

INPLASY

Comparative efficacy and safety of ESWL, RIRS, mini-PCNL, and PCNL for lower pole renal stones: a systematic review and network meta-analysis of randomized controlled trials

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ADMINISTRATIVE INFORMATION

Support - None.**Review Stage at time of this submission** - Completed but not published.**Conflicts of interest** - None declared.**INPLASY registration number:** INPLASY202660039**Amendments** - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 8 June 2026 and was last updated on 8 June 2026.

INTRODUCTION

Review question / Objective To compare the efficacy and safety of extracorporeal shock wave lithotripsy (ESWL), retrograde intrarenal surgery (RIRS), mini-percutaneous nephrolithotomy (mini-PCNL), and standard percutaneous nephrolithotomy (PCNL) for the treatment of lower pole renal stones through a network meta-analysis of randomized controlled trials. To compare the efficacy and safety of extracorporeal shock wave lithotripsy (ESWL), retrograde intrarenal surgery (RIRS), mini-percutaneous nephrolithotomy (mini-PCNL), and standard percutaneous nephrolithotomy (PCNL) for the treatment of lower pole renal stones through a network meta-analysis of randomized controlled trials.

Rationale Lower pole renal stones present unique management challenges due to the unfavorable anatomical drainage angle, which impairs spontaneous stone passage and reduces stone-free rates with certain treatments. Available

interventions include ESWL, RIRS, mini-PCNL, and standard PCNL, each with distinct efficacy and safety profiles. While pairwise meta-analyses have compared individual treatment pairs, no network meta-analysis has simultaneously compared all four modalities across multiple outcomes including stone-free rate, complications, operative time, hospital stay, and re-treatment rate. This network meta-analysis aims to provide a comprehensive evidence synthesis to guide clinical decision-making for lower pole renal stone management.

Condition being studied Lower pole renal calculi (nephrolithiasis) in adult patients. The lower pole is defined by its anatomical location within the kidney, characterized by an acute infundibulopelvic angle that impairs stone clearance. Patients with symptomatic or treatment-indicated lower pole stones of any size are included.

METHODS

Search strategy Search Strategy

Comparative efficacy and safety of ESWL, RIRS, mini-PCNL, and PCNL for lower pole renal stones: a network meta-analysis of randomized controlled trials

Database 1: PubMed

Search date: 2026-06-07 | Records retrieved: 100

No language restriction. No date restriction (searched from inception).

(lower pole OR lower calyx OR lower caliceal OR inferior pole OR inferior calyx OR inferior caliceal) AND (stone OR

stones OR calculi OR urolithiasis) AND (RIRS OR retrograde intrarenal surgery OR flexible ureteroscopy OR

ureteroscopy OR URS OR UAS OR PCNL OR mini-PCNL OR miniaturized percutaneous nephrolithotomy OR ESWL

OR shock wave lithotripsy) AND (randomized controlled trial)

Database 2: Embase

Search date: 2026-06-07 | Records retrieved: 261

No language restriction. No date restriction (searched from inception).

('lower pole' OR (lower AND pole) OR 'lower calyx' OR (lower AND ('calyx'/exp OR calyx)) OR 'lower caliceal' OR

(lower AND caliceal) OR 'inferior pole' OR (inferior AND pole) OR 'inferior calyx' OR (inferior AND ('calyx'/exp OR

calyx)) OR 'inferior caliceal' OR (inferior AND caliceal)) AND ('stone'/exp OR stone OR stones OR 'calculi'/exp OR

calculi OR 'urolithiasis'/exp OR urolithiasis) AND (rirs OR 'retrograde intrarenal surgery'/exp OR 'retrograde intrarenal

surgery' OR (retrograde AND intrarenal AND ('surgery'/exp OR surgery)) OR 'flexible ureteroscopy'/exp OR 'flexible

ureteroscopy' OR (flexible AND ('ureteroscopy'/exp OR ureteroscopy)) OR 'ureteroscopy'/exp OR ureteroscopy OR

urs OR uas OR 'pcnl'/exp OR pcnl OR 'mini pcnl'/exp OR 'mini-pcni' OR 'miniaturized percutaneous nephrolithotomy'/exp OR 'miniaturized percutaneous nephrolithotomy' OR (miniaturized AND percutaneous AND

('nephrolithotomy'/exp OR nephrolithotomy)) OR 'eswl'/exp OR eswl OR 'shock wave lithotripsy'/exp OR 'shock wave

lithotripsy' OR (('shock'/exp OR shock) AND ('wave'/exp OR wave) AND ('lithotripsy'/exp OR lithotripsy))) AND

('randomized controlled trial'/exp OR 'randomized controlled trial' OR (randomized AND controlled AND ('trial'/exp OR trial)))

Summa.

Participant or population Adults aged ≥ 18 years with symptomatic or treatment-indicated lower pole renal calculi of any size. Patients with solitary kidney, bleeding disorders, uncorrected coagulopathy, or active urinary tract infection are excluded.

Intervention Extracorporeal shock wave lithotripsy (ESWL), retrograde intrarenal surgery (RIRS, including flexible and digital ureteroscopy), mini-percutaneous nephrolithotomy (mini-PCNL, including all miniaturized PCNL variants with tract size ≤ 20 Fr), and standard percutaneous nephrolithotomy (PCNL, tract size > 20 Fr).

Comparator All four interventions serve as both intervention and comparator within the network: ESWL, RIRS, mini-PCNL, and PCNL. ESWL is used as the reference node.

Study designs to be included Randomized controlled trials (RCTs) only. Quasi-randomized trials will be included but flagged as high risk of bias.

Eligibility criteria Inclusion: RCTs comparing at least two of the four interventions (ESWL, RIRS, mini-PCNL, PCNL) in adults with lower pole renal stones, reporting at least one pre-specified outcome. Exclusion: non-RCT designs, conference abstracts without full text, studies on pediatric populations, studies not specifically reporting lower pole outcomes, open or laparoscopic surgery, medical expulsive therapy, and ECIRS.

Information sources PubMed and Embase, searched from inception to June 7, 2026, without language or date restrictions.

Main outcome(s) Stone-free rate (SFR), defined as absence of residual stones or clinically insignificant residual fragments on imaging at the primary follow-up time point as reported by each study.

Additional outcome(s) Overall complication rate (any Clavien-Dindo grade); major complication rate (Clavien-Dindo grade $\geq III$); operative time (minutes); length of hospital stay (days); re-treatment or auxiliary procedure rate.

Data management Data were extracted by one reviewer using a standardized form and checked by a senior supervisor. Extracted variables include study design, sample size, patient demographics, stone characteristics, intervention details, SFR definition, imaging modality, follow-up duration, and outcome data.

Quality assessment / Risk of bias analysis Risk of bias was assessed using the Cochrane Risk of Bias 2.0 (RoB 2.0) tool, evaluating five domains: randomization process, deviations from intended interventions, missing outcome data, measurement of the outcome, and selection of the reported result. Overall judgment: low risk, some concerns, or high risk.

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Author 2 - Chang CH - Provided clinical expertise, supervised the study design and methodology, and critically reviewed the manuscript. Conceived the study, designed the protocol, performed.

Strategy of data synthesis Frequentist random-effects network meta-analysis using MetaInsight (NICE Decision Support Unit). Binary outcomes reported as odds ratios (OR) with 95% CI; continuous outcomes as mean differences (MD) with 95% CI. Treatment rankings estimated using P-scores. Heterogeneity assessed using I^2 , Q statistic, and τ^2 . Inconsistency evaluated by node-splitting method.

Subgroup analysis None pre-specified.

Sensitivity analysis Five pre-specified sensitivity analyses: (SA-1) excluding studies with non-CT-based SFR assessment; (SA-2) excluding studies enrolling exclusively obese patients (BMI >30 kg/m²); (SA-3) excluding studies applying the strictest SFR definition; (SA-4) excluding studies with semi-rigid ureteroscopy classified under the RIRS node; (SA-5) splitting miniaturized PCNL node into mini-PCNL and ultra-mini/micro-PCNL if network connectivity allows.

Language restriction None.

Country(ies) involved Taiwan. Taipei.

Other relevant information This review is registered retrospectively. The review question, eligibility criteria, primary outcome, and analytical approach were defined prior to data analysis. All deviations from the original protocol have been documented.

Keywords Network meta-analysis; lower pole renal stones; stone-free rate; percutaneous nephrolithotomy; flexible ureteroscopy; shock wave lithotripsy; urolithiasis; randomized controlled trial.

Dissemination plans Results will be submitted for publication in a peer-reviewed urology journal.

Contributions of each author

Author 1 - Hsiang Yi Lee - Conceived the study, designed the protocol, performed the literature search, screened studies, extracted data, assessed risk of bias, conducted the network meta-analysis, and drafted the manuscript.