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SYSTEMATIC REVIEW AND META-ANALYSIS

Ureteroscopic Lithotripsy versus Extracorporeal Shock Wave Lithotripsy for Ureteral Stones According to Stone Size and Location: A Systematic Review and Meta-Analysis of Randomized Controlled Trials

Muhammad Rizki Fonna[1*], Ahmad Fauzan[2], Wilda Putri Utami[1]

[1]Medical Education Study Programme, Faculty of Medicine, Universitas Abulyatama, Aceh, Indonesia
[2]Department of Urology, Faculty of Medicine, Universitas Malikussaleh, Lhokseumawe, Indonesia

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***Corresponding author**
Muhammad Rizki Fonna
E-mail: mrizkifonna1996@gmail.com

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ABSTRACT

Background: Ureteroscopic lithotripsy (URS) and extracorporeal shock wave lithotripsy (SWL) are first-line treatments for ureteral stones, but their relative benefit by stone size and location has not been estimated from randomized evidence alone.

Objective: To compare stone-free rate, retreatment, auxiliary procedures, and complications after URS versus SWL for ureteral stones, by stone size and location.

Methods: We searched PubMed/MEDLINE, Scopus, Europe PMC, and OpenAlex for randomized and quasi-randomized trials comparing URS with SWL. Risk ratios (RR) were pooled with random-effects models (DerSimonian–Laird, Hartung–Knapp), including within-trial strata by stone location and size. Risk of bias (RoB 2) and certainty (GRADE) were rated.

Results: Twenty-three trials (3,507 participants) were included. URS achieved a higher stone-free rate than SWL (84.6% versus 67.1%; RR 1.26, 95% confidence interval [CI] 1.14 to 1.39; 22 trials; I^2 80.9%). For proximal stones, the RR was 1.26 (95% CI 1.10 to 1.45) above 10 mm and 1.10 (95% CI 0.83 to 1.47) at 10 mm or smaller (p = 0.14 for the difference); distal size strata came from one trial. Retreatment was less frequent after URS (RR 0.17, 95% CI 0.08 to 0.39); auxiliary procedures and complications did not differ significantly. Egger's test suggested small-study effects (p = 0.005), and trim-and-fill attenuated the RR to 1.10 (95% CI 0.98 to 1.25). Certainty was very low.

Conclusion: URS clears ureteral stones more often than SWL and reduces retreatment, but small-study effects make the size of the benefit uncertain; SWL remains a reasonable noninvasive option for small proximal stones.

1. Introduction

Urolithiasis is among the most common conditions that urologists treat. According to the Global Burden of Disease 2021 study, there were about 106 million incident cases and 693,444 disability-adjusted life years worldwide. Asia carried the largest burden, men a higher one,[1,2] and the lifetime risk differed widely across regions and socio-demographic strata.[3] Adults of working age bore a disproportionate share.[4] In population-based cohorts, new stone episodes grow more frequent with age.[5] Indonesia illustrates the cost: urolithiasis was the primary kidney disease in 10.3% of adults on kidney replacement therapy in five tertiary centers in Jakarta.[6] Stones that obstruct the upper urinary tract for too long do harm. Many ureteral stones pass on their own, and trials of medical expulsive therapy for small distal stones continue.[7,8] Larger, obstructing, infected or persistently painful stones need active removal.

Extracorporeal shock wave lithotripsy (SWL) and ureteroscopic lithotripsy (URS) are the two first-line active treatments for ureteral stones. SWL is noninvasive. It is usually done as an outpatient procedure with analgesia or sedation. Recent cohort studies of SWL for ureteral stones show that success depends on stone location, size and volume, density, impaction and the degree of hydronephrosis,[9–14] while positioning, ultrasound guidance and timing of treatment have been examined as further modifiers.[15–17] Ureteroscopy clears the stone under direct vision, usually in a single procedure, and modern holmium and thulium fiber lasers have improved fragmentation efficiency in randomized trials.[18–21] It does, however, need anesthesia and frequently a ureteral stent with its attendant symptoms,[22–24] and it carries risks of infection, ureteral injury and late stricture.[25–29] Cost, resource use and patient-reported quality of life also differ between the two.[30–33]

Choosing between the two is a trade-off between efficacy and invasiveness, and it depends on where the stone lies and how large it is. Recent comparative cohort studies reported higher clearance with URS in some subgroups and similar results in others.[34–37] In these studies, though, allocation follows stone characteristics and patient preference. Confounding by indication cannot be separated from the treatment effect. Large non-randomized comparisons in other populations share the limitation.[38] Earlier meta-analyses pooled randomized and non-randomized studies with size subgroups only,[39] included ten studies of mixed design,[40] concentrated on flexible ureteroscopy and mostly renal stones,[41] or summarized other reviews.[42] Definitions of the stone-free state vary widely, and so does the imaging that confirms it; both change the apparent stone-free rate.[43–47] The large pragmatic TISU trial[48] and recent randomized trials from Asia, the Middle East and Europe have not been pooled with earlier trials in a framework that treats stone location and size together.

The choice matters beyond the stone itself. Ureteroscopy usually calls for general or spinal anesthesia and an operating theater. It often leaves a stent that must be removed at a

second visit. SWL can be repeated as an outpatient procedure, but several sessions and extra imaging may pass before the patient is stone-free.[30,48] In health systems where SWL is offered in only some centers and endourological expertise sits in referral hospitals, a reliable estimate of the stone-free advantage by stone location and size would help clinicians decide whom to treat locally and whom to refer. It would also let patients weigh one invasive procedure against a noninvasive one with a less certain result.

This review differs from earlier syntheses in two respects. It restricts the comparison to randomized and quasi-randomized trials, which avoids confounding by indication when allocation is random. It also estimates the relative and absolute effect of URS versus SWL separately for each combination of stone location and size, using within-trial strata. A meta-regression on mean stone size and analyses of the stone-free definition, the timing and imaging of assessment and the SWL retreatment policy complement these estimates. The aim was to compare the stone-free rate after URS and SWL for ureteral stones by stone size and location, and to compare retreatment, auxiliary procedures, complications, hospital stay and procedure time. The certainty of evidence was rated for each outcome.

2. Methods

2.1. Study Design and Setting

This systematic review and meta-analysis was reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement.[49] The review question, eligibility criteria, outcomes and analysis plan were defined before the searches were run. PubMed/MEDLINE, Scopus, Europe PMC and OpenAlex were searched from their inception without language restrictions. Each search combined three concept blocks (ureteral stone, ureteroscopy and SWL) with a sensitivity-oriented filter for randomized and prospective designs. The PubMed string was: ("Ureteral Calculi"[Mesh] OR ureterolithiasis[tiab] OR (ureter*[tiab] AND (stone*[tiab] OR calcul*[tiab] OR lithiasis[tiab]))) AND ("Ureteroscopy"[Mesh] OR ureteroscop*[tiab] OR ureterorenoscop*[tiab] OR ureterolithotrips*[tiab] OR URS[tiab] OR URSL[tiab] OR "intracorporeal lithotripsy"[tiab]) AND ("Lithotripsy"[Mesh:NoExp] OR "High-Energy Shock Waves"[Mesh] OR "shock wave*"[tiab] OR shockwave*[tiab] OR "shock-wave*"[tiab] OR ESWL[tiab] OR SWL[tiab] OR "extracorporeal lithotripsy"[tiab]) AND (randomized controlled trial[pt] OR controlled clinical trial[pt] OR randomized[tiab] OR randomized[tiab] OR randomly[tiab] OR randomization[tiab] OR randomization[tiab] OR "Random Allocation"[Mesh] OR "Clinical Trials as Topic"[Mesh:NoExp] OR trial[ti] OR prospective*[tiab]) NOT ("Animals"[Mesh] NOT "Humans"[Mesh]). The Scopus string was: TITLE-ABS-KEY((ureter* W/3 (stone* OR calcul* OR lithiasis)) OR ureterolithiasis) AND TITLE-ABS-KEY(ureteroscop* OR ureterorenoscop* OR ureterolithotrips* OR urs OR ursl OR "intracorporeal lithotripsy") AND TITLE-ABS-KEY("shock wave*" OR shockwave* OR "shock-wave*" OR eswl OR swl OR "extracorporeal lithotripsy") AND TITLE-ABS-KEY(random* OR trial OR prospective*) AND DOCTYPE(ar). Equivalent title-abstract strings were used in Europe PMC and OpenAlex (Supplementary Table S1). The reference lists of the included trials and of previous systematic reviews were screened for further trials.

2.2. Participants and Eligibility

Table 1 sets out the eligibility criteria, built on the population, intervention, comparator, outcome and study design framework. Randomized controlled trials and quasi-randomized trials (alternation or a similar non-random sequence) were eligible. They had to compare URS with SWL as the primary treatment of ureteral stones and report at least one outcome by allocated arm. A trial with a third arm, for example laparoscopic ureterolithotomy, contributed only its URS and SWL arms. No participant was therefore counted twice. Extended-mid ureteral stones were analyzed with distal stones; the trial defined these as stones overlying the sacroiliac joint and extending towards the pelvic ureter. Trials that included renal stones counted only when ureteral stones were reported separately. Full reports in journals indexed in MEDLINE, Scopus or Web of Science were required.

Table 1. Eligibility criteria.

Element	Inclusion	Exclusion
Population	Adults (or predominantly adult samples) with a ureteral stone in any location and of any size requiring active removal	Pediatric-only trials; pregnancy; stones in transplanted or anomalous kidneys; steinstrasse or stones after failed primary treatment; renal stones without separate ureteral data
Intervention	Ureteroscopic lithotripsy as primary treatment: semirigid or flexible ureteroscopy with intracorporeal lithotripsy (laser, pneumatic, ultrasonic or electrohydraulic), with or without basket extraction and stenting	Push-back of the stone followed by renal treatment; percutaneous antegrade approaches
Comparator	In situ SWL as primary treatment, with repeat sessions as allowed by the trial protocol	SWL after ureteral manipulation or as salvage after failed ureteroscopy
Outcomes	Stone-free rate at the trial's primary assessment (primary); single-session stone-free rate, retreatment, auxiliary or further intervention, complications, fever or urinary infection, hospital stay, procedure time	Trials reporting none of these outcomes by allocated arm
Design and report	Randomized or quasi-randomized controlled trials with parallel groups; full reports in journals indexed in MEDLINE, Scopus or Web of Science	Non-randomized comparisons, patient-preference allocation, conference abstracts, reviews and duplicate reports (most complete report retained)

SWL, extracorporeal shock wave lithotripsy.

2.3. Variables and Data Collection

Records from the four databases were merged and de-duplicated on PubMed identifier, digital object identifier and normalized title. A rule-based triage removed records that were clearly conference abstracts, non-primary publications, pediatric studies or reports with no URS-SWL comparison. All remaining records were screened on title and abstract, and potentially eligible reports were assessed in full. A piloted form captured the following data: country, design and method of randomization, numbers randomized and analyzed, age,

sex, stone location and size range, mean stone size, ureteroscope type and intracorporeal energy source, lithotripter and number of SWL sessions allowed, definition of the stone-free state, imaging used and its timing, and all outcomes by arm. When reported separately, stone-free counts were also taken within trials by stone size (10 mm or smaller versus larger than 10 mm) and location. Where outcomes appeared only as percentages, counts were obtained by multiplying the percentage by the arm denominator and were checked against the reported percentages. One reviewer screened records and extracted data. A second reviewer checked every extracted number against the source report, and disagreements were resolved by discussion.

If a trial reported the stone-free rate at several time points, we took the one it designated as primary, or, when none was designated, the latest assessment within three months of treatment. The stone-free rate after a single session of the allocated treatment was extracted separately whenever available. Retreatment meant a repeat session of the allocated modality. Auxiliary or further intervention meant any additional procedure as defined by each trial: crossover to the other modality, percutaneous drainage or a secondary procedure for residual fragments. Counts derived from reported percentages are marked in Table 2. Supplementary Table S2 lists the reports excluded at full-text assessment, with reasons.

Every report was checked for internal consistency before inclusion. We compared the numbers randomized and analyzed, counts and percentages, the abstract, text and tables, and reports from the same center or author group. Where reports described the same patients yet differed irreconcilably in study period, intervention or arm-level results, they were excluded as duplicate publications with conflicting data. Trials with inconsistencies that did not block extraction were kept and flagged. A sensitivity analysis removed them. If the abstract and the results tables disagreed, we used the tables.

Risk of bias was assessed for the stone-free outcome with the revised Cochrane risk-of-bias tool for randomized trials (RoB 2), whose reliability improves with structured implementation guidance.[50] The five domains (randomization process, deviations from the intended interventions, missing outcome data, measurement of the outcome and selection of the reported result) were judged as low risk, some concerns or high risk, and the overall judgement followed the worst domain. Alternation was rated as high risk in the randomization domain. The domain-level judgements and their reasons are given in Supplementary Table S3.

The primary outcome was the stone-free rate at each trial's primary assessment, as the trial defined it: complete clearance or clinically insignificant residual fragments. Secondary outcomes were the stone-free rate after a single session of the allocated treatment, retreatment with the allocated modality, auxiliary or further intervention, any complication, postoperative fever or urinary infection, hospital stay and procedure time. Risk ratios (RR) of URS versus SWL expressed the binary outcomes, so an RR above 1 for the stone-free rate favors URS, and mean differences (MD) expressed the continuous ones. Equation 1 gives the log risk ratio and its variance for each trial i. Zero cells received a continuity correction of 0.5.

$$y_i = \ln\left(\frac{a_i/n_{1i}}{c_i/n_{2i}}\right), \quad v_i = \frac{1}{a_i} - \frac{1}{n_{1i}} + \frac{1}{c_i} - \frac{1}{n_{2i}} \tag{1}$$

We preferred the risk ratio to the odds ratio. The stone-free state is a common outcome, and for such outcomes odds ratios overstate the relative effect; risk ratios also translate directly into absolute effects at a given baseline risk. Each trial's stone-free denominator was used as reported, with no imputation of missing outcomes. Trials in which every participant in both arms was stone-free stayed in the primary analysis with the continuity correction, so that all randomized evidence contributed. A sensitivity analysis removed them.

The pooled risk difference (RD) was estimated with the same random-effects model, and the number needed to treat (NNT) was its reciprocal, rounded up. Absolute effects per 1000 patients treated (ARD_{1000}) were derived from the pooled RR and the median SWL stone-free rate across trials, as shown in Equation 2; the same baseline was used in the summary of findings, where the effect was also shown at the lower and upper quartiles of the SWL stone-free rate.

$$\mathrm{ARD}_{1000} = 1000 \times p_{\mathrm{SWL}} \times (\mathrm{RR} - 1), \quad \mathrm{NNT} = \frac{1}{\mathrm{RD}} \tag{2}$$

2.4. Statistical Analysis

Trials were pooled with a random-effects inverse-variance model. The between-trial variance was estimated with the DerSimonian–Laird method (Equation 3), the pooled log RR was the weighted mean in Equation 4, and its 95% confidence interval (CI) used the Hartung–Knapp adjustment with a t distribution on k–1 degrees of freedom (Equation 5), which keeps the nominal coverage when trials are few and heterogeneous.[51]

$$\tau^2 = \max\left\{0, \frac{Q-(k-1)}{\sum_i w_i - \frac{\sum_i w_i^2}{\sum_i w_i}}\right\}, \quad w_i = \frac{1}{v_i} \tag{3}$$

$$\hat{\mu} = \frac{\sum_i w_i^* y_i}{\sum_i w_i^*}, \quad w_i^* = \frac{1}{v_i + \tau^2} \tag{4}$$

$$\hat{\mu} \pm t_{k-1,0.975}\sqrt{\frac{\sum_i w_i^*(y_i - \hat{\mu})^2}{(k-1)\sum_i w_i^*}} \tag{5}$$

Cochran's Q and I^2 quantified heterogeneity (Equation 6), with I^2 values of 25%, 50% and 75% taken as low, moderate and substantial. A 95% prediction interval (Equation 7) described the range of true effects expected in a new trial setting.[52]

$$Q = \sum_i w_i (y_i - \hat{\mu}_{\mathrm{FE}})^2 ,$$
$$I^2 = \max\left\{0, \frac{Q-(k-1)}{Q}\right\} \times 100\% \quad (6)$$

$$\hat{\mu} \pm t_{k-2,0.975}\sqrt{\tau^2 + \mathrm{SE}^2(\hat{\mu})} \quad (7)$$

We pre-specified subgroup analyses by trial-level stone location (proximal, distal, mixed) and stone size class (10 mm or smaller, larger than 10 mm, mixed). Further subgroups were intracorporeal energy source, SWL retreatment policy (single session versus retreatment counted), timing of the stone-free assessment (4 weeks or less versus later), risk of bias and allocation method. Each had a test for subgroup differences. The location-by-size analysis pooled the within-trial strata in four cells (proximal or distal, 10 mm or smaller or larger than 10 mm); this keeps each comparison randomized. A mixed-effects meta-regression of the log RR on each trial's mean stone size (Equation 8) used the Hartung–Knapp adjustment.

$$y_i = \beta_0 + \beta_1 x_i + u_i + \varepsilon_i,$$
$$u_i \sim N(0, \tau^2),$$
$$\varepsilon_i \sim N(0, v_i) \quad (8)$$

Some trials contributed strata to more than one location-by-size cell. The test across the four cells therefore ignores the correlation between strata from the same trial. Because the two proximal cells are the comparison of greatest clinical interest, we tested them separately as well. That result was read together with the trial-level subgroup analysis by stone size and with the meta-regression.

Sensitivity analyses repeated the primary analysis without the Hartung–Knapp adjustment, with restricted maximum likelihood and Paule–Mandel estimators of the between-trial variance and with a Mantel–Haenszel common-effect model. They also excluded, in turn, trials at high risk of bias, quasi-randomized trials, trials whose counts were derived from percentages, trials with internal reporting inconsistencies and trials in which all participants in both arms were stone-free; repeated the analysis in the trials that assessed stone-free status with computed tomography; and used the single-session stone-free rate as the outcome. A leave-one-out analysis assessed the influence of each trial. Complications were also pooled after excluding the trial that recorded only serious events.

When at least ten trials were available, small-study effects were examined with a funnel plot, Egger's regression, Harbord's score test and Peters' regression, with trim-and-fill as a complement.[53] Peters' regression uses the inverse of the sample size and gives fewer false-positive results for ratio measures of common binary outcomes. The tests were read together and not one by one. Analyses used R 4.5.3 with the meta and metafor packages. Two-sided $p < 0.05$ was taken as statistically significant, and subgroup analyses other than stone location and size were treated as exploratory.

The Core GRADE approach rated the certainty of evidence for each outcome.[54] Evidence from randomized trials started as high certainty. Ratings were lowered for risk of bias (most of the weight from trials with some concerns or high risk), inconsistency (I^2 of at least 50% or a prediction interval that included no effect), imprecision (a 95% CI that included no effect or appreciable benefit and harm, or fewer than 300 events) and possible small-study effects. Differences in the definition, imaging and timing of the stone-free assessment were handled under inconsistency and not indirectness, so the same concern did not lower the rating twice. Small-study effects were judged from all the tests and the trim-and-fill estimate together. Supplementary Table S4 gives the reasons for each rating.

2.5. Ethical Approval

Not applicable. This review analyzed published, de-identified data and did not require ethics approval or consent to participate.

3. Results

3.1. Study selection

The searches identified 1,494 records: 495 from PubMed/MEDLINE, 346 from Scopus, 474 from OpenAlex and 179 from Europe PMC. After the removal of 541 duplicates and 528 records marked ineligible by rule-based triage, 425 records were screened on title and abstract, and 34 reports were sought for retrieval. Three reports could not be retrieved and 31 were assessed in full.

Seven of the reports assessed in full were excluded. Five described allocation by patient or surgeon preference even though the study was called a trial. Two reports from the same center described the same 94 patients but differed in study period, intracorporeal energy source, follow-up time and arm-level results, and they were excluded as duplicate publications with conflicting data. In all, 23 trials reported in 24 reports were included, as illustrated in Figure 1.

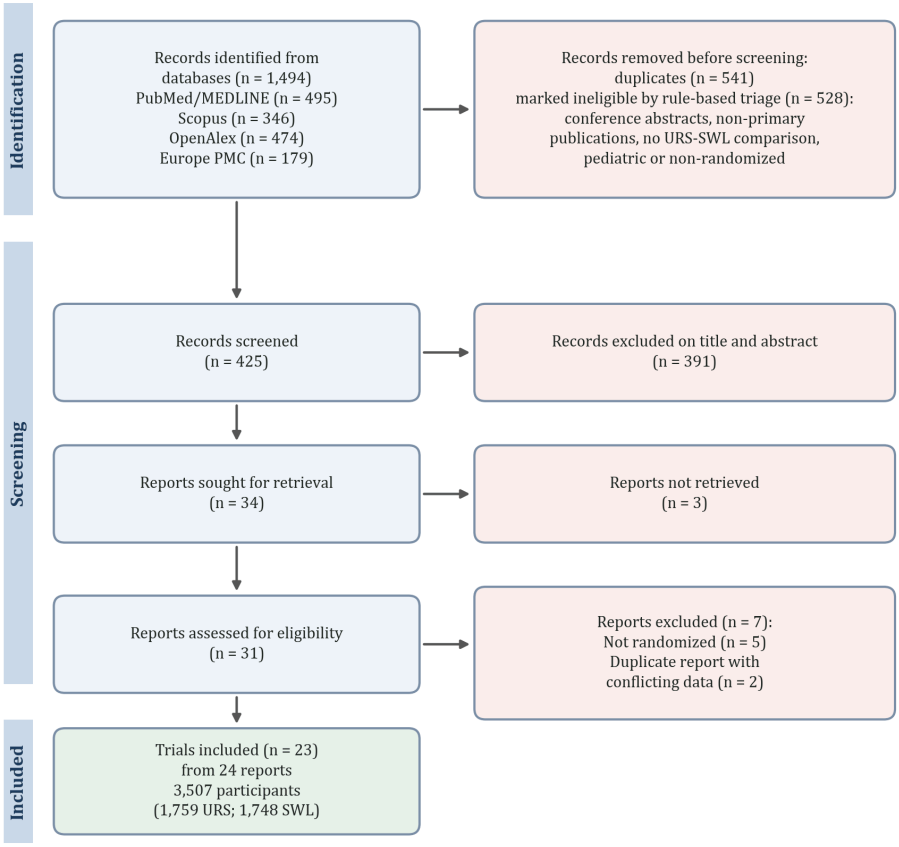


Figure 1. PRISMA 2020 flow diagram of the identification, screening and inclusion of trials.

3.2. Characteristics of the included trials

The 23 trials allocated 3,507 participants (1,759 to URS and 1,748 to SWL) in 12 countries. Nine trials were conducted in Pakistan; the rest came from Brazil, Egypt, Germany, India, Iran, Italy, the Netherlands, Taiwan, Turkey, the United States and the United Kingdom. Trial size ranged from 28 to 613 participants (median 114), and among the trials that contributed to the primary outcome the largest allocated 398. One trial used alternate allocation, and the others described random allocation.

Eighteen trials reported age, and the mean age of the arms ranged from 27 to 54 years. In the trials that reported sex, men made up 33% to 86% of the arms. Fourteen trials enrolled proximal (upper) ureteral stones, seven enrolled distal (lower) or extended-mid stones, and two enrolled stones in any location. Nine trials were restricted to stones larger than 10 mm, and four reported stone-free counts separately for stones of 10 mm or smaller and larger than 10 mm. The mean stone size ranged from 6.0 to 20.5 mm across arms.

Intracorporeal lithotripsy was pneumatic in seven trials and laser in five, ultrasonic or mixed energy was used in two, and nine reports did not specify the energy source; one trial used flexible ureteroscopy. Stone-free status was assessed with plain radiography, often combined with ultrasonography, in most trials and with computed tomography in four, between one week and three months after treatment.

SWL protocols allowed two to four sessions, or stated no limit. Only one trial assessed the primary stone-free outcome after a single SWL session. In all the others, the stone-free rate at the primary assessment included patients who had received repeat sessions. The large pragmatic TISU trial measured the need for further intervention and not imaging-confirmed clearance. It therefore contributed only to the secondary outcomes.[48,55] Table 2 details the characteristics of each trial.

Table 2. Characteristics of the included trials (ordered by year of publication).

Trial	Country	Design	Location	Size (inclusion)	Mean size, mm	n URS / SWL	Energy source	Stone-free definition; imaging	Stone-free URS vs SWL	RoB 2
Hendrikx 1999 †[56]	Netherlands	RCT	Distal	Extended-mid and distal ureteral stones	NR	87 / 69	Not reported	Stone-free at 12 weeks; imaging not reported	79/87 vs 35/69	Some concerns
Pearle 2001 †[57]	USA	RCT	Distal	≤15 mm	NR	32 / 32	Not reported	Resolution of the target stone; KUB	29/29 vs 29/29	Some concerns
Lee 2006[58]	Taiwan	RCT	Proximal	≥15 mm	18.5 / 17.9	20 / 22	Mixed	Stone-free or residual stone <=3 mm; KUB, US or IVU	7/20 vs 14/22	High
Salem 2009[59]	Egypt	Quasi-randomized	Proximal	5–20 mm	9.39 / 8.85	100 / 100	Pneumatic	Stone-free without any residual fragment; KUB + US	96/100 vs 71/100	High
Verze 2010 †[60]	Italy	RCT	Distal	5–15 mm	NR	136 / 137	Not reported	Overall stone-free; imaging not reported	129/136 vs 127/137	Some concerns

Trial	Country	Design	Location	Size (inclusion)	Mean size, mm	n URS / SWL	Energy source	Stone-free definition; imaging	Stone-free URS vs SWL	RoB 2
Islam 2012[61]	Pakistan	RCT	Distal	<25 mm	12.8 / 12.82	68 / 68	Pneumatic	Complete stone clearance; KUB + US	64/68 vs 50/68	Some concerns
Lopes Neto 2012 †[62]	Brazil	RCT	Proximal	>10 mm	NR	16 / 14	Not reported	Stone-free (success); imaging not reported	10/16 vs 5/14	Some concerns
Rabani 2012[63]	Iran	RCT	Proximal	>12 mm (12–26 mm)	17.59 / 17.69	32 / 30	Not reported	Stone-free on KUB and ultrasound; KUB + US	25/32 vs 19/30	Some concerns
Manzoor 2013 †[64]	Pakistan	RCT	Proximal	10–15 mm	11.32 / 10.84	199 / 199	Pneumatic	Stone-free on plain radiograph; KUB	115/199 vs 98/199	Some concerns
Ozturk 2013 †[65]	Turkey	RCT	Proximal	10–20 mm	13.2 / 13.2	48 / 52	Laser	Stone-free or residual fragments <4 mm (blinded assessor); KUB + US	39/48 vs 42/52	Some concerns
Kumar 2015[66]	India	RCT	Proximal	<20 mm	12.5 / 12.3	90 / 90	Laser	Stone-free at 3 months; imaging not reported	78/90 vs 74/90	Some concerns
Wazir 2015[67]	Pakistan	RCT	Distal	6–12 mm	9.18 / 9.18	112 / 112	Pneumatic	No stone or fragments <4 mm; KUB + US	101/112 vs 75/112	Some concerns
Mehrabi 2016[68]	Iran	RCT	Proximal	5–15 mm	10.44 / 11.85	27 / 32	Laser	Clearance or residual fragments <4 mm; KUB + US	23/27 vs 28/32	Some concerns
Imran 2017[69]	Pakistan	RCT	Proximal	≥10 mm	20.5 / 16	14 / 16	Pneumatic	Stone clearance; KUB + US; CT at 2 months	9/14 vs 6/16	Some concerns
Rehman 2019[70]	Pakistan	RCT	Proximal	10–20 mm	14.86 / 14.75	57 / 57	Not reported	Complete clearance; imaging not reported	48/57 vs 30/57	Some concerns
Adnan 2021[71]	Pakistan	RCT	Distal	<15 mm	9.8 / 9.8	50 / 50	Pneumatic	Complete stone clearance; CT	44/50 vs 33/50	Some concerns
Dasgupta 2021 (TISU)[48]	United Kingdom	RCT	Mixed	Any size (95% ≤10 mm)	6 / 6	307 / 306	Laser	Not assessed (need for further intervention); Clinical/radiological follow-up	Not assessed	Some concerns
El-Abd 2022[72]	Egypt	RCT	Proximal	5–15 mm	11.3 / 11.1	90 / 90	Ultrasonic	Clearance of all fragments (residual fragments <4 mm counted as not stone-free); KUB + NCCT	80/90 vs 70/90	Some concerns
Schoenthaler 2022[73]	Germany	RCT	Mixed	Single upper urinary tract stone ≤20 mm (ureteral subset)	8.4 / 7.8	15 / 13	Not reported	Complete stone clearance; imaging not reported	15/15 vs 10/13	Some concerns
Sarwar 2023[74]	Pakistan	RCT	Proximal	10–15 mm	12.67 / 12.63	30 / 30	Pneumatic	Stone-free on plain radiograph; KUB	28/30 vs 18/30	High
Mustafa 2024[75]	Pakistan	RCT	Proximal	10–15 mm	10.64 / 11.01	84 / 84	Laser	No visible residual fragments or fragments <4 mm; KUB + US	70/84 vs 54/84	Some concerns
Ali 2025[76]	Pakistan	RCT	Proximal	≥5 mm	11.48 / 10.92	25 / 25	Not reported	Complete clearance (residual stone >3 mm = failure); NCCT or US	23/25 vs 11/25	Some concerns
Jain 2026[77]	India	RCT	Distal	Any size (NCCT-confirmed lower ureteral stone)	11.07 / 10.91	120 / 120	Not reported	Stone clearance on plain KUB; KUB	114/120 vs 67/120	Some concerns

† Counts derived from reported percentages. Size is the inclusion range; mean stone size is given as URS / SWL arm in mm. n, participants allocated (URS / SWL); stone-free denominators are those of the trial's stone-free assessment. Stone-free is events/total, URS vs SWL, at the trial's primary assessment. CT, computed tomography; IVU, intravenous urography; KUB, plain radiograph of kidneys, ureters and bladder; NCCT, non-contrast CT; NR, not reported; RoB 2, overall risk-of-bias judgement; SWL, shock wave lithotripsy; URS, ureteroscopic lithotripsy; US, ultrasonography.

3.3. Risk of bias

For the stone-free outcome, 20 trials raised some concerns and three were at high risk of bias. No trial was at low risk in all domains (Figure 2). In the randomization domain, four trials described both an adequate random sequence and its concealment. Seventeen raised some concerns, and two were at high risk. One trial was at high risk for deviations from the intended interventions. Missing outcome data raised some concerns in seven trials and high risk in one. Measurement of the outcome raised concerns in twenty trials, because assessors aware of the treatment judged stone-free status on plain radiography or ultrasonography. Selection of the reported result raised concerns in twenty-one, as no pre-specified analysis plan was available.

The three high-risk judgements followed alternate allocation,[59] exclusion of nine patients after randomization for treatment preference,[58] and contradictory descriptions of the design and baseline data.[74] In ten trials the trustworthiness assessment found internal reporting inconsistencies that did not prevent extraction, such as an abstract that disagreed with the tables or percentages incompatible with the reported denominators. Six trials had stone-free counts derived from reported percentages. Supplementary Table S3 gives the domain-level judgements and their reasons.



Figure 2. Risk of bias of the included trials for the stone-free outcome (RoB 2). Top: judgement for each domain and overall (green, low risk; amber, some concerns; red, high risk). Bottom: proportion of trials in each category. D1, randomization process; D2, deviations from the intended interventions; D3, missing outcome data; D4, measurement of the outcome; D5, selection of the reported result.

3.4. Primary outcome: stone-free rate

Across 22 trials (2,888 participants), 1,226/1,449 patients (84.6%) were stone-free after URS and 966/1,439 (67.1%) after SWL. The stone-free rate ranged from 35% to 100% after URS and from 36% to 100% after SWL across trials. The pooled RR was 1.26 (95% CI 1.14 to 1.39; $p < 0.001$), with substantial heterogeneity (I^2 = 80.9%, 95% CI 72.0% to 87.0%; τ^2 = 0.0271; Q = 110.19, df = 21, $p < 0.001$), and the 95% prediction interval of 0.88 to 1.79 included no effect, as illustrated in Figure 3. Individually, eleven trials showed a significant advantage of URS, none showed a significant advantage of SWL, and two had point estimates below 1.

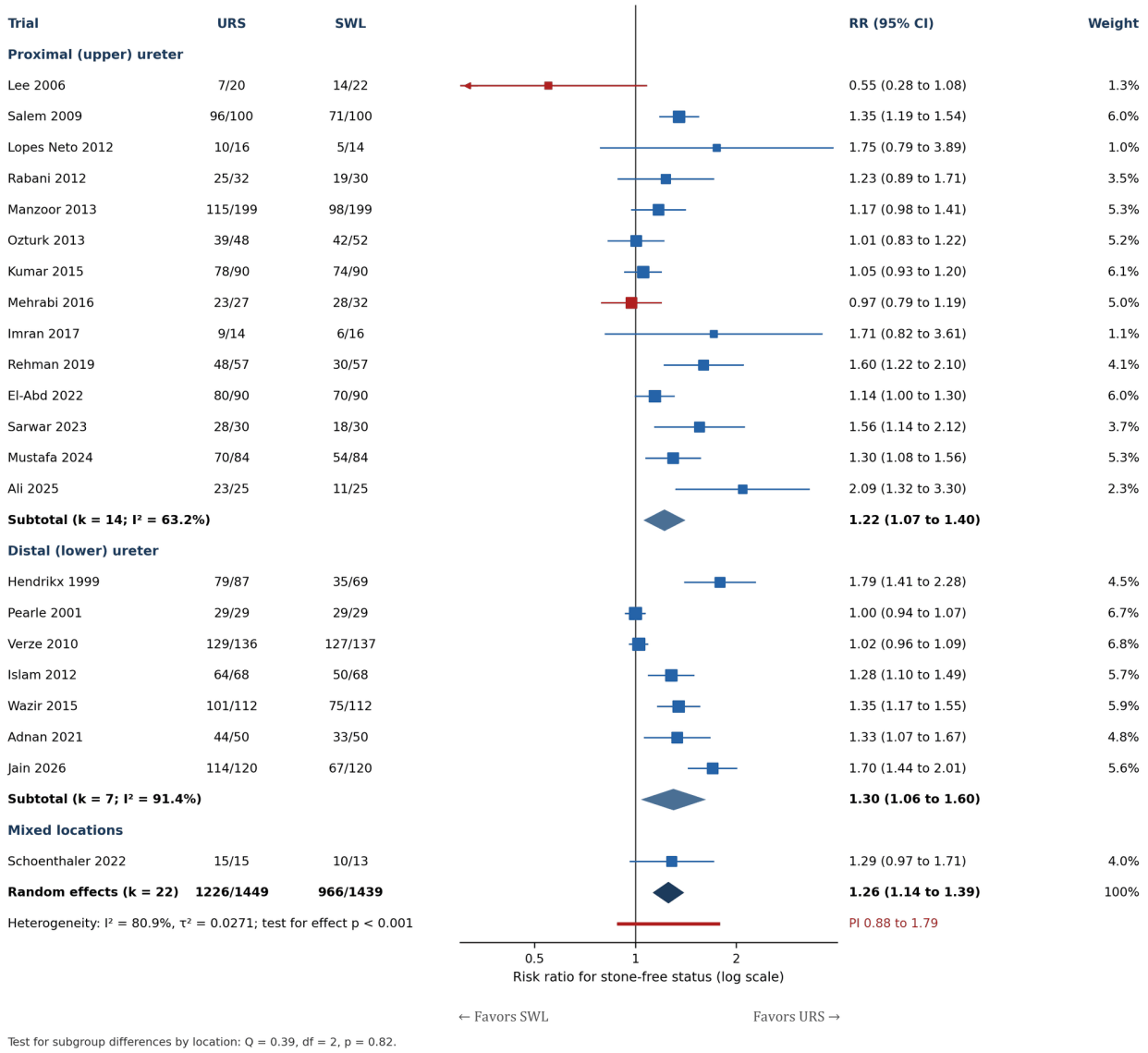


Figure 3. Forest plot of the risk ratio (RR) for stone-free status at the primary assessment, ureteroscopic lithotripsy (URS) versus shock wave lithotripsy (SWL), grouped by stone location. Squares are trial estimates (size proportional to random-effects weight) with 95% confidence intervals; diamonds are random-effects pooled estimates (DerSimonian–Laird, Hartung–Knapp) and the red bar the 95% prediction interval. Counts are stone-free/total.

The pooled risk difference was 0.17 (95% CI 0.10 to 0.25), corresponding to a number needed to treat of 6 (95% CI 5 to 10). Applied to the median SWL stone-free rate of the trials (65.1%), the pooled RR corresponds to 167 more stone-free patients per 1000 treated with URS (89 to 252); at the lower and upper quartiles of SWL clearance (53.4% and 77.6%) the difference would be 137 and 198 per 1000, respectively.

Pooled by trial-level location, the RR was 1.22 for proximal stones (95% CI 1.07 to 1.40; k = 14; I^2 = 63.2%) and 1.30 for distal stones (95% CI 1.06 to 1.60; k = 7; I^2 = 91.4%), with no significant difference between locations (Q = 0.39, df = 2, p = 0.82).

3.5. Stone location and size

The within-trial strata, which keep each location-by-size comparison randomized, are illustrated in Figure 4. For proximal stones of 10 mm or smaller, 94.5% of patients were stone-free after URS and 85.0% after SWL (RR 1.10, 95% CI 0.83 to 1.47; k = 3; I^2 = 68.1%), an absolute difference of 9.5 percentage points. For proximal stones larger than 10 mm, 73.7% of patients were stone-free after URS and 58.8% after SWL (RR 1.26, 95% CI 1.10 to 1.45; k = 12; I^2 = 49.6%), a difference of 14.9 percentage points. The two proximal cells did not differ significantly (ratio of RR 1.14; Q = 2.15, df = 1, p = 0.14).

For distal stones, data split at 10 mm came from a single trial.[77] Among stones of 10 mm or smaller, 96.5% of patients were stone-free after URS and 50.8% after SWL (RR 1.90, 95% CI 1.48 to 2.44). For larger stones the figures were 93.5% after URS and 61.4% after SWL (RR 1.52, 95% CI 1.23 to 1.89). In that trial SWL was limited to two sessions and clearance was judged on plain radiography at three months, and its SWL clearance for small stones lay at the lower end of the range reported by the other distal trials (51% to 100%). These distal strata drove the test across all four cells (Q = 17.46, df = 3, p < 0.001). Grouping all strata by size regardless of location gave an RR of 1.23 (95% CI 0.80 to 1.91) for stones of 10 mm or smaller (4 strata) and 1.28 (95% CI 1.13 to 1.46) for larger stones (13 strata; p = 0.79 for the difference).

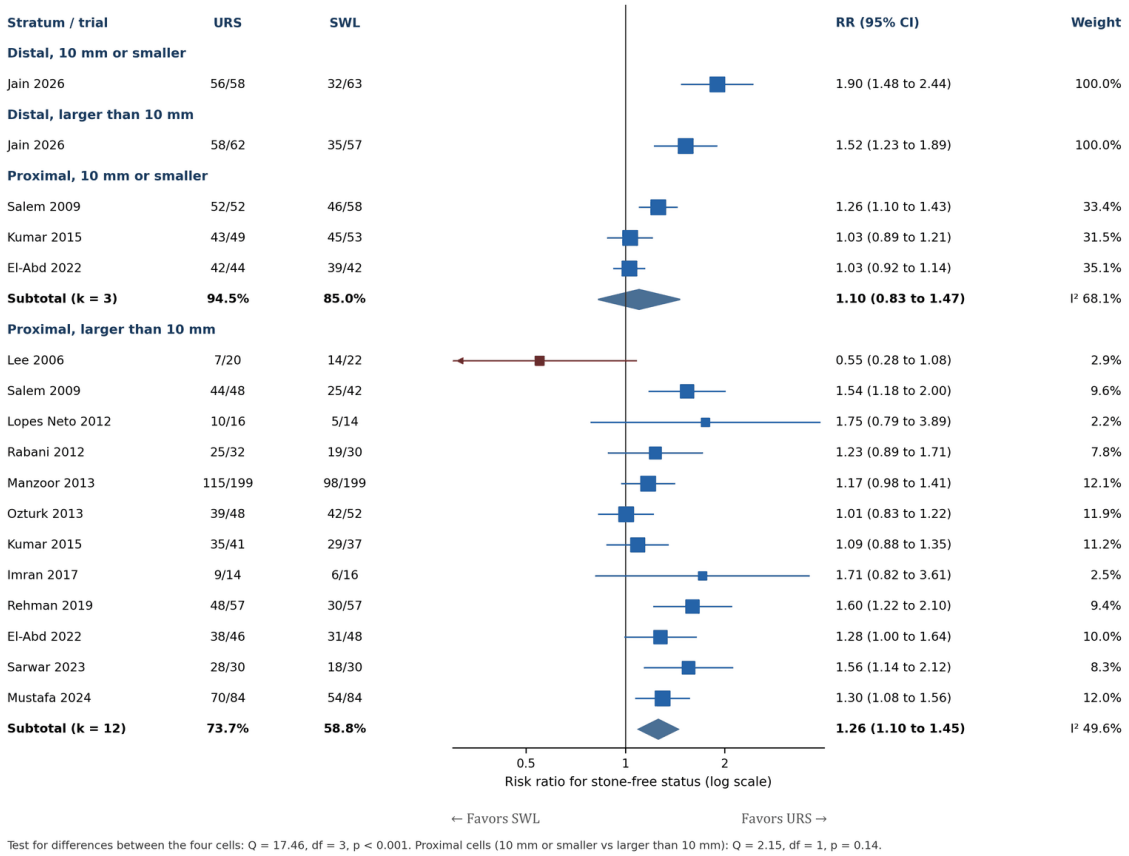


Figure 4. Within-trial comparisons of stone-free status by stone location and size (10 mm or smaller versus larger than 10 mm). Each row is the URS versus SWL comparison within one stratum of a trial; diamonds are random-effects pooled estimates for each location-by-size cell, with the pooled stone-free percentages after URS and SWL. Trials contributing to both proximal cells appear twice.

At trial level, the RR was 1.25 (95% CI 1.03 to 1.53) in the nine trials restricted to stones larger than 10 mm and 1.26 (95% CI 1.10 to 1.43) in the trials of mixed sizes (p = 0.99). The RR did not change significantly with mean stone size (ratio of RR 0.984 per millimeter, p = 0.46; 18 trials), and mean size explained 0.7% of the between-trial variance, as illustrated in Figure 5.

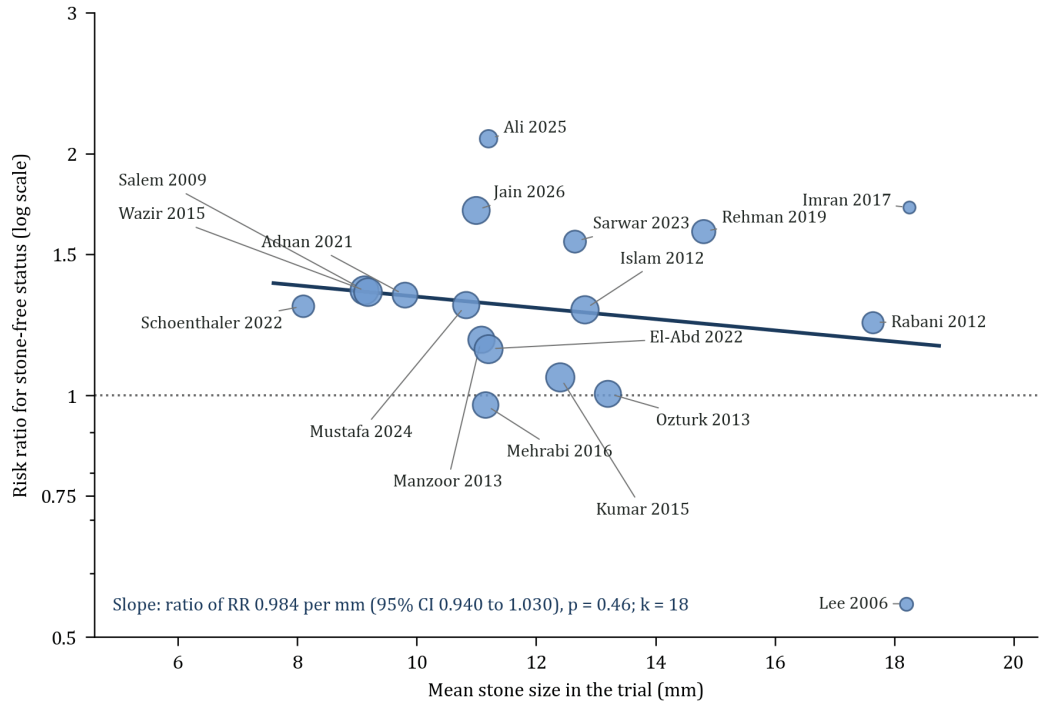


Figure 5. Meta-regression of the log risk ratio for stone-free status on the mean stone size of each trial. Circle area is proportional to the random-effects weight; the line is the fitted mixed-effects regression (Hartung–Knapp).

Among the exploratory trial-level subgroups, the RR was larger in trials using pneumatic lithotripsy (RR 1.32, 95% CI 1.24 to 1.41; k = 7; I^2 = 0.0%) than in trials using laser (RR 1.08, 95% CI 0.89 to 1.31; k = 4; I^2 = 44.0%; test for differences Q = 9.39, df = 2, p = 0.009). Assessments within four weeks (RR 1.29, 95% CI 1.09 to 1.52; k = 9; I^2 = 83.1%) and later assessments (RR 1.30, 95% CI 1.10 to 1.52; k = 9; I^2 = 78.4%; p = 0.48 for the difference) gave similar effects. The SWL retreatment policy, risk of bias and allocation method did not modify the effect either, as detailed in Table 3.

Table 3. Subgroup analyses, location-by-size strata and meta-regression for the stone-free rate.

Analysis	k	RR (95% CI)	I^2 (%)	p (difference or slope)
Trial-level subgroups				
Stone location: Distal (lower) ureter	7	1.30 (1.06 to 1.60)	91.4	0.82
Stone location: Proximal (upper) ureter	14	1.22 (1.07 to 1.40)	63.2	
Stone location: Mixed locations	1	1.29 (0.97 to 1.71)	–	
Stone size (trial level): Mixed sizes	13	1.26 (1.10 to 1.43)	86.5	0.99
Stone size (trial level): Larger than 10 mm	9	1.25 (1.03 to 1.53)	54.8	
Intracorporeal energy source: Other or not reported	11	1.30 (1.06 to 1.59)	87.2	0.009
Intracorporeal energy source: Pneumatic	7	1.32 (1.24 to 1.41)	0.0	
Intracorporeal energy source: Holmium laser	4	1.08 (0.89 to 1.31)	44.0	
SWL retreatment policy: SWL retreatment counted	21	1.25 (1.12 to 1.39)	80.6	0.35
SWL retreatment policy: Single SWL session	1	1.35 (1.19 to 1.54)	–	
Timing of assessment: More than 4 weeks	9	1.30 (1.10 to 1.52)	78.4	0.48
Timing of assessment: 4 weeks or less	9	1.29 (1.09 to 1.52)	83.1	
Timing of assessment: Not reported	4	1.05 (0.63 to 1.76)	51.6	
Risk of bias: Low risk or some concerns	19	1.25 (1.13 to 1.38)	80.9	0.90
Risk of bias: High risk of bias	3	1.21 (0.39 to 3.77)	73.7	
Allocation: Randomized	21	1.25 (1.12 to 1.39)	80.6	0.35
Allocation: Quasi-randomized	1	1.35 (1.19 to 1.54)	–	
Within-trial strata (location by size)				
Distal, 10 mm or smaller	1	1.90 (1.48 to 2.44)	–	< 0.001
Distal, larger than 10 mm	1	1.52 (1.23 to 1.89)	–	
Proximal, 10 mm or smaller	3	1.10 (0.83 to 1.47)	68.1	
Proximal, larger than 10 mm	12	1.26 (1.10 to 1.45)	49.6	
All strata, stones 10 mm or smaller	4	1.23 (0.80 to 1.91)	87.4	0.79
All strata, stones larger than 10 mm	13	1.28 (1.13 to 1.46)	52.0	
Meta-regression				
Mean stone size (per 1 mm), ratio of RR	18	0.98 (0.94 to 1.03)	–	0.46

Risk ratio (RR) above 1 favors ureteroscopic lithotripsy. The last column gives the p value of the test for subgroup differences (first row of each variable), of the test across strata, or of the meta-regression slope. Strata are within-trial comparisons by stone location and size; trials contribute to more than one cell. CI, confidence interval; SWL, shock wave lithotripsy.

3.6. Secondary outcomes

Stone-free status after a single session favored URS more strongly (RR 1.72, 95% CI 1.02 to 2.92; k = 6; I^2 = 88.2%), corresponding to 277 more stone-free patients per 1000 (7 to 618). Retreatment with the allocated modality was much less frequent after URS (RR 0.17, 95% CI 0.08 to 0.39; k = 9; I^2 = 59.5%), or 332 fewer retreatments per 1000 patients (246 to 371 fewer), probably because repeat SWL sessions were planned in most trials.

Auxiliary or further intervention did not differ significantly (RR 0.97, 95% CI 0.62 to 1.53; k = 10; I^2 = 69.5%). Any complication was numerically more frequent after URS (RR 1.22, 95% CI 0.87 to 1.72; k = 12; I^2 = 64.9%), and the result was similar after excluding the trial that recorded only serious events (RR 1.27, 95% CI 0.89 to 1.83; k = 11). Complications were defined differently across trials, from any adverse event to serious events requiring intervention. Postoperative fever or urinary infection did not differ significantly (RR 1.83, 95% CI 0.74 to 4.56; k = 6; I^2 = 0.0%).

Hospital stay was longer after URS (MD 1.02 days, 95% CI 0.04 to 1.99; k = 4; I^2 = 84.9%). In three trials the difference was close to one day, and in one it was 2.9 days. Four trials reported procedure time, with extreme heterogeneity (MD 18.77 minutes, 95% CI −35.72 to 73.26; k = 4; I^2 = 99.5%), so it is described and not interpreted: SWL was shorter in two

trials, URS was shorter in one, and the two did not differ in one. Figure 6 summarizes the pooled estimates, and Table 4 gives the summary of findings with the certainty of evidence for each outcome.

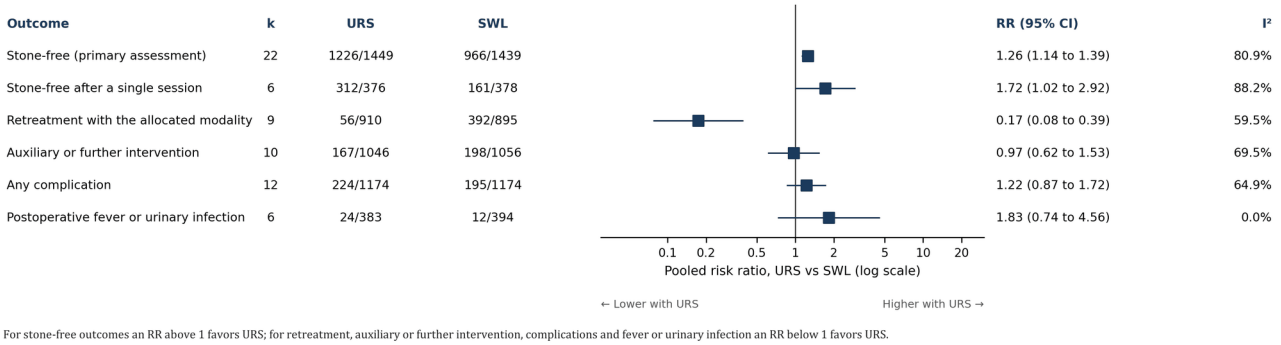


Figure 6. Pooled risk ratios (95% confidence interval, log scale) of URS versus SWL for the primary and secondary binary outcomes; I^2, between-trial heterogeneity. For stone-free outcomes an RR above 1 favors URS; for retreatment, auxiliary procedures and complications an RR below 1 indicates fewer events with URS.

Table 4. Summary of findings: ureteroscopic lithotripsy versus shock wave lithotripsy for ureteral stones.

Outcome	k	URS events/total	SWL events/total	Effect (95% CI)	I^2 (%)	Difference per 1000 at median SWL risk (95% CI)	Difference per 1000 at lower / upper quartile	GRADE certainty
Stone-free rate (primary assessment)	22	1226/1449	966/1439	1.26 (1.14 to 1.39)	80.9	+167 (+89 to +252)	+137 / +198	Very low
Stone-free after a single session	6	312/376	161/378	1.72 (1.02 to 2.92)	88.2	+277 (+7 to +618)	+241 / +324	Low
Retreatment with the allocated modality	9	56/910	392/895	0.17 (0.08 to 0.39)	59.5	−332 (−371 to −246)	−263 / −371	Low
Auxiliary or further intervention	10	167/1046	198/1056	0.97 (0.62 to 1.53)	69.5	−6 (−82 to +115)	−4 / −6	Very low
Any complication	12	224/1174	195/1174	1.22 (0.87 to 1.72)	64.9	+17 (−10 to +54)	+14 / +28	Very low
Postoperative fever or urinary infection	6	24/383	12/394	1.83 (0.74 to 4.56)	0.0	+33 (−10 to +141)	+7 / +49	Very low
Hospital stay (days)	4	–	–	MD 1.02 (0.04 to 1.99)	84.9	–	–	Not graded
Procedure time (minutes)	4	–	–	MD 18.77 (−35.72 to 73.26)	99.5	–	–	Not graded

Events/total by arm; RR, risk ratio of URS versus SWL (random effects, DerSimonian–Laird with Hartung–Knapp adjustment); MD, mean difference (URS minus SWL). Differences per 1000 patients apply the pooled RR to the median SWL risk across trials (Equation 2) and to its lower and upper quartiles. Reasons for rating down are given in Supplementary Table S4. CI, confidence interval; GRADE, Grading of Recommendations Assessment, Development and Evaluation.

3.7. Sensitivity analyses and small-study effects

In the leave-one-out analysis the pooled RR ranged from 1.23 (omitting Hendrikx 1999[56]) to 1.28 (omitting Pearle 2001[57]), and every estimate excluded no effect. Alternative estimators of the between-trial variance gave RRs of 1.26 (restricted maximum likelihood) and 1.26 (Paule–Mandel), and the Mantel–Haenszel common-effect model gave 1.26 (95% CI 1.21 to 1.32). The estimate was similar after excluding trials at high risk of bias (RR 1.25, 95% CI 1.13 to 1.38; k = 19), the quasi-randomized trial (RR 1.25, 95% CI 1.12 to 1.39; k = 21), trials with internal reporting inconsistencies (RR 1.24, 95% CI 1.06 to 1.44; k = 12), trials whose counts were derived from percentages (RR 1.30, 95% CI 1.16 to 1.45; k = 16) and the trial in which all participants were stone-free (RR 1.28, 95% CI 1.15 to 1.41; k = 21).

The four trials that assessed clearance with computed tomography gave an RR of 1.38 (95% CI 0.92 to 2.07), a point estimate similar to the primary analysis with a wider interval. These analyses are illustrated in Figure 7.

The funnel plot was asymmetrical, as illustrated in Figure 8. Egger's test (p = 0.005) and Harbord's test (p = 0.04) suggested small-study effects, whereas Peters' test did not (p = 0.81). Trim-and-fill imputed eight trials on the side of smaller effects and attenuated the RR to 1.10 (95% CI 0.98 to 1.25).

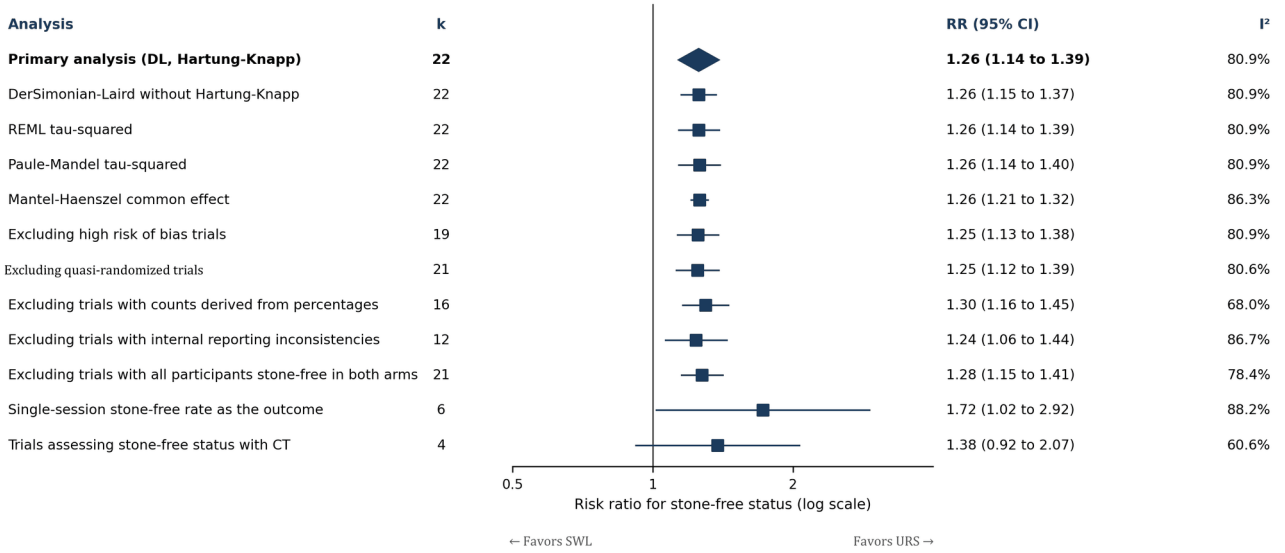


Figure 7. Sensitivity analyses of the primary outcome under alternative estimators, models and trial sets. The dark diamond is the primary analysis. DL, DerSimonian–Laird; REML, restricted maximum likelihood; PM, Paule–Mandel; CT, computed tomography.

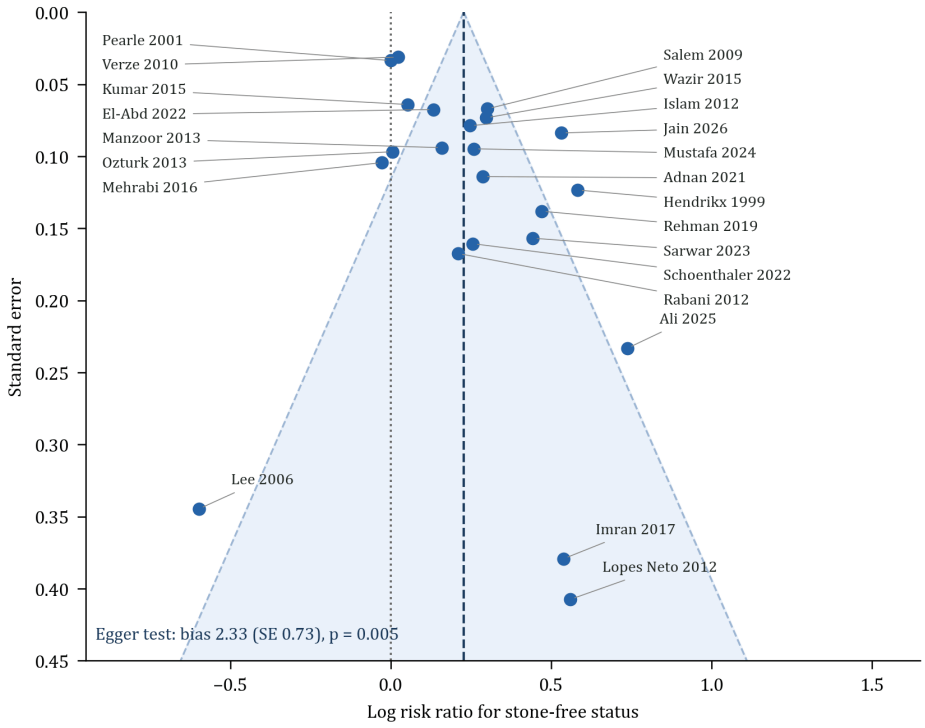


Figure 8. Funnel plot of trial log risk ratios for stone-free status against their standard errors. The dashed line marks the pooled estimate, the dotted line no difference and the shaded region the pseudo 95% confidence limits.

4. Discussion

4.1. Principal findings

In this meta-analysis of 23 randomized and quasi-randomized trials, URS left more patients stone-free than SWL. The pooled RR was 1.26 (95% CI 1.14 to 1.39), the absolute gain was about 17.5 percentage points, and retreatment fell by more than 80%, largely because repeat SWL sessions were planned in most trials. The size of this benefit is nevertheless uncertain. Two of three tests suggested small-study effects. The trim-and-fill estimate (1.10) was compatible with no difference, the prediction interval included no effect, and the certainty of evidence was very low.

URS showed a significant advantage for proximal stones larger than 10 mm. The estimate for proximal stones of 10 mm or smaller was smaller and imprecise. The two proximal cells did not differ significantly, so for small proximal stones the data show an absence of evidence of a difference, not evidence that the treatments are equivalent. Auxiliary procedures, complications and postoperative infection did not differ significantly. Hospital stay was about one day longer after URS.

4.2. Comparison with previous syntheses

Earlier syntheses point the same way. Their effects appear larger, although they are expressed as odds ratios or on different scales (OR 0.40 for SWL versus URS; RR 0.57 for SWL versus URS) and are not directly comparable with the present RR. A review that combined five randomized and thirteen

non-randomized studies found an odds ratio of 0.40 for stone-free status with SWL versus URS, with size subgroups only.[39] A meta-analysis of ten mixed-design studies also favored URS for the overall stone-free rate.[40] A recent meta-analysis centred on flexible ureteroscopy and mainly renal stones reported stone-free rates of 82.2% after URS and 64.4% after SWL.[41] An umbrella review estimated a risk ratio of 0.57 for SWL relative to URS.[42] Stated in the same direction, the present RR of 1.26 corresponds to an SWL-to-URS ratio of 0.80.

Two features of this review explain the smaller effect. It excludes non-randomized comparisons, where patients with smaller, less obstructing stones are steered towards SWL. It also includes the TISU trial, in which up to two SWL sessions were non-inferior to URS for the need for further intervention.[48] That trial's economic evaluation found SWL less costly but linked to slightly fewer quality-adjusted life-years.[30] A large non-randomized comparison in children found no clinically meaningful difference in clearance, yet patient-reported outcomes were better after SWL.[38] Pragmatic randomized trials in renal stones have weighed clearance against quality of life and cost in the same way.[78] Recent comparative cohort studies again reported higher clearance with URS in some subgroups and similar results in others.[34–37] What does this review add? It gives a randomized estimate for each location-by-size cell where data allow, and it shows how far the overall advantage of URS depends on how the stone-free state is measured.

4.3. Clinical and biological plausibility

The pattern by location and size is biologically plausible. A shock wave has to fragment the stone in situ, inside an often collapsed ureter. Then the fragments must pass. Fragmentation falls with stone size, volume, density and impaction, and clearance falls with hydronephrosis and with the time a stone has stayed in one place.[9–14] These effects may accumulate beyond 10 mm, which would fit the clearer URS advantage for large proximal stones. Ureteroscopy removes or dusts the stone under vision, whatever its density. Holmium and thulium lasers are still being compared in randomized trials, and one of them found the thulium fiber laser superior in clearing stones.[18–21]

In the distal ureter the pelvic bones and bowel gas complicate targeting. Positioning and ultrasound guidance have been evaluated as ways to improve SWL results there.[15,16] A semirigid ureteroscope reaches this segment most easily. Even so, the distal location-by-size estimates come from a single trial with a two-session SWL limit and radiographic assessment at three months, and they should not be generalized. The pooled RR across all distal trials, 1.30 (95% CI 1.06 to 1.60), was close to that for proximal stones.

The larger effect in pneumatic-lithotripsy trials is exploratory. It should not be read as an advantage of pneumatic energy. Energy source was confounded with region, period and lithotripter generation: six of the seven pneumatic trials took place in Pakistan, whereas the four laser trials came from India, Iran, Pakistan and Turkey, one of them using flexible ureteroscopy. Services that use contemporary lasers may find the laser estimate (RR 1.08, 95% CI 0.89 to 1.31) the more relevant reference. Its confidence interval included no effect, but it rests on only four trials and cannot exclude a clinically important advantage of URS.

4.4. Heterogeneity and the definition of the stone-free state

Heterogeneity was considerable (I^2 80.9%). It probably reflects, at least in part, how and when clearance was measured. Most trials used plain radiography and ultrasonography one to twelve weeks after treatment, which misses small or radiolucent fragments, and only four used computed tomography. The stone-free rate also depends on whether residual fragments up to 3 or 4 mm are accepted, as zero-fragment and CT-based definitions show.[43–45] Prediction tools for ureteroscopy outcomes point to the same dependence on stone burden and impaction.[46,47] Timing of assessment and restriction to computed tomography trials left the estimate largely unchanged. Even so, these analyses had little power to detect a modest modification of the effect.

In all but one trial the primary assessment included repeat SWL sessions, so the primary RR compares a single URS procedure with a short course of SWL. For a single session the RR was larger, 1.72 (95% CI 1.02 to 2.92), which matters to patients who value one definitive treatment. The prediction interval (0.88 to 1.79) includes no effect. A well-run SWL service may therefore approach the results of URS in some settings. The absolute difference depends on the local SWL stone-free rate: 137 per 1000 at an SWL clearance of 53.4%, and 198 per 1000 at 77.6%. Services can apply the relative effect to their own SWL results.

4.5. Small-study effects and robustness

The three tests for small-study effects did not agree. Egger's and Harbord's tests suggested asymmetry. Peters' test, which relates the effect to sample size and not to the standard error, did not. For risk ratios of a common outcome, trials in which most patients in both arms become stone-free have small standard errors and risk ratios close to 1. This creates an association between effect size and precision that does not necessarily reflect selective publication.[53] Differences in stone size, technique and outcome definition between small and large trials can produce the same pattern.

Trim-and-fill assumes that asymmetry arises from missing trials. It tends to over-correct when heterogeneity is large. Its estimate of 1.10 is therefore better read as a lower bound than as an unbiased estimate of the effect, and the certainty of evidence was rated down for possible small-study effects to allow for both interpretations. The primary estimate, by contrast, was stable across estimators, models and trial subsets. Omitting any single trial, or excluding trials at high risk of bias, with reporting inconsistencies, with counts derived from percentages or with complete clearance in both arms, gave RRs between 1.23 and 1.30. Every confidence interval excluded no effect.

4.6. Safety, resources and patient experience

Retreatment was less frequent after URS (RR 0.17, 95% CI 0.08 to 0.39). Auxiliary procedures were not fewer, because ureteral stents, conversions and secondary SWL for migrated fragments counted against URS. Complications were numerically more frequent after URS (RR 1.22, 95% CI 0.87 to 1.72), as the risks of infection, ureteral injury and stricture in contemporary series would predict.[25–28] Stents add symptoms that modern designs and shorter dwell times relieve only in part.[22–24] The complication estimate was imprecise and rested on heterogeneous definitions. A clinically important excess of harm with URS cannot be excluded, and neither can its absence.

Hospital stay was longer after URS. Day-case ureteroscopy, however, did not increase 30-day complications in a recent cohort.[29] Stone-specific quality-of-life scores change differently after each type of stone surgery.[33] A recent comparison of distal stones found similar quality of life and a shorter recovery after SWL.[37] Costs depend on stent use, reuse of instruments and reimbursement systems.[31,32] The clearance

benefit of URS must be set against anesthesia, a stent, a longer stay and a possibly higher complication rate. Patients differ here: those who prioritize a single definitive procedure will strike a different balance from those who prefer to avoid anesthesia.

4.7. Strengths and limitations

The review was restricted to randomized comparisons and searched four databases without language limits. Within-trial strata were pooled so that the location-by-size comparisons stayed randomized. Each report was assessed for trustworthiness. Stone size was examined as a continuous moderator, several definitions of the outcome were explored in sensitivity analyses, and the certainty of each outcome was graded with absolute effects at different baseline risks.

Several limitations apply. First, no trial was at low risk of bias in every domain, and ten reports contained internal inconsistencies, although excluding them did not change the result. Second, Egger's and Harbord's tests suggested small-study effects. Trim-and-fill attenuated the RR to a value whose confidence interval included no effect, so the true benefit may be smaller. Third, the distal location-by-size cells rested on a single trial, only four trials reported strata split at 10 mm, and strata from the same trial are not independent. Fourth, the meta-regression used each trial's mean stone size, available for 18 of 22 trials, and trial-level associations cannot be applied directly to individual patients.

Fifth, trials differed in how they defined, imaged and timed the outcome, and some counts had to be derived from reported percentages. Sixth, Embase, the Cochrane Library and trial registries such as ClinicalTrials.gov were not searched separately. Only full reports in indexed journals were eligible. Several small regional trials were therefore excluded. Seventh, one reviewer screened and extracted, and a second verified the numbers, so the work was not duplicated. Last, most trials used semirigid ureteroscopy with pneumatic lithotripsy and older lithotripters, and the estimates may not transfer directly to services that use modern lasers and flexible instruments.

4.8. Implications for practice and research

For proximal stones larger than 10 mm, the randomized evidence supports URS as the treatment more likely to clear the stone in one procedure. For proximal stones of 10 mm or smaller, no significant difference was found. The pooled stone-free rates were 94.5% after URS and 85.0% after SWL. The confidence interval, however, is compatible with a clinically important advantage of URS. Patient preference, anesthetic risk and local resources can therefore guide the choice. For distal stones URS was favored across trials, and the single trial with size strata favored it in both size groups.

In Indonesia, urolithiasis was the primary kidney disease in one in ten patients on kidney replacement therapy in five tertiary centers in Jakarta,[6] so prompt and effective clearance of stones matters. Future trials should report outcomes by stone location and size. They should use low-dose computed tomography and a zero-fragment definition. They should also record retreatment, stents, complications graded with a standard classification, and patient-reported outcomes, follow current reporting standards and have a pre-specified analysis plan.

5. Conclusion

This systematic review and meta-analysis of 23 randomized and quasi-randomized trials found a higher stone-free rate with ureteroscopic lithotripsy than with extracorporeal shock wave lithotripsy for ureteral stones (RR 1.26, 95% CI 1.14 to 1.39), or about 17.5 additional stone-free patients per 100 treated. Retreatment fell markedly. Small-study effects, however, make the size of the benefit uncertain. The advantage was clearest for proximal stones larger than 10 mm. For proximal stones of 10 mm or smaller no significant difference was found, and the distal size-specific estimates rest on a single trial. Auxiliary procedures, complications and postoperative infection did not differ significantly. Hospital stay was about one day longer after ureteroscopy, and complications were numerically more frequent.

The certainty of the evidence was very low. After adjustment for small-study effects the pooled estimate was compatible with no difference, the trials defined and measured the stone-free state differently, and no trial was free of risk of bias. Clinicians can present ureteroscopy as the option more likely to clear larger proximal stones in one procedure, at the cost of anesthesia, a stent and a longer stay. For small proximal stones, shock wave lithotripsy remains a reasonable noninvasive first choice. Patient preference, anesthetic risk and the availability of each service should shape the decision. To settle the size of the benefit, adequately powered trials should stratify by stone location and size, use computed tomography with a zero-fragment definition, and record patient-reported outcomes and costs.

Declarations

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Conflicts of interest

The authors declare no conflicts of interest.

AI use

The authors did not use generative artificial intelligence tools in preparing this manuscript.

Author contributions

M.R.F.: Conceptualization, Methodology, Investigation (literature search), Data curation, Formal analysis, Software, Writing – original draft. W.P.U.: Investigation (screening), Validation (data checking), Writing – review & editing. A.F.: Validation (urological interpretation of results), Supervision, Writing – review & editing. All authors approved the final version.

Data availability

The extracted dataset, risk-of-bias judgments, and analysis code are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

Not applicable. This review analyzed published, de-identified data and did not require ethics approval or consent to participate.

Consent for publication

Consent for publication was not required for this review.

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