

Fluoroscopic-Guided Versus Ultrasound-Assisted Extracorporeal Shock Wave Lithotripsy for Renal Stones: A Prospective Randomized Single-Centre Study

Amit Chandan¹, Hemant Kamal², Devendra Singh Pawar³, Parvartandeep Singh¹, Akshay Gupta¹

¹Senior Resident, Department of Urology, Pt. B.D. Sharma PGIMS, Rohtak, Haryana, India. ²Professor, Department of Urology, Pt. B.D. Sharma PGIMS, Rohtak, Haryana, India. ³Senior Professor and HOD, Department of Urology, Pt. B.D. Sharma PGIMS, Rohtak, Haryana, India.

Abstract

Background: Extracorporeal shock wave lithotripsy (ESWL) is an established non-invasive treatment for selected renal calculi. Accurate stone localization is essential for effective shock-wave delivery. Fluoroscopy has traditionally been used for targeting, while ultrasound offers real-time localization without ionizing radiation. Evidence comparing the two approaches remains heterogeneous. The objective is to compare the efficacy and safety of fluoroscopic (FS)-guided ESWL with ultrasound (USG)-guided ESWL for renal stones up to 20 mm. **Material and Methods:** This prospective randomized single-centre study was conducted at the Department of Urology, Pt. B.D. Sharma PGIMS, Rohtak, from January 2024 to December 2025. Adults with a single renal stone measuring 5–20 mm and eligible for ESWL were randomly allocated to FS-guided or USG-guided treatment (65 patients per group). Stone characteristics, shock frequency, energy, procedure duration, number of sessions, treatment outcome and post-procedural complications were assessed. Treatment success was defined as stone-free status or residual fragments <4 mm (clinically insignificant residual fragments). **Results:** The two groups were comparable at baseline with respect to age, sex, renal laterality, stone location, skin-to-stone distance, stone size and stone density. Treatment success was significantly higher with FS-guided ESWL than with USG-guided ESWL (83.1% vs 67.7%; $p=0.042$), with corresponding failure rates of 16.9% and 32.3%. Shock frequency, energy requirements and procedure duration did not differ significantly between groups across sessions. Overall pain intensity was similar ($p=0.757$), as was hematuria (3.1% vs 4.6%; $p=0.999$). No cases of urosepsis or steinstrasse were reported in either group. Up to three ESWL sessions were used, and the thesis reported no significant difference in the need for ancillary procedures. **Conclusion:** In this study population, FS-guided ESWL achieved a higher treatment success rate than USG-guided ESWL, while both approaches demonstrated comparable procedural parameters and short-term safety outcomes. USG-guided ESWL remains a clinically useful alternative when fluoroscopy is undesirable or unsuitable. Larger multicentre randomized studies with longer follow-up, radiation-dose assessment and cost-effectiveness analysis are warranted.

Keywords: renal calculi, extracorporeal shock wave lithotripsy, ESWL, fluoroscopy, ultrasonography, stone-free rate, urolithiasis.

Received: 20 August 2026

Revised: 11 September 2026

Accepted: 22 September 2026

Published: 12 October 2026

INTRODUCTION

Urolithiasis is a common urological condition, and extracorporeal shock wave lithotripsy (ESWL) remains an important non-invasive treatment option for appropriately selected renal stones. The technique fragments calculi through externally generated shock waves and can be performed with limited invasiveness and short recovery. Contemporary guidance and clinical practice continue to use ESWL for selected renal stones, particularly when stone size, location and patient-specific factors are favourable.^[1–3] The effectiveness of ESWL is influenced by stone size and composition, stone density, skin-to-stone distance, renal anatomy, stone location, patient positioning, respiratory movement and the ability to maintain accurate targeting throughout treatment.^[5–9] Lower-pole anatomy may be particularly relevant because infundibular dimensions and the infundibulopelvic angle can influence fragment clearance.^[8,9]

Precise imaging guidance is therefore central to ESWL. Fluoroscopy has traditionally been used for stone

localization because it provides rapid visualization and is incorporated into many lithotripter systems. Ultrasound has increasingly been used as an alternative targeting modality, with the advantages of real-time imaging and avoidance or reduction of ionizing radiation exposure. Ultrasound can also facilitate localization of stones that may be difficult to visualize fluoroscopically.^[4,15–22]

Comparative evidence, however, is inconsistent. Some studies have reported similar outcomes or non-inferiority of ultrasound-

Address for correspondence: Dr. Amit Chandan

Senior Resident, Department of Urology, Pt. B.D. Sharma PGIMS, Rohtak, Haryana, India

E-mail: chandan.amit@gmail.com

DOI:

10.21276/amt.2026.v13.i3.1117

How to cite this article: Chandan A, Kamal H, Pawar DS, Singh P, Gupta A. Fluoroscopic-Guided Versus Ultrasound-Assisted Extracorporeal Shock Wave Lithotripsy for Renal Stones: A Prospective Randomized Single-Centre Study. *Acta Med Int.* 2026;13(3):618-622.

guided ESWL, whereas other studies have demonstrated higher success with ultrasound or fluoroscopy depending on patient and stone characteristics.^[15–22] A systematic review also found that ultrasound guidance generally produced comparable safety outcomes, although differences in stone-free rates were inconsistent across studies.^[17]

The present study was undertaken to compare FS-guided and USG-guided ESWL for renal stones up to 20 mm, with particular emphasis on treatment success, post-procedural complications and procedural characteristics.

Aim and Objectives

Aim: To compare the efficacy and safety of fluoroscopic-guided ESWL with ultrasound-assisted ESWL for renal stones.

Primary objective: To compare treatment success/stone-free outcome after FS-guided versus USG-guided ESWL for renal stones up to 20 mm.

Secondary objectives: To compare post-procedural pain, hematuria, urosepsis, steinstrasse, number of sessions, shock frequency, energy requirement and procedure duration between the two techniques.

MATERIALS AND METHODS

Study design and setting: This was a prospective randomized single-centre comparative study conducted in the Department of Urology, Pt. B.D. Sharma Post Graduate Institute of Medical Sciences, Rohtak, Haryana, a tertiary-care referral centre. The study period was January 2024 to December 2025. The thesis reports institutional ethical clearance and written informed consent from all participants.

Participants: Adults with a single renal stone measuring 5–20 mm who were candidates for ESWL and had not received prior treatment were eligible. Exclusion criteria were multiple or staghorn calculi; stones outside the specified size range; abnormal renal anatomy; severe renal insufficiency; radiolucent stones; distal urinary tract obstruction; inability to target the stone because of skeletal deformity; uncorrected coagulopathy; active urinary tract infection; pregnancy; age <18 years; unwillingness to undergo SWL; and calyceal diverticular stones.

Randomization and intervention: After written informed consent and baseline evaluation, participants were randomly allocated in a 1:1 ratio using Random Allocation Software 2.0 to FS-guided or USG-guided ESWL. A total of 130 patients were included, with 65 patients in each group.

ESWL was performed on an outpatient basis using a Sonolith iMove lithotripter (EDAP TMS, Version 5). Stone targeting was performed with a Skanray C-arm for the FS group and an Esoate/MyLabX5 ultrasound system for the USG group. Patients were positioned prone and were treated without anaesthesia or analgesia according to the study protocol. Up to 3000 shocks per session were delivered at 10–12 kV and 60–100 shocks/min. DJ stenting was performed for stones >10 mm and in patients with a solitary functioning kidney. NSAIDs and antibiotics were prescribed after each session.

Baseline assessment and follow-up: Baseline evaluation included history, physical examination, routine blood and urine investigations, coagulation profile, urine culture, abdominal ultrasonography, X-ray KUB and CT urography. Stone size, location, skin-to-stone distance, infundibular measurements and Hounsfield-unit density were assessed using CT imaging. After each ESWL session, X-ray KUB or USG KUB was obtained at approximately 2 weeks. Repeat ESWL was performed when fragmentation was absent or inadequate. NCCT KUB was obtained when imaging suggested no stone, incomplete fragmentation or clinically insignificant residual fragments.

Outcome definitions: The thesis defined ESWL success as stone-free status or residual stone fragments <4 mm, classified as clinically insignificant residual fragments. Treatment was considered failed when residual fragments ≥4 mm persisted after three sessions or when an ancillary procedure was required for stone removal. Secondary safety outcomes included pain intensity, hematuria, urosepsis and steinstrasse.

Sample size: The sample size was based on effect estimates from Chang et al.,^[18] Assuming success estimates of 40% and 18% for the two groups, with a two-sided 95% confidence level and 80% power, the thesis calculated 65 participants per group, giving a total sample size of 130.

Statistical analysis: Continuous variables were compared using independent-samples t tests. Categorical variables were compared using chi-square tests, with Fisher's exact test used when expected frequencies were low. A p value <0.05 was considered statistically significant. Analyses were performed using SPSS version 24.0 (IBM Corp., NY, USA).

RESULTS

A total of 130 patients were analyzed, with 65 allocated to each group. The baseline characteristics were well balanced, with no statistically significant intergroup differences in age, sex, renal laterality, stone location, skin-to-stone distance, stone size or stone density.

Table 1: Baseline demographic and stone characteristics

Variable	FS-guided (n=65)	USG-guided (n=65)	p value
Age, years, mean ± SD	47.18 ± 6.30	46.15 ± 6.16	0.348
Male sex, n (%)	35 (53.8)	38 (58.5)	0.596
Right kidney, n (%)	39 (60.0)	34 (52.3)	0.377
Left kidney, n (%)	26 (40.0)	31 (47.7)	0.377
Lower-pole calyx, n (%)	15 (23.1)	12 (18.5)	0.928
Upper-pole calyx, n (%)	27 (41.5)	28 (43.1)	0.928
Mid-pole calyx, n (%)	17 (26.2)	18 (27.7)	0.928
Renal pelvis, n (%)	6 (9.2)	7 (10.8)	0.928
Skin-to-stone distance, mm, mean ± SD	74.34 ± 5.07	74.66 ± 4.78	0.709
Stone size, mm, mean ± SD	14.43 ± 2.74	14.83 ± 2.96	0.425
Stone density, HU, mean ± SD	901.38 ± 92.02	897.46 ± 106.68	0.823

No baseline variable differed significantly between groups (all $p>0.05$), indicating good comparability of demographic and stone-related characteristics before treatment.

Table 2: Procedural characteristics

Parameter	Session	FS-guided	USG-guided	p value
Shock frequency (bpm)	1	78.28 $\pm$ 6.36	79.97 $\pm$ 6.53	0.137
Shock frequency (bpm)	2	77.85 $\pm$ 5.33	77.45 $\pm$ 4.71	0.651
Shock frequency (bpm)	3	86.43 $\pm$ 4.57	87.52 $\pm$ 4.11	0.155
Mean energy (J)	1	65.17 $\pm$ 1.64	65.65 $\pm$ 1.70	0.106
Mean energy (J)	2	65.92 $\pm$ 1.23	66.35 $\pm$ 1.54	0.081
Mean energy (J)	3	66.91 $\pm$ 0.72	66.81 $\pm$ 0.58	0.425
Procedure duration (min)	1	40.72 $\pm$ 3.62	41.57 $\pm$ 4.74	0.252
Procedure duration (min)	2	40.76 $\pm$ 4.17	41.85 $\pm$ 4.77	0.169
Procedure duration (min)	3	43.29 $\pm$ 1.95	43.78 $\pm$ 2.02	0.160

Shock frequency, energy requirement and procedure duration were comparable between groups in all three sessions, with no statistically significant differences.

Table 3: Post-procedural safety outcomes

Outcome	FS-guided (n=65)	USG-guided (n=65)	p value
Nil pain, n (%)	1 (1.5)	1 (1.5)	0.757
Mild pain, n (%)	56 (86.2)	53 (81.6)	0.757
Moderate pain, n (%)	8 (12.3)	11 (16.9)	0.757
Severe pain, n (%)	0 (0.0)	0 (0.0)	0.757
Hematuria present, n (%)	2 (3.1)	3 (4.6)	0.999
Urosepsis present, n (%)	0 (0.0)	0 (0.0)	—
Steinstrasse present, n (%)	0 (0.0)	0 (0.0)	—

The overall pain distribution and incidence of hematuria were not significantly different between groups. No urosepsis or steinstrasse occurred in either group, supporting a similar observed short-term safety profile.

Table 4: Primary treatment outcome

Outcome	FS-guided (n=65)	USG-guided (n=65)	p value
Success, n (%)	54 (83.1)	44 (67.7)	0.042
Failure, n (%)	11 (16.9)	21 (32.3)	0.042

FS-guided ESWL achieved a significantly higher treatment success rate than USG-guided ESWL (83.1% vs 67.7%; $p=0.042$), with a correspondingly lower failure rate (16.9% vs 32.3%).

Sessions and ancillary procedures: The study protocol allowed up to three ESWL sessions. The thesis reports that no patient required more than three sessions and that there was no statistically significant difference in the overall number of sessions. Ancillary procedures were required in 2 patients in the FS-guided group (RIRS) and in 5 patients in the USG-guided group (3 RIRS and 2 PCNL). The source narrative describes the difference as not statistically significant, but a corresponding p value is not reported in the thesis; therefore, the present manuscript does not assign a new significance value.

Inference: The number of ESWL sessions was similar between groups. Although ancillary procedures numerically occurred more often after USG-guided ESWL, the available source does not provide a p value for this comparison.

DISCUSSION

The principal finding of this study was that FS-guided ESWL produced a significantly higher treatment success rate than USG-guided ESWL (83.1% vs 67.7%; $p=0.042$) in patients with renal stones up to 20 mm. Importantly, this difference was observed despite comparable baseline demographic and stone characteristics, including stone size, density, location and skin-to-stone distance. The balanced baseline profile strengthens the interpretation that the

observed difference in treatment outcome was associated with the targeting modality, although residual confounding cannot be excluded.

Our findings are consistent with some comparative studies. Periasamy et al. reported success/stone-free rates of 75.5% with fluoroscopy and 70.8% with ultrasound, without a statistically significant difference.^[15] Chiang et al. similarly reported 83.7% versus 81.8% for fluoroscopy and ultrasound, respectively.^[16] The present study therefore agrees with the direction of these studies, although the magnitude of difference was greater in the present cohort.

Conversely, several studies have demonstrated equivalent or superior outcomes with ultrasound guidance. Van Besien et al., in a randomized prospective study, reported stone-free rates of 52% with ultrasound versus 42% with fluoroscopy and concluded that ultrasonography was not inferior.^[19] Smith et al. reported 60% versus 45% for ultrasound and fluoroscopy, respectively.^[20] Arunagiri et al. reported 86.2% with ultrasound compared with 83.1% with fluoroscopy.^[21] while Keskin et al. reported 84% versus 72% in favour of ultrasound targeting.^[22] These differences across studies suggest that ESWL outcome is multifactorial rather than determined solely by imaging modality.

One plausible explanation for the higher success observed with fluoroscopic targeting in the present study is more consistent visualization and targeting of the calculus during shock-wave

delivery. Fluoroscopy may facilitate rapid confirmation of stone position and allow repeated targeting when respiratory movement or patient movement occurs. Ultrasound, although radiation-free and capable of real-time imaging, is more dependent on operator experience, acoustic windows and stone visibility. The relative advantage of either method may therefore vary according to stone location, body habitus, stone size, renal anatomy and operator expertise. The present study found no significant differences in shock frequency, energy requirement or procedure duration at any treatment session. This suggests that the higher success with fluoroscopy was not accompanied by a measurable increase in these procedural parameters. The similarity in session duration is also relevant for clinical workflow because changing the targeting modality did not materially alter treatment time under the study protocol.

Safety outcomes were comparable. Most patients experienced only mild pain, and the difference in overall pain distribution was not significant. Hematuria occurred in 3.1% of the fluoroscopy group and 4.6% of the ultrasound group, with no significant difference. No urosepsis or steinstrasse was reported in either group. These observations are broadly consistent with the systematic review by Duarsa et al. and with comparative studies reporting similar complication profiles.^[16,17] The absence of urosepsis and steinstrasse in this cohort should nevertheless be interpreted cautiously because zero events in a sample of 130 patients do not establish that the risk is absent.

An important potential advantage of ultrasound guidance is avoidance of ionizing radiation. The present study did not report fluoroscopy time or radiation dose, so a quantitative comparison of radiation exposure cannot be made from these data. This is an important endpoint for future studies, particularly in patients who may undergo repeated procedures. Ultrasound may also be particularly useful in selected patients in whom fluoroscopic visualization is difficult or undesirable, although patient selection and operator expertise remain important.

The study has several strengths, including prospective randomized allocation, balanced baseline characteristics, standardized ESWL equipment and protocol, and assessment of both efficacy and safety outcomes. However, interpretation should consider the single-centre design, relatively modest sample size, approximately three-month follow-up, and absence of a cost-effectiveness analysis. The study also does not provide radiation-dose measurements, detailed stone composition data, or a multivariable analysis of predictors of treatment success. In addition, the source document contains an inconsistency in terminology, describing the design as both randomized/prospective and prospective observational; the allocation method and overall thesis framing support the randomized interpretation used in this manuscript.

Taken together, the results suggest that FS-guided ESWL may provide a higher probability of successful treatment in this particular patient population, while USG-guided ESWL offers comparable short-term safety and procedural characteristics. The choice of modality should therefore be individualized rather than based solely on efficacy, taking

into account stone characteristics, body habitus, availability of equipment, operator expertise and the clinical importance of avoiding ionizing radiation.

Strengths:

- Prospective randomized allocation with equal group sizes.
- Comparable baseline demographic and stone characteristics.
- Assessment of efficacy, procedural parameters and multiple safety outcomes.
- Use of a defined treatment-success criterion and structured follow-up.

Limitations:

- Single-centre design and relatively small sample size.
- Follow-up was approximately three months, limiting assessment of long-term recurrence and renal outcomes.
- Radiation exposure was not quantified.
- No cost-effectiveness analysis was performed.
- The source does not provide a p value for the ancillary-procedure comparison.
- The study does not report multivariable modelling of predictors of treatment success.

CONCLUSION

Among adults with single renal stones measuring 5–20 mm who underwent ESWL, FS-guided treatment achieved a significantly higher success rate than USG-guided treatment (83.1% vs 67.7%; $p=0.042$). Shock frequency, energy requirement, procedure duration and observed short-term complications were comparable between groups. No urosepsis or steinstrasse was observed. These findings support FS-guided ESWL as an effective targeting approach in this cohort, while USG-guided ESWL remains a useful alternative when avoidance of fluoroscopy is clinically desirable or fluoroscopic targeting is unsuitable. Larger multicentre randomized studies with longer follow-up, radiation-dose assessment and economic evaluation are needed.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Gastroenterology and urology devices; reclassification of the extracorporeal shock wave lithotripter. Food and Drug Administration, HHS. Final rule. Fed Regist. 2000;65(154):48609-48612.
2. Hayes JM, Ding SL. Pancreatic stone and treatment using ERCP and ESWL procedures: a case study and review. N Z Med J. 2012;125(1361):89-97.
3. Tzelves L, Türk C, Skolarikos A. European Association of Urology Urolithiasis Guidelines: Where Are We Going. Eur Urol Focus. 2021;7(1):34-38.
4. Goren MR, Goren V, Ozer C. Ultrasound-guided shockwave lithotripsy reduces radiation exposure and has better outcomes for pediatric cystine stones. Urol Int. 2017;98(4):429-435.
5. Nafie S, Dyer JE, Minhas JS, Mills JA, Khan MA. Efficacy of a

- mobile lithotripsy service: a one-year review of 222 patients. *Scand J Urol*. 2014;48(3):324-327.
6. Chung VY, Turney BW. The success of shock wave lithotripsy in treating moderate-sized (10–20 mm) renal stones. *Urolithiasis*. 2016;44(5):441-444.
7. Nielsen TK, Jensen JB. Efficacy of commercialised extracorporeal shock wave lithotripsy service: a review of 589 renal stones. *BMC Urol*. 2017;17(1):59.
8. Abdel-Khalek M, Sheir KZ, Mokhtar AA, Eraky I, Kenawy M, Bazeed M. Prediction of success rate after extracorporeal shock-wave lithotripsy of renal stones: a multivariate analysis model. *Scand J Urol Nephrol*. 2004;38(2):161-167.
9. Lee CC, Lin WR, Hsu JM, Chow YC, Tsai WK, Chiang PK, et al. Comparison of electrohydraulic and electromagnetic extracorporeal shock wave lithotriptors for upper urinary tract stones in a single center. *World J Urol*. 2019;37(5):931-935.
10. Fontanet S, Farré A, Oriol Angerri, Kanashiro A, Suquilanda E, Bollo J, et al. Bowel perforation after extracorporeal wave lithotripsy: a review of the literature. *J Clin Med*. 2023;12(3):1052.
11. Wang X, Zhang B, Zhu Y, et al. Abdominal aortic rupture after extracorporeal shockwave lithotripsy: a rare case report and literature review. *J Int Med Res*. 2020;48.
12. IuG A, Rapoport LM, Rudenko VI. Modern aspects of classification of the complications of extracorporeal shock wave lithotripsy. *Urologia J*. 2014;(6):57-60.
13. D'Addessi A, Vittori M, Racioppi M, Pinto F, Sacco E, Bassi P. Complications of extracorporeal shock wave lithotripsy for urinary stones: to know and to manage them—a review. *ScientificWorldJournal*. 2012;2012:619820.
14. Gitonga EN, Shen H. Small bowel obstruction and strangulation secondary to an adhesive internal hernia post ESWL for right ureteral calculi: a case report and review of literature. *BMC Gastroenterol*. 2021;21(1):176.
15. Periasamy P, Narashimman J, Maruthamuthu R, Ramakrishnan R, Vankadara K. The comparison of outcomes between USG guided ESWL vs fluoroscopy guided ESWL—our institutional experience. *Asian J Med Sci*. 2024;15(2):227-230.
16. Chiang YT, Chen SM, Tsui HM, Juang HH, Lin CW, Chiang MH, et al. Ultrasound-guided extracorporeal shock wave lithotripsy with minimal x-ray exposure prevented genitourinary tract injury in patients with urolithiasis in Taiwan. *Sci Prog*. 2023;106(4).
17. Duarsa GWK, Putra CN, Ivandi K, Wiryadana KA, Tirtayasa PMW, Pribadi F. Comparison of ultrasonography and fluoroscopy as guides for extracorporeal shock wave lithotripsy in nephrolithiasis patients: a systematic review. *Med J Indones*. 2022;31(3):160-169.
18. Chang TH, Lin WR, Tsai WK, Chiang PK, Chen M, Tseng JS, Chiu AW. Comparison of ultrasound-assisted and pure fluoroscopy-guided extracorporeal shockwave lithotripsy for renal stones. *BMC Urol*. 2020;20(1):183.
19. Van Besien J, Uvin P, Hermie I, Tailly T, Merckx L. Ultrasonography is not inferior to fluoroscopy to guide extracorporeal shock waves during treatment of renal and upper ureteric calculi: a randomized prospective study. *Biomed Res Int*. 2017;2017:1-7.
20. Smith H, Bryant D, KooNg J, Chapman R, Lewis G. Extracorporeal shockwave lithotripsy without radiation: ultrasound localization is as effective as fluoroscopy. *Urol Ann*. 2016;8(4):454.
21. Arunagiri A. Comparative study of efficacy of localization and fragmentation of renal stone by USG and fluoroscopy guided ESWL. *J Clin Diagn Res*. 2017;6(9):1-4.
22. Keskin SK, Keser F. Comparison of extracorporeal shock wave lithotripsy success rates between ultrasound targeting and X-ray targeting. *Endourol Bull*. 2023;15(3):109-114.