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Flexible Ureteroscopy with Thulium Fiber Laser for Staghorn Stones: A prospective single-arm non-randomized interventional study

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Abstract

Background: Staghorn renal stones remain challenging to manage because of their size and anatomical complexity. Flexible ureteroscopy (FURS) with a Thulium Fiber Laser (TFL) is emerging as a minimally invasive alternative to conventional approaches.

Objective: To evaluate the effectiveness and safety of TFL-FURS for staghorn renal stones.

Methods: This prospective, single-arm, non-randomized interventional study included 101 patients undergoing TFL-FURS according to predefined eligibility criteria. Demographics, clinical, stone-specific, and perioperative variables were recorded. Stone clearance was assessed postoperatively. Statistical comparisons and logistic regression were used to identify predictors of the stone-free rate (SFR). A p-value <0.05 was considered statistically significant.

Results: The overall stone clearance was 83.2% (84/101). Patients without clearance had significantly larger stone volume (19,996.2 vs. 13,422.8 mm^3; p = 0.009). In univariable analyses, greater stone volume, higher total laser energy, and longer lasering time were associated with lower odds of clearance. In multivariable analyses, only Hounsfield Units (HU) were independently associated with lower odds of clearance (OR = 0.994, p = 0.016). Among 50 patients who underwent postoperative DMSA renography, 5 (10%) had minor renal scarring, while the remaining 45 (90%) showed no evidence of scarring. Creatinine and eGFR improved significantly postoperatively (p = 0.01 for both). Stone composition, morphology, comorbidities, and laterality were not significantly associated with clearance.

Conclusion: TFL-FURS appears effective and safe modality for managing staghorn renal stones. HU independently predicted lower clearance and may help in preoperative planning.

Keywords: Thulium Fiber Laser, Flexible Ureteroscopy, Staghorn Renal Stones, Stone-Free Rate; Predictors.

Introduction:

Urolithiasis is a major urological disease worldwide. The prevalence of urolithiasis ranges from 1% to 20%, with higher rates observed in developed countries and certain geographic areas (1–3). These stones progressively enlarge and extend into multiple renal calyces, resulting in branched calculi, hence the term "staghorn" calculi (4).

The management of staghorn stones is challenging due to their branched structure, high recurrence rate, and association with infectious processes (5–7). Available novel treatment modalities for staghorn stones include percutaneous nephrolithotomy (PCNL) and combined retrograde intrarenal surgery (RIRS) (6,8,9).

PCNL is recommended for stones larger than 2 cm, multiple stones, and stones located in the inferior calyces(10–13) Although it is a minimally invasive and safer technique, complications may include Bleeding, visceral injuries, and nephrocutaneous fistula formation (11, 12).

We previously reported encouraging outcomes from the first 32 consecutive patients undergoing flexible ureteroscopy (FURS) with the Thulium Fiber Laser (TFL) for staghorn calculi (9).

Based on these observations, we conducted this prospective study to evaluate the effectiveness of FUR with TFL for staghorn renal stones.

Methodology:

Study design and setting:

This prospective, single-arm, non-randomized interventional study was conducted in the urology section of Hazm Mebaireek General Hospital, Hamad Medical Corporation, Qatar, from February 2024 to January 2026 (2 years).

Ethical Considerations:

The Institutional Review Board (IRB) of Hamad Medical Corporation approved this study under reference number MRC-01-24-497. We conducted all procedures in accordance with the Declaration of Helsinki and institutional ethical guidelines. Written informed consent was obtained from all participants for participation and use of their clinical data.

Participants and Eligibility Criteria:

Inclusion criteria included prospectively screened adult patients with CT-confirmed staghorn renal calculi and no abnormal urinary tract anatomy. Exclusion criteria encompassed patients with bleeding disorders, abnormal anatomical features, and active urinary tract infection.

Sample size:

Consecutive eligible consenting patients were enrolled. To date, we have operated on 101 patients with staghorn stones using flexible ureteroscopy.

Data collection:

All parameters were prospectively documented at baseline and evaluated after stratification by stone-clearance status. Stone volume was calculated using the ellipsoid formula (length × width × depth × 0.523), with measurements obtained from preoperative CT imaging in accordance with the European Association of Urology (EAU) guidelines.

Intervention:

All participants underwent FURS-TFL under general anesthesia by a urologist with experience of more than 300 flexible ureteroscopies. A guidewire was placed cystoscopically in the ureter, followed by ureteroscopy to assess ureteral caliber and confirm the absence of ureteric stones. A ureteral access sheath is then inserted over the second guidewire.

A flexible ureteroscope is introduced through the ureteral access sheath into the upper ureter/pelvis, and the stone is dusted with TFL, using fragmentation and popcorning when clinically indicated.

Outcome Measures

The primary objective was stone clearance, defined as the absence of residual fragments or the presence of clinically insignificant residual fragments (≤4 mm) on postoperative CT imaging at one-month follow-up. Secondary outcomes included intraoperative and postoperative metrics such as operating time, lasering time, total energy used, perioperative complications graded according to the Clavien-Dindo classification, the need for second-look surgeries, and renal scarring assessed via postoperative DMSA scan.

Statistical analysis:

Stata BE, 18th edition, was used for statistical analysis. Categorical data were presented as frequencies and percentages, and continuous variables were displayed as mean ± standard deviation or median (interquartile range). Parametric/non-parametric and categorical tests were used to compare stone-clearance and non-clearance groups of patients. Factors associated with stone-free status were identified using univariable logistic regression; variables with $p \leq 0.20$ or with clinical significance were included in a multivariable logistic regression model to identify independent predictors, which were then presented as odds ratios with 95% confidence intervals. Statistical significance was defined as a p-value < 0.05.

Results

The study included 101 patients. The mean age was 42.5 ± 9.35 years. Stone laterality, composition, morphology, BMI, and comorbidities were not associated with SFR (Table 1).

Stone volume ranged from 3183 to 70,865 mm^3, (median 14,124.7 mm^3) and was significantly greater in the non-clearance group (19,996.2 mm^3 vs 13,422.8 mm^3, p = 0.009). Hounsfield units were higher in the non-clearance group (1080 vs 950), but the difference was not statistically significant (p = 0.09). Overall, the median Hounsfield units were 1000 (IQR 625–1200).

Sixty-seven patients had partial staghorn (pelvis and one or two calyces), and thirty-four had total staghorn (pelvis and three calyces). Statistical significance was not shown in any of the comparisons.

The most prevalent stone type was calcium oxalate (44.5%), followed by uric acid (24.5%) and combined calcium oxalate–uric acid (20.6%). Clearance did not significantly correlate with any stone composition group (p = 0.43). Preoperative stent (22.7% vs 11.8% in the non-clearance group) did not significantly correlate with successful stone clearance (p = 0.32).

Except for creatinine (p=0.01) and eGFR (p=0.01), which showed statistically significant improvements, most hematologic values remained stable after treatment.

Table 1: Baseline Characteristics Stratified by Stone Clearance (Zero Fragments + CIRF (<=4mm))

Variable	Overall (n = 101)	Stone Clearance		p-value
		Yes (n = 84)	No (n = 17)	
Age (years) (Mean ± SD)	42.5 ± 9.35	42.7 ± 9	41.7 ± 11	0.67
BMI (kg/m²) (Mean ± SD)	28.5 ± 4.7	28.4 ± 4.8	29.1 ± 4.7	0.2

Diabetes Mellitus N (%)		24	18 (21.69%)	6 (37.5%)	0.18
Hypertension N (%)		29	23 (27.4%)	6 (35.3%)	0.48
CAD N (%)		7	6 (7.2%)	1 (5.9%)	0.03
High Uric Acid N (%)		5	4 (4.8%)	1 (5.9%)	0.03
Laterality N (%)	**Right**	38	33 (39.29%)	5 (29.41%)	0.45
	Left	63	51 (60.71%)	12 (70.59%)	
Nationality N (%)		Top: India (29%), Pakistan (16%), Nepal (15%)	-	-	0.487
Stone Volume (mm³) Median (Min-Max):		14,124.7 [3183 – 70,865]	13,422.8 [3183 – 53,838]	19,996.2 [8796 – 70,685]	0.009
Hounsfield Units Median (IQR)		1000 (625–1200)	950 (595–1200)	1080 (970–1200)	0.09
History of Stone disease N (%)		58	51 (60.7%)	7 (41.2%)	0.14
Past Surgical History N (%)		27	24 (27.4%)	3 (23.5%)	0.75
Stone Morphology N (%)					0.88
Partial staghorn (pelvis + one or two calyces) N (%)		67	56 (83.58%)	11 (16.42%)	
Complete staghorn (pelvis + three calyces) N (%)		34	28 (82.35%)	6 (17.65%)	
Preoperative Stent N (%)		21	19 (22.7%)	2 (11.8%)	0.32
Stone Composition N (%)		63	51 (60.71%)	12 (70.58%)	0.43
Calcium Oxalate N (%)		28 (44.5%)	20 (39.3%)	8 (66.7%)	

Uric Acid N (%)	16 (24.5%)	15 (29.5%)	1 (8.4%)	
Calcium Oxalate + Uric Acid N (%)	13 (20.63%)	10 (19.7%)	3 (25%)	
Calcium Oxalate Mono- and Dihydrate N (%)	4 (6.35%)	4 (7.84%)	0	
Calcium Phosphate N (%)	1 (1.59%)	1 (1.96%)	0	
Calcium Phosphate + Uric Acid N (%)	1 (1.59%)	1 (1.96%)	0	

Univariable logistic regression shows that larger stone volume (OR = 0.9999, 95% CI: 0.99991–0.9998, p = 0.005), higher total energy use (OR = 0.99, 95% CI: 0.98–0.996, p = 0.007), and longer lasering time (OR = 0.99, 95% CI: 0.98–0.99, p = 0.02) were significantly associated with lower odds of achieving stone clearance. Both total efficiency (p = 0.091) and operating time (p = 0.059) displayed marginally significant results. Stone clearance was not significantly correlated with other perioperative and anatomical factors, such as calyceal location, stone composition, preoperative stenting, suction sheath use, basket use, frequency, pulse energy, dusting or fragmentation technique, and stone treatment efficiency.

Only Hounsfield Units (HU) emerged as an independent predictor of stone clearance in multivariable analysis (OR = 0.994, 95% CI: 0.989–0.999, p = 0.016). All other stone and operative characteristics were not statistically significant (p > 0.05). Higher HU levels were associated with a decreased likelihood of achieving stone clearance.

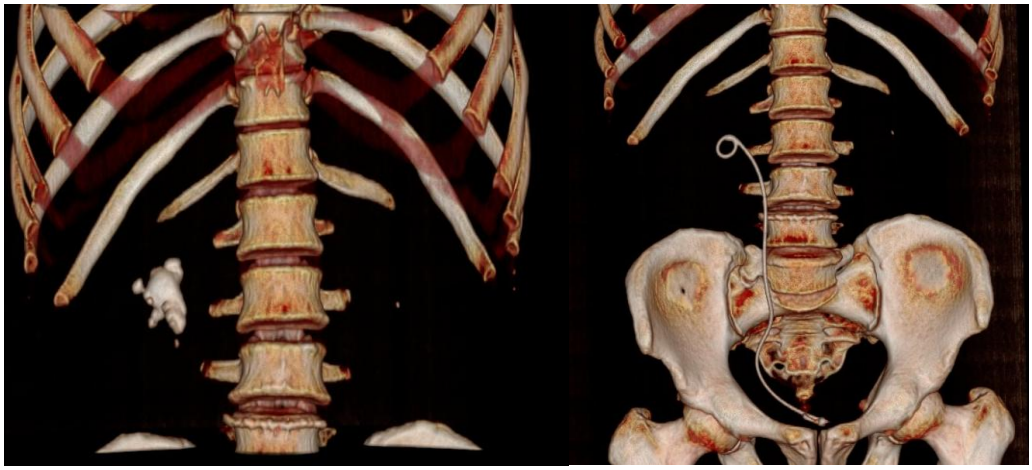


Fig. 1 CT scan (3D) before and after treatment with flexible ureteroscopy and Thulium fiber laser lithotripsy for complete staghorn stone.

Table 2 shows that 54.5% of patients were stone-free (Grade A), 83.2% had SFR or CIRF ≤4 mm, and 16.8% had residual fragments >4 mm.

SFR Grade	Definition	n (%)
Grade A	No residual fragments	55 (54.5)
Grade B	CIRF ≤ 2 mm	10 (9.9)
Grade C	CIRF 3–4 mm	19 (18.8)
Grade D	Residual > 4 mm	17 (16.8)
Total	–	101 (100.0)

Most complications were Clavien-Dindo low-grade: 15 Grade I, two Grade II, and one Grade IV complication that required ICU care due to urosepsis.

Fifty patients had postoperative DMSA renograms; only five showed minor scarring with no moderate or severe scarring.

Table 3: Clavien-Dindo Complications, Type, and Treatment

Clavien-Dindo	n (%)	Type of Complication	Treatment Provided
Grade I	15 (83.3%)	Flank pain, dysuria	Painkillers

Grade II	2 (11.1%)	Fever	Painkillers + Antibiotics
Grade IV	1 (5.6%)	Urosepsis (ICU)	IV antibiotics, supportive

As shown in Table 4, patients who did not achieve stone clearance had significantly longer lasering time and operative duration, as well as higher total energy use (all $p < 0.05$). Groups did not differ significantly in pulse energy, frequency, dusting, fragmentation, or operative efficiency. Postoperative outcomes, including stent duration and length of stay, were similar. Most procedures were performed as day-care surgeries (99%). Most patients (86.1%) achieved stone-free status after a single session. Second-look procedures were required in 14 patients, most commonly RIRS (9), followed by ESWL (4) and URS (1).

Table 4: Perioperative outcomes

Variable	Overall (n=101)	Stone Clearance: Yes (n=84)	Stone Clearance: No (n=17)	p-value
Lasering time, min (median [IQR])	120 (85–155)	120 (79–150)	150 (120–180)	0.005
Operative time, hmin (median [IQR])	140 (100–180)	140 (100–180)	160 (140–210)	0.013
Pulse energy (J), median [IQR]	0.5 (0.5–0.6)	0.5 (0.5–0.6)	0.5 (0.5–0.6)	0.908
Frequency (Hz), median [IQR]	25 (20–30)	24 (20–30)	25 (24–30)	0.215
Dusting, n (%)	95	79 (94.1)	16 (94.1)	0.991
Fragmentation, n (%)	20	15 (17.9)	5 (29.4)	0.276

Total energy used (kJ), median [IQR]	79.5 (53–116.6)	75.8 (50–102)	118.2 (79–162)	0.004
Stone Treatment Efficiency (STE), median [IQR]	109.5 (84.4–175.8)	109.5 (84.4–175.8)	109.5 (84.4–175.8)	0.132
Operative Efficiency (OE), median [IQR]	95.3 (69.6–156.9)	95.3 (69.6–156.9)	95.3 (69.6–156.9)	0.055
Post-op JJ stent duration, days (median [IQR])	14 (14–21)	14 (14–21)	14 (14–21)	0.996
Time to discharge, Hours (median [IQR])	5 (4–6)	5 (4–6)	4.5 (4–5)	0.080
Daycare procedure, n (%)	100	84	16	0.025

Table 5 shows that, regarding device-related factors, the choice of ureteral access sheath and the type of flexible ureteroscope did not differ significantly between groups (*p = 0.064 and 0.068, respectively*). All procedures utilized a Thulium fiber laser.

Table 5: Device-related factors

Variable	Overall	Stone Clearance: Yes	Stone Clearance No	p-value
Ureteral access sheath size, n (%)				0.064
– 10/12/35	1	1 (1.2)	0 (0.0)	
– 10/12/45	1	0 (0.0)	1 (5.9)	
– 10/12/46	48	41 (48.8)	7 (41.2)	
– 11/13/46	27	24 (28.6)	3 (17.7)	
– 11/13/50	5	5 (6.0)	0 (0.0)	
– 12/14/40	1	1 (1.2)	0 (0.0)	

– 12/14/45	2	2 (2.4)	0 (0.0)	
– 12/14/46	14	8 (9.5)	6 (35.3)	
– 12/14/50	2	2 (2.4)	0 (0.0)	
Flexible URS type, n (%)				
– OTU	82	70 (83.3)	12 (70.6)	
– MacroLux	12	9 (10.7)	3 (17.7)	
– Pusen	3	3 (3.6)	0 (0.0)	0.068
– FlexXC	1	1 (1.2)	0 (0.0)	
– Scivita	1	0 (0.0)	1 (5.9)	
– Storz	1	0 (0.0)	1 (5.9)	
– Sheejeen	1	1 (1.2)	0 (0.0)	
Laser type, n (%)	101	101 (100%) Thulium	101 (100%) Thulium	-

Discussion:

Percutaneous nephrolithotomy is the first-line therapy for staghorn stones, according to the American Urological Association and European Urological Association guidelines, but carries risks including bleeding, infection, and visceral injury (11,14) (15). Flexible ureteroscopy (FURS) combined with laser lithotripsy may offer an alternative approach, achieving high stone-free rates with minimal complications. In our cohort, we found a total complication rate of 17.82%, with grade IV occurring in only 1% of all treated cases. This aligns with other studies reporting 15.1% complications, most commonly postoperative fever (9.6%) (15, 16). Only one patient experienced a serious incident requiring ICU care; most postoperative complications were mild and managed conservatively.

A lower stone clearance was associated with larger stone volume. These findings are consistent with research by Mohamed et al., which reported an SFR of 90.7% for stones smaller than 3 cm and 75% for those larger than 3 cm (18). Most patients were stone-free after a single session, whereas the non-clearance group required second-look operations more often.

In our study, 99% of procedures were performed as day-care cases, whereas PCNL series consistently report that most procedures are performed as inpatient admissions, with hospitalization rates ranging from about 70% to nearly 100% and average lengths of stay typically between 2 and 4 days (18, 19).

In our study, 54.5% of patients were stone-free, with no residual fragments. This closely agrees with Tawiz et al., who reported a Grade A SFR of 53% (9). Consistent with prior research, Hounsfield units (HU) independently predict stone-free status (13,16,17).

Among the 50 patients who underwent postoperative DMSA evaluation, we observed minor (focal) cortical scarring in 5 patients, with no moderate or severe scarring in any case; the remaining patients showed no evidence of cortical defects despite longer lasering time. This supports the safety profile of TFL-FURS for staghorn calculi.

Limitations: This study has several limitations.

First, the single-center design and moderate sample size, with no randomization and no comparison group, may limit generalizability.

Second, an experienced endourologist performed all procedures, so the results may not be reproducible in centers with less experience.

Conclusion

FURS with TFL appears to be a safe and feasible treatment option for selected patients with Staghorn stones, with acceptable stone clearance, low complication rates, and a shorter hospital stay. Hounsfield units are an important indicator of stone clearance, emphasizing the value of preoperative evaluation in optimizing outcomes.

Authors Contribution:

T.G., A.B., and M.S. conceived and designed the study. T.G., A.B., M.A., M.I., B.T., A.E., H.A., M.E., A.M., M.J.H., and M.A.G. contributed to patient recruitment, data collection, and clinical investigation. A.B. contributed to data curation, statistical analysis, and drafting of the manuscript. V.G. contributed to methodology, interpretation of results, and critical revision of the manuscript. T.G. and M.S. supervised the study. All authors reviewed and approved the final manuscript.

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Competing Interests

The authors declare no competing interests.

Data Availability

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request, subject to Hamad Medical Corporation institutional and ethical requirements.

References

1. Pietropaolo A, Proietti S, Geraghty R, Skolarikos A, Papatsoris A, Liatsikos E, et al. Trends of 'urolithiasis: interventions, simulation, and laser technology' over the last 16 years (2000–2015) as published in the literature (PubMed): a systematic review from European section of Uro-technology (ESUT). World J Urol. 2017 Nov 1;35(11):1651–8. doi:10.1007/s00345-017-2055-z PubMed PMID: 28593477.

2. Raheem OA, Khandwala YS, Sur RL, Ghani KR, Denstedt JD. Burden of Urolithiasis: Trends in Prevalence, Treatments, and Costs. Eur Urol Focus. 2017 Feb 1;3(1):18–26. doi:10.1016/J.EUF.2017.04.001 PubMed PMID: 28720363.

3. Nikitin O, Samchuk P, Krasiuk O, Korytskyi A, Nasheda S. Urolithiasis: from past to present. The Ukrainian Scientific Medical Youth Journal. 2023 Oct 27;142(4):102–11. doi:10.32345/USMYJ.4(142).2023.102-111

4. Karki N, Leslie SW. Struvite and Triple Phosphate Renal Calculi. StatPearls. 2023 May 30. PubMed PMID: 33760542.

5. Pastore AL, Palleschi G, Silvestri L, Leto A, Ripoli A, Fuschi A, et al. Combined laparoscopic pyelolithotomy and endoscopic pyelolithotripsy for staghorn calculi: long-term follow-up results from a case series. Ther Adv Urol. 2016;8(1):3. doi:10.1177/1756287215607417 PubMed PMID: 26834835.

6. Ananda NF, Setiawan KG, Almeira V, Meutia FL, Rahmat FA, Achmadsyah A, et al. Effective management of large renal stones using retrograde intrarenal surgery with combined direct in-scope suction and flexible and navigable ureteral access sheath: a case report. Frontiers in Urology. 2025 Oct 24;5:1634754. doi:10.3389/FRURO.2025.1634754/TEXT

7. Aboumarzouk OM, Monga M, Kata SG, Traxer O, Somani BK. Flexible ureteroscopy and laser lithotripsy for stones >2 cm: a systematic review and meta-analysis. J Endourol. 2012 Oct 1;26(10):1257–63. doi:10.1089/END.2012.0217 PubMed PMID: 22642568.

8. Nguyen AM, Do HH, Van Nguyen D, Vo LH. Innovations in kidney stone management: mini-PCNL for staghorn calculi in resource-limited settings. Frontiers in Urology. 2025;5:1555624. doi:10.3389/FRURO.2025.1555624 PubMed PMID: 40777612.

9. Gul T, laymon M, Alrayashi M, Abdelkareem M, Salah M. Successful treatment of staghorn stones with flexible ureteroscopy and thulium fiber laser (TFL) lithotripsy: initial experience with 32 cases. Urolithiasis. 2024 Dec 1;52(1):102. doi:10.1007/S00240-024-01598-9 PubMed PMID: 38937284.

10. Rashid AO, Mahmood SN, Amin AK, Bapir R, Buchholz N. Multitract percutaneous nephrolithotomy in the management of staghorn stones. African Journal of Urology. 2020 Dec 1;26(1):74-. doi:10.1186/S12301-020-00086-X/TABLES/4

11. Tzelves L, Türk C, Skolarikos A. European Association of Urology Urolithiasis Guidelines: Where Are We Going? Eur Urol Focus. 2021 Jan 1;7(1):34–8. doi:10.1016/J.EUF.2020.09.011 PubMed PMID: 33011151.

12. Jiao B, Luo Z, Huang T, Zhang G, Yu J. A systematic review and meta-analysis of minimally invasive vs. standard percutaneous nephrolithotomy in the surgical management of renal stones. Exp Ther Med. 2021 Jan 15;21(3). doi:10.3892/ETM.2021.9645 PubMed PMID: 33574911.

13. Zhu W, Liu Y, Liu L, Lei M, Yuan J, Wan SP, et al. Minimally invasive versus standard percutaneous nephrolithotomy: a meta-analysis. Urolithiasis. 2015 Aug 5;43(6):563–70. doi:10.1007/S00240-015-0808-Y PubMed PMID: 26242465.

14. Assimos D, Krambeck A, Miller NL, Monga M, Murad MH, Nelson CP, et al. Surgical Management of Stones: American Urological Association/Endourological Society Guideline, PART I. J Urol. 2016 Oct 1;196(4):1153–60. doi:10.1016/J.JURO.2016.05.090 PubMed PMID: 27238616.

15. Gadzhiev N, Malkhasyan V, Akopyan G, Petrov S, Jefferson F, Okhunov Z. Percutaneous nephrolithotomy for staghorn calculi: Troubleshooting and managing complications. Asian J Urol. 2020 Apr 1;7(2):139–48. doi:10.1016/J.AJUR.2019.10.004 PubMed PMID: 32257807.

16. Keat WOL, Somani BK, Pietropaolo A, Chew BH, Chai CA, Inoue T, et al. Do Hounsfield Units have any significance in predicting intra- and postoperative outcomes in retrograde intrarenal surgery using Holmium and Thulium fiber laser? Results from the FLEXible ureteroscopy Outcomes Registry (FLEXOR). World J Urol. 2023 Nov 1;41(11):2881–8. doi:10.1007/S00345-023-04362-7/METRICS PubMed PMID: 36929407.

17. Moon HW, Taeyb M, Park YH, Bae WJ, Ha US, Hong SH, et al. The impact of Hounsfield unit-related variables on percutaneous nephrolithotomy outcomes. Sci Rep. 2022 Dec 1;12(1). doi:10.1038/S41598-022-23383-7 PubMed PMID: 36323761.