



Mini-Percutaneous Nephrolithotomy versus Retrograde Intrarenal Surgery for Lower Pole Renal Calculi of 15–25 mm: A Multi-Center Prospective Randomized Trial

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Abstract

Management of lower pole renal calculi measuring 15 to 25 mm remains controversial, with clinical contention between minimally invasive Mini-Percutaneous Nephrolithotomy (Mini-PCNL, 14–18 Fr sheath) and Flexible Ureteroscopy / Retrograde Intrarenal Surgery (RIRS) with high-power Holmium/Thulium fiber laser lithotripsy. In this prospective, randomized multi-center comparative trial conducted across tertiary academic centers in South Korea and Australia, 180 consecutive patients with single radiopaque lower pole stones (15–25 mm) were randomized 1:1 to either Mini-PCNL (n = 90) or RIRS (n = 90). The primary endpoint was stone-free rate (SFR) evaluated by non-contrast computed tomography (NCCT) at 4 weeks postoperatively (defined as no residual fragments > 2 mm). Mini-PCNL achieved a statistically superior initial SFR compared to RIRS (93.3% [84/90] vs 78.9% [71/90], $p = 0.007$), significantly reducing the need for secondary auxiliary procedures (2.2% vs 14.4%, $p = 0.003$). While RIRS was associated with shorter hospital length of stay (1.2 ± 0.4 vs 2.6 ± 0.7 days, $p < 0.001$) and lower postoperative visual analogue pain scores (VAS: 2.1 vs 3.8, $p < 0.001$), total operative duration was significantly longer in the RIRS cohort (74.5 ± 14.2 vs 52.8 ± 11.6 min, $p < 0.001$). Overall complication rates (modified Clavien-Dindo) were equivalent (13.3% in Mini-PCNL vs 11.1% in RIRS, $p = 0.654$), with zero major Grade IV/V complications or blood transfusions in either group. Mini-PCNL provides superior single-session stone clearance for 15–25 mm lower pole calculi, whereas RIRS offers faster convalescence when anatomical lower pole infundibulopelvic angles are favorable.

Keywords: Kidney Calculi; Mini-PCNL; Retrograde Intrarenal Surgery; RIRS; Lower Pole Nephrolithiasis; Stone-Free Rate; Holmium Laser

Abbreviations

Mini-PCNL: Mini-Percutaneous Nephrolithotomy; RIRS: Retrograde Intrarenal Surgery; SFR: Stone-Free Rate; NCCT:

Non-Contrast Computed Tomography; IPA: Infundibulopelvic Angle; VAS: Visual Analogue Scale; TFL: Thulium Fiber Laser.

Introduction

Lower pole renal calculi represent a distinct anatomical and surgical challenge due to gravity-dependent dependent calyces, acute infundibulopelvic angles (IPA < 30°), and narrow infundibular width, which impede spontaneous fragment clearance [1,2].

For stones measuring 15 to 25 mm, international urological guidelines (EAU and AUA) list both Retrograde Intrarenal Surgery (RIRS) and Percutaneous Nephrolithotomy (PCNL) as viable treatment options [3,4]. The advent of miniaturized PCNL (Mini-PCNL, 14–18 Fr) utilizing vacuum-assisted suction sheaths has markedly reduced tract-related bleeding and renal parenchymal trauma, directly challenging RIRS as the premier minimally invasive modality [5,6].

Materials and Methods

Between January 2023 and August 2024, 180 patients aged 18–75 with single radiopaque lower pole stones (maximum diameter 15–25 mm on pre-op NCCT) were enrolled across two academic tertiary centers (Seoul National University Hospital and Royal Melbourne Hospital). Patients were randomized 1:1 via computer-generated allocation to Mini-PCNL (n = 90) or RIRS (n = 90).

Mini-PCNL procedures utilized a 16 Fr suction-evacuation ClearPetra sheath with a 12 Fr nephroscope and Holmium:YAG laser lithotripsy (2.1 J, 20 Hz). RIRS procedures utilized flexible digital ureterorenoscopes (Olympus URF-V3 / Boston Scientific LithoVue) through a 10/12 Fr ureteral access sheath with high-power dusting (0.4 J, 50 Hz). Stone clearance was assessed at 4 weeks via non-contrast CT.

Results and Comparative Outcomes

Baseline demographic and stone characteristics were balanced between the two cohorts (mean stone size: 18.6 ± 2.8 mm in Mini-PCNL vs 18.2 ± 3.1 mm in RIRS, p = 0.38).

At 4-week NCCT evaluation, Mini-PCNL achieved a statistically superior primary stone-free rate (93.3% vs 78.9%, p = 0.007). Only 2 patients (2.2%) in the Mini-PCNL group required secondary auxiliary procedures compared to 13 patients (14.4%) in the RIRS group (p = 0.003). Mean operative time was significantly shorter in Mini-PCNL (52.8 ± 11.6 vs 74.5 ± 14.2 min, p < 0.001), whereas hospital stay was shorter in the RIRS group (1.2 ± 0.4 vs 2.6 ± 0.7 days, p < 0.001) [7,8].

Discussion and Clinical Practice Recommendations

Our multi-center randomized trial confirms that Mini-PCNL delivers superior single-session stone clearance for intermediate-sized (15–25 mm) lower pole renal calculi, eliminating the need for staged re-look procedures [9,10].

However, RIRS remains an outstanding outpatient option for patients with favorable lower pole anatomy (IPA > 45°), severe bleeding diatheses, or morbid obesity where percutaneous tract establishment carries heightened risks.

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