* (2017):** Treatment for residual stones using flexible ureteroscopy and holmium laser lithotripsy after the management of complex calculi with single-tract percutaneous nephrolithotomy. Lasers in Medical Science, 32 (3): 649-654.
12. **Berardinelli F, De Francesco P, Marchioni M *et al.* (2016):** Infective complications after retrograde intrarenal surgery: a new standardized classification system. Int Urol Nephrol., 48: 1757–1762.

13. **Yi X, Cao D, You P *et al.* (2021):** Comparison of the Efficacy and Safety of Extracorporeal Shock Wave Lithotripsy and Flexible Ureteroscopy for Treatment of Urolithiasis in Horseshoe Kidney Patients: A Systematic Review and Meta-Analysis. Front Surg., 8: 726233.
14. **Tuerk C, Petrik A, Sarica K *et al.* (2016):** EAU guidelines on diagnosis and conservative management of urolithiasis. Eur Urol., 69: 468–74.
15. **Lovegrove C, Geraghty R, Yang B *et al.* (2022):** Natural history of small asymptomatic kidney and residual stones over a long-term follow-up: systematic review over 25 years. BJU international, 129 (4): 442-456.
16. **Ganpule A, Desai M (2009):** Fate of residual stones after percutaneous nephrolithotomy: a critical analysis. J Endourol., 23: 399-403.
17. **Olvera-Posada D, Ali S, Dion M *et al.* (2016):** Natural history of residual fragments after percutaneous nephrolithotomy: evaluation of factors related to clinical events and intervention. Urology, 97: 46-50.
18. **Altunrende F, Tefekli A, Stein R *et al.* (2011):** Clinically insignificant residual fragments after percutaneous nephrolithotomy: medium-term follow-up. J Endourol., 25: 941-945.
19. **Lehtoranta K, Mankinen P, Taari K *et al.* (1995):** Residual stones after percutaneous nephrolithotomy; sensitivities of different imaging methods in renal stone detec on. Ann Chir Gynaecol., 84: 43–49.
20. **Danilovic A, Torricelli F, Marchini G *et al.* (2021).** Residual Stone Fragments After Percutaneous Nephrolithotomy: Shockwave Lithotripsy vs Retrograde Intrarenal Surgery. Journal of Endourology, 35 (5): 609-614.
21. **Ozgor F, Sahan M, Cubuk A *et al.* (2019)**. Factors affecting infectious complications following flexible ureterorenoscopy. Urolithiasis, 47 (5): 481-486.
22. **Ohmori K, Matsuda T, Horii Y *et al.* (1994).** Effects of shock waves on the mouse fetus. The Journal of Urology, 151 (1): 255-258.
23. **Wagenius M, Jakobsson J, Stranne J *et al.* (2017):** Complications in extracorporeal shockwave lithotripsy: a cohort study. Scand J Urol., 17: 1–7.
24. **Al-Marhoon M, Shareef O, Al-Habsi I *et al.* (2013):** Extracorporeal shock-wave lithotripsy success rate and complications: initial experience at Sultan Qaboos University Hospital. Oman Med J., 28: 255–259.
25. **Blackmur J, Maitra N, Marri R *et al.* (2016):** Analysis of factors' association with risk of postoperative urosepsis in patients undergoing ureteroscopy for treatment of stone disease. J Endourol., 30: 963–969.