

Mini-ECIRS versus Multiple-Tract Mini-PCNL in the Management of Complex Renal Stones: A Narrative Review

Ashraf Mohamed Sami Shahin, Esam Abdelmohsen Mahmoud Desoky, Karim Elsayed Mohamed Elmeligy, Hamdy Mohamed Desoky

Urology Department, Faculty of Medicine, Zagazig University, Egypt

***Corresponding author:** Karim Elsayed Mohamed Elmeligy

Email: karimelmeligy300@gmail.com,

Abstract:

Background: Complex renal stones remain a significant challenge in endourological practice because of their large stone burden, involvement of multiple calyces, and complex intrarenal anatomy. Percutaneous nephrolithotomy (PCNL) is an established treatment for large and complex renal calculi; however, complete stone clearance may require multiple access tracts. Multiple-tract mini-PCNL has emerged as an alternative approach that provides direct access to different stone-bearing calyces while using miniaturized instruments to minimize access-related morbidity. Endoscopic combined intrarenal surgery (ECIRS) combines antegrade percutaneous nephroscopy with retrograde flexible ureteroscopy, allowing simultaneous access to different regions of the collecting system. Further miniaturization has led to the development of mini-ECIRS, which aims to achieve effective stone clearance while reducing renal parenchymal injury and the need for additional percutaneous punctures. Nevertheless, the optimal surgical approach for complex renal stones remains controversial, particularly regarding stone-free rates, operative time, blood loss, postoperative complications, and the need for secondary procedures. This review discusses the anatomical rationale, indications, technical principles, and clinical applications of multiple-tract mini-PCNL and mini-ECIRS, highlighting their potential advantages, limitations, and current evidence gaps to support surgical decision-making.

Keywords: Complex renal stones; Multiple-tract mini-PCNL; Mini-ECIRS; Percutaneous nephrolithotomy; Flexible ureteroscopy; Stone-free rate; Postoperative complications.

Introduction:

Mini-PCNL was introduced to reduce access related complication of standard PCNL, and also in patients with large staghorn or complex stone, a single tract may not provide access to all calyceal groups, for this reason the technique of multiple-tract mini-PCNL was developed. By creating two or more miniaturized percutaneous tracts, surgeons could directly access separate stone-bearing calyces, improve maneuverability, and achieve more complete stone clearance without the need for a single large tract.

Recent advances in imaging guidance, tract dilation systems, nephroscopes, and intracorporeal lithotripsy devices have further refined multiple-tract mini-PCNL. The procedure is now considered an important option for managing complex renal stones, offering a balance between high stone-free rates and reduced morbidity compared with conventional multiple-tract standard PCNL.

In the 2010s, studies by **Zeng et al. (1)** and subsequent research by **Zhong et al. (2)** contributed significantly to the advancement of miniaturized percutaneous renal surgery. Their studies showed that the use of multiple mini-tracts could provide high stone-free rates in patients with complex renal calculi while keeping complication rates within acceptable limits. As a result, current clinical guidelines consider miniaturized PCNL techniques, including multiple-tract mini-PCNL, to be effective treatment options for appropriately selected patients with large and complex kidney stones.

Anatomical rationale

The renal collecting system consists of the renal pelvis, major calyces, and minor calyces, which are arranged in a three-dimensional configuration within the renal parenchyma. The spatial relationship between individual calyces and their infundula has an important influence on the feasibility of reaching renal calculi through a particular percutaneous access **(3)**.

A single tract may provide excellent access to one calyceal group while providing a relatively indirect route to another. This becomes particularly relevant when stone material extends from the renal pelvis into multiple calyces or when a branching calculus occupies several regions of the collecting system **(4)**.

The orientation of the renal calyces means that access to one part of the collecting system does not necessarily provide an optimal working trajectory toward another part. Excessive deflection or manipulation of rigid instruments may consequently be required when attempting to treat distant calyceal components through a single tract **(5)**.

Therefore, the anatomical distribution of the stone rather than stone size alone may determine whether one access route is sufficient. Complex stones occupying multiple calyceal groups may require complementary access routes to achieve satisfactory visualization and instrumentation of the collecting system **(4)**.

This anatomical consideration is particularly important in staghorn calculi, in which the stone frequently extends from the renal pelvis into several calyceal branches. The three-dimensional configuration of these stones can make complete clearance through a single access technically challenging **(6)**.

The rationale for multiple tracts is therefore based primarily on providing appropriate access to different regions of the collecting system rather than simply increasing the number of instruments used during the procedure **(6)**.

Indications of Multiple tract Mini-PCNL

Multiple tract Mini-PCNL is primarily indicated for patients with large and complex renal calculi in whom complete stone clearance is unlikely to be achieved through a single percutaneous access. The technique is particularly suitable for complete or partial staghorn stones, stones occupying multiple calyceal groups, and complex calculi associated with unfavorable intrarenal anatomy. In such cases, attempting to treat the entire stone burden through a single tract may require excessive nephroscope angulation and torque, which can compromise visualization and increase the risk of infundibular or parenchymal injury.

Additional indications include residual stones remaining after initial tract clearance, stones distributed in widely separated calyces, and situations where direct access to different calyceal groups is necessary to facilitate efficient fragmentation and extraction.

The use of multiple mini-tracts aims to improve stone-free rates while preserving the advantages of miniaturized access, including reduced bleeding, less postoperative pain, and decreased renal parenchymal trauma compared with larger standard PCNL tracts.

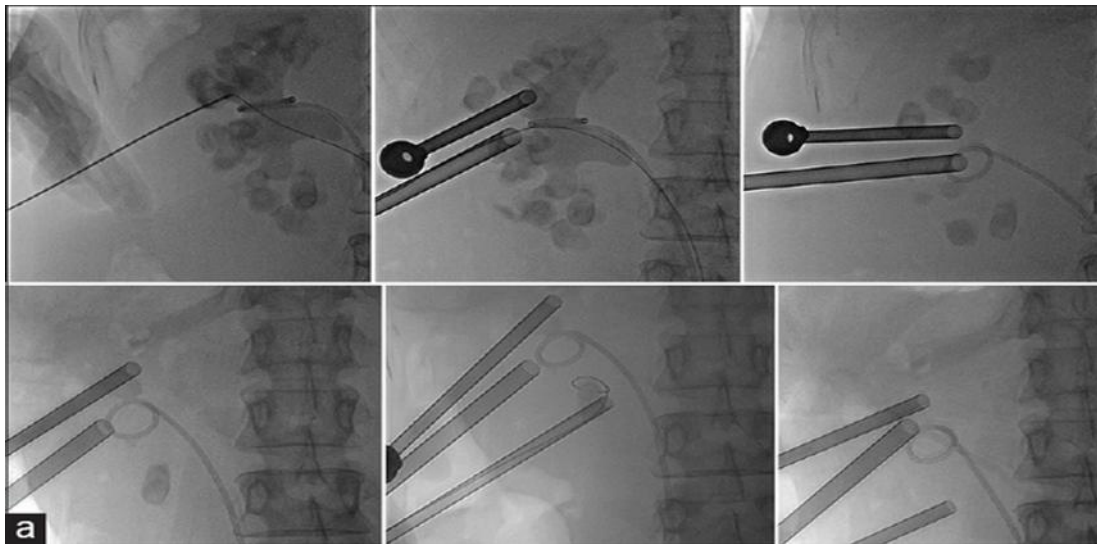


Figure (9): These are images captured during fluoroscopy by C-arm in the 5-tract case. With three incision sites because 2 tracts were punctured through the previous skin incision and reached different calyx. (7).

ECIRS

Historical Development

The concept of Endoscopic Combined Intrarenal Surgery (ECIRS) evolved from attempts to improve the management of large and complex renal calculi by combining the advantages of percutaneous nephrolithotomy (PCNL) and retrograde intrarenal surgery (RIRS). During the early development of PCNL, the procedure was traditionally performed in the prone position, which provided adequate access to the collecting system but was associated with several anesthetic and positioning-related limitations. To overcome these drawbacks, alternative patient positions were introduced, culminating in the development of the Galdakao-modified supine Valdivia (GMSV) position. This position enabled simultaneous antegrade and retrograde access to the upper urinary tract and created the foundation for the modern ECIRS technique (8).

The formal introduction of ECIRS was reported by **Scoffone et al.** (8), when they described the combined use of nephroscopy and flexible ureteroscopy in the GMSV position for the treatment of large and complex urolithiasis. Their prospective study demonstrated that ECIRS was a safe and effective procedure with high stone-free rates and the potential to reduce the need for multiple percutaneous tracts. The authors highlighted the advantages of the “four-hand” technique, in which simultaneous antegrade and retrograde manipulation improves visualization, facilitates stone relocation, and enhances fragment extraction (8).

Subsequent publications further established ECIRS as a logical evolution of PCNL rather than a completely new procedure. Cracco and Scoffone later emphasized that the combined antegrade–retrograde approach exploits the full spectrum of endourological instrumentation and allows individualized treatment according to stone burden and collecting system anatomy.

During the following decade, refinements in flexible ureteroscopy, laser lithotripsy, and miniaturized percutaneous instruments expanded the indications of ECIRS and improved its safety profile (9).

More recently, comparative studies and systematic reviews have shown that ECIRS can achieve excellent stone-free rates for complex renal stones while potentially reducing renal parenchymal trauma by avoiding additional access tracts (8).

Patient positioning

Patient positioning represents a fundamental component of Endoscopic Combined Intrarenal Surgery (ECIRS) because it directly influences renal access, ergonomics, anesthetic management, and the feasibility of simultaneous antegrade and retrograde procedures. The original and most widely adopted position for ECIRS is the Galdakao-modified supine Valdivia (GMSV) position, in which the patient is placed in a modified supine posture with the ipsilateral flank elevated and the lower limbs positioned asymmetrically to allow retrograde ureteroscopic access. This configuration enables concurrent percutaneous nephroscopy and flexible ureteroscopy, facilitating the “four-hand” technique and improving access to different calyces (8).

ECIRS performed in the GMSV position achieved high stone-free rates while providing important anesthesiological advantages and avoiding additional procedure-related complications. The position allows simultaneous antegrade and retrograde manipulation, which enhances stone relocation and fragment extraction (8).

Subsequently, The GMSV position is described as a major evolution of conventional prone PCNL because it offers improved airway control, easier patient monitoring, reduced cardiovascular and respiratory compromise, and better operative coordination between surgeons (9).

Alternative positions have also been described. Prone split-leg ECIRS permits simultaneous retrograde access while maintaining the traditional prone orientation familiar to many endourologists. More recently, the lateral decubitus (LD) position has been investigated as another modification of ECIRS. A comparative study by Otsuka et al. reported that ECIRS in the LD position was safe and effective, with stone-free and complication rates comparable to those achieved in the GMSV position. In addition, the LD position was associated with shorter fluoroscopy time and a modest reduction in operative time (10)



Figure (10): Galdakao-modified Valdivia position (11)

Mini ECIRS

Concept and Rationale

Mini-endoscopic combined intrarenal surgery represents a further refinement of the ECIRS concept through the incorporation of a miniaturized percutaneous tract. The main objective of this approach is to preserve the high stone clearance potential of combined antegrade and retrograde endoscopic surgery while reducing the tissue trauma associated with percutaneous access.

The rationale for Mini-ECIRS is particularly relevant in patients with complex renal calculi, in whom achieving complete clearance through a single conventional percutaneous tract may be difficult and multiple tracts may consequently be required. Instead of increasing the number of percutaneous accesses, Mini-ECIRS combines a small-caliber percutaneous tract with FURS, allowing the two routes to complement each other according to the location and configuration of the stone burden.

Thus, the principal distinction between conventional ECIRS and Mini-ECIRS is not the concept of combined endoscopic access itself, but rather the miniaturization of the percutaneous component. This modification is intended to reduce renal parenchymal injury while maintaining adequate working access for fragmentation and extraction of substantial stone burdens.

Development of Mini-ECIRS

The development of Mini-ECIRS followed the progressive miniaturization of PCNL instruments and the increasing adoption of FURS. Following the establishment of ECIRS as an effective approach for complex renal calculi, investigators sought to determine whether the percutaneous component could be reduced in size without compromising the effectiveness of the combined procedure.

A major step in this development was the study by **Hamamoto et al. (12)** who evaluated the simultaneous use of flexible ureteroscopy and mini-PCNL for the treatment of large renal calculi. Their technique used an 18-Fr percutaneous tract together with a 14-Fr ureteral access sheath. The authors reported that the combined approach achieved a higher initial stone-free rate than either mini-PCNL or conventional PCNL alone, while also demonstrating a favorable operative profile.

Subsequent studies progressively reduced the diameter of the percutaneous tract. Mini-ECIRS has subsequently been performed using smaller access sheaths, including approximately 16.5 Fr and, in selected techniques, smaller calibers. This evolution reflects the broader trend toward minimizing the morbidity of percutaneous renal surgery while maintaining sufficient working space for effective lithotripsy and fragment evacuation.

The development of Mini-ECIRS therefore represents a transition from “multiple access for complete clearance” toward “complementary access for complete clearance.” In this strategy, the flexible ureteroscope compensates for areas that are difficult to reach through the mini-percutaneous tract, potentially reducing the need for additional punctures.

Technical Principles

The technical principle of Mini-ECIRS is based on assigning different tasks to the antegrade and retrograde components according to stone location.

The mini-percutaneous tract provides direct access to the renal collecting system and allows effective fragmentation and extraction of relatively large stone fragments.

In contrast, the FURS provides access to calyces that may be unfavorable for the percutaneous trajectory, particularly lower-pole or anatomically remote calyces.

This complementary access is particularly useful in complex stones with a heterogeneous distribution throughout the pelvicalyceal system. Rather than attempting to reach every stone through the nephroscope, the retrograde instrument can be used to identify, manipulate, relocate, or fragment stones in areas that are difficult to approach antegradely.

Accordingly, the success of Mini-ECIRS depends less on maximizing the diameter or number of percutaneous tracts and more on optimizing the interaction between the two endoscopic approaches.

Mini-ECIRS in Complex Renal Stones

The potential value of Mini-ECIRS becomes most apparent in complex renal stone disease. Large staghorn calculi and stones involving multiple calyces often present a difficult access problem because the stone burden may extend beyond the reach of a single percutaneous trajectory.

Mini-ECIRS offers an integrated approach that c

ombines percutaneous and retrograde endoscopic access, allowing stones located outside the principal percutaneous trajectory to be addressed through flexible ureteroscopy. This complementary access can facilitate more comprehensive management of complex stone burdens while potentially reducing the need for additional renal punctures. Therefore, the potential benefit of Mini-ECIRS lies not only in the use of a smaller percutaneous tract, but also in its ability to optimize access to different regions of the collecting system while minimizing the number of percutaneous punctures.

Research Gap

Over the past two decades, remarkable advances in endourology have transformed the management of complex renal stones. Conventional PCNL has remained the gold-standard treatment for renal calculi larger than 2 cm because of its superior stone-free rates compared with other minimally invasive techniques. Continuous technological innovations have led to the development of miniaturized PCNL systems and, more recently, Endoscopic Combined Intrarenal Surgery (ECIRS), both of which aim to improve surgical efficacy while minimizing perioperative morbidity. Despite these advances, the optimal surgical strategy for patients with complex renal stones remains controversial.

Multiple-Tract Mini-PCNL has been widely adopted for patients with extensive stone burden involving multiple calyces, as it allows direct access to different parts of the collecting system and facilitates complete stone removal. Nevertheless, increasing the number of percutaneous access tracts has raised concerns regarding cumulative renal parenchymal injury, increased blood loss, prolonged operative time, and a potentially higher risk of postoperative complications. Conversely, Mini-ECIRS combines antegrade and retrograde endoscopic approaches, enabling simultaneous visualization of the collecting system and improving access to difficult calyces without necessarily requiring multiple renal punctures. This approach has been proposed to achieve comparable or even superior stone clearance while reducing surgical morbidity (1).

Although numerous studies have evaluated the outcomes of Mini-PCNL and ECIRS individually, direct comparative studies specifically evaluating Mini-ECIRS versus Multiple-Tract Mini-PCNL remain relatively limited. Furthermore, the published literature has demonstrated inconsistent findings regarding several clinically important outcomes (1).

While some studies have reported higher stone-free rates and lower complication rates with Mini-ECIRS, others have found no statistically significant differences between the two techniques. Similarly, controversy persists regarding operative time, fluoroscopy exposure, intraoperative blood loss, postoperative pain, hospital stay, and the need for secondary procedures (13).

Another important limitation of the currently available evidence is the considerable heterogeneity among published studies. Differences in patient selection criteria, definitions of complex renal stones, stone burden assessment, surgeon experience, patient positioning, tract size, energy sources for lithotripsy, postoperative imaging modalities used to determine stone-free status, and follow-up duration make direct comparison between studies difficult. Moreover, many published reports are retrospective, single-center studies with relatively small sample sizes, thereby limiting the strength and generalizability of their conclusions.

Current international guidelines from both the European Association of Urology (EAU) and the American Urological Association (AUA) recognize PCNL as the standard treatment for large and complex renal stones but do not provide definitive recommendations favoring Mini-ECIRS over Multiple-Tract Mini-PCNL because of the limited high-quality comparative evidence. Consequently, the choice of surgical approach is often based on surgeon preference, institutional experience, and individual patient characteristics rather than robust evidence (14).

Therefore, there remains a clear need for well-designed comparative studies evaluating the efficacy and safety of Mini-ECIRS and Multiple-Tract Mini-PCNL using standardized outcome measures.

Such studies may provide stronger evidence regarding stone-free rates, perioperative complications, operative efficiency, preservation of renal function, postoperative recovery, and the need for auxiliary procedures.

References:

1. Zeng, G., Zhong, W., Chen, W., Wu, W., & Yuan, J. (2010). MINIMALLY INVASIVE PERCUTANEOUS NEPHROLITHOTOMY FOR STAGHORN CALCULI: A NOVEL SINGLE SESSION APPROACH VIA MULTI-TRACTS: 1457. *Journal of Urology*, 183(4), e561.
2. Zhong, W., Zeng, G., Wu, W., Chen, W., & Wu, K. (2011). Minimally invasive percutaneous nephrolithotomy with multiple mini tracts in a single session in treating staghorn calculi. *Urological research*, 39(2), 117-122.
3. Sampaio, F. J. B. (2000). Renal anatomy: Endourologic considerations. *Urologic Clinics of North America*, 27(4), 585–607.
4. Verma, A., Tomar, V., & Yadav, S. (2016). Complex multiple renal calculi: stone distribution, pelvicalyceal anatomy and site of puncture as predictors of PCNL outcome. *Springerplus*, 5(1), 1356.
5. Aron, M., Yadav, R., Goel, R., Kolla, S. B., Gautam, G., Hemal, A. K., & Gupta, N. P. (2005). Multi-tract percutaneous nephrolithotomy for large complete staghorn calculi. *Urologia internationalis*, 75(4), 327-332.
6. Balaji, S., Ganpule, A., Herrmann, T., Sabnis, R., & Desai, M. (2020). Contemporary role of multi-tract percutaneous nephrolithotomy in the treatment of complex renal calculi. *Asian Journal of Urology*, 7(2), 102-109.
7. Tsai, I. C., Chen, Z. H., Lee, K. H., Liu, C. L., Huang, S. K., & Chiu, A. W. (2022). Single versus multiple mini-tract percutaneous nephrolithotomy for staghorn renal stone: A single-center study. *Urological Science*, 33(1), 35-41.
8. Scoffone, C. M., Cracco, C. M., Cossu, M., Grande, S., Poggio, M., & Scarpa, R. M. (2008). Endoscopic combined intrarenal surgery in Galdakao-modified supine Valdivia position: A new standard for percutaneous nephrolithotomy? *European Urology*, 54(6), 1393–1403.
9. Cracco, C. M., & Scoffone, C. M. (2011). ECIRS (Endoscopic Combined Intrarenal Surgery) in the Galdakao-modified supine Valdivia position: A new life for percutaneous surgery? *World Journal of Urology*, 29(6), 821–827.
10. Otsuka, I., Terada, N., Iwamoto, H., Kobayashi, T., & Kamoto, T. (2023). Comparison of safety and efficacy in endoscopic combined intrarenal surgery performed in the lateral decubitus and Galdakao-modified supine Valdivia positions. *Urology*, 173, 74–80.
11. Ibarluzea, G., Scoffone, C. M., Cracco, C. M., Poggio, M., Porpiglia, F., Terrone, C., ... & Scarpa, R. M. (2007). Supine Valdivia and modified lithotomy position for simultaneous antegrade and retrograde endourological access. *BJU international*, 100(1), 233.
12. Hamamoto, S., Yasui, T., Okada, A., Taguchi, K., Kawai, N., Ando, R., ... & Kohri, K. (2014). Endoscopic combined intrarenal surgery for large calculi: simultaneous use of flexible ureteroscopy and mini-percutaneous nephrolithotomy overcomes the disadvantageous of percutaneous nephrolithotomy monotherapy. *Journal of endourology*, 28(1), 28-33.
13. Chen, Z. H., Lee, K. H., Tseng, W. H., Su, C. C., Hsieh, K. L., Lim, C. Y., & Huang, S. K. (2022). Comparison of mini endoscopic combined intrarenal surgery and multitract minimally invasive percutaneous nephrolithotomy specifically for kidney staghorn stones: a single-centre experience. *BMC urology*, 22(1), 93.
14. Assimos, D., Krambeck, A., Miller, N. L., Monga, M., Murad, M. H., Nelson, C. P., ... & Matlaga, B. R. (2016). Surgical management of stones: American urological association/endourological society guideline, PART I. *The Journal of urology*, 196(4), 1153-1160.