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RESEARCH

Endoscopic Combined Intra Renal Surgery versus Percutanous Nephrolithotomy: utcomes of a matched case-control analyis

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Abstract

Purpose To compare the efficacy and safety outcomes of Endoscopic Combined Intrarenal Surgery (ECIRS) and Percutaneous Nephrolithotomy (PCNL) in the treatment of kidney stones.

Methods A retrospective matched case–control study was conducted from July 2022 to January 2024, utilizing prospectively collected kidney stone databases from two centers. Patients who underwent PCNL or ECIRS for kidney stone treatment were included. Cases and controls were matched based on stone complexity, using the Guy's Stone Score (GSS) in a 1:2 ratio. Computed tomography (CT) was performed 90 days postoperatively to assess the stone free rate, defined as the absence of residual fragments. The analyzed variables included age, sex, body mass index (BMI), ASA score, comorbidities, stone diameter, GSS, operative time, number of accesses, blood transfusions, hemoglobin drop, hospital stay, stone free rate, and complication rates. Statistical analysis was performed using the Student's t-test for continuous variables and the Chi-square or Fisher's exact test for categorical variables, with significance set at $p<0.05$.

Results A total of 165 patients were included (55 in the ECIRS group and 110 in the PCNL group). Demographic characteristics were comparable between groups. ECIRS demonstrated a higher stone-free rate (81.8% vs. 56.4%; $p=0.001$), particularly in complex cases (GSS 3 and 4) (79.2% vs. 41.7%; $p=0.003$). There was no significant difference in complication rates between the two groups (21.8% vs. 26.4%; $p=0.607$).

Conclusion ECIRS is an effective treatment, particularly for large and complex kidney stones, offering higher success rates compared to PCNL, with similar complication rates.

Keywords Percutaneous nephrolithotomy · Endoscopic combined intra renal surgery · Computed tomography · Kidney stone

Introduction

The management of staghorn calculi and large kidney stones remains a significant challenge for urologists. Percutaneous nephrolithotomy (PCNL) has long been considered the gold standard treatment for such cases, offering superior stone-free rates (SFR) compared to other minimally invasive techniques, such as retrograde intrarenal surgery (RIRS) [1–3]. However, in more complex cases, PCNL often requires multiple accesses, and concerns exist about its steep learning curve and the potential for severe complications [4].

PCNL has been refined over the decades, with advancements in access technique, patient positioning, instrumentation, and lithotripsy devices [5]. In 1988, Bagley [6] first described the concept of combining renal surgeries, which was later expanded by Ibarluzea [7], who suggested ureteroscopy as an integral part of PCNL, rather than just a complementary tool. In 2008, Scoffone [8] introduced the term ECIRS (Endoscopic Combined Intra Renal Surgery) to describe a technique performed in the Galdakao-modified supine Valdivia position, gaining widespread attention. ECIRS allows simultaneous access to renal calyces via both

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antegrade and retrograde approaches, optimizing the efficacy and safety of PCNL.

Discussions within the urological community have highlighted the advantages of ECIRS, including its versatility in stone manipulation throughout the urinary tract, reduced radiation exposure, and the potential to avoid multiple percutaneous accesses [9]. While both PCNL and ECIRS are effective for simple cases, PCNL remains more challenging for complex stone burdens, often resulting in lower success rates.

The aim of this study is to compare ECIRS and PCNL in terms of efficacy and safety in the management of complex kidney stones.

Materials and methods

Study design

A retrospective case–control study was conducted from July 2022 to January 2024, utilizing prospectively collected kidney stone databases from two medical centers. Electronic medical records were reviewed to identify patients who underwent PCNL or ECIRS for kidney stone treatment. The indications for surgery included single or multiple renal stones larger than 2 cm, as well as symptomatic stones smaller than 2 cm when first-line treatments, such as shockwave lithotripsy or ureteroscopy, had failed. Patients under 18 years of age and those with anatomical abnormalities of the urinary tract, including pelvic kidney, duplicated renal collecting systems, or horseshoe kidney, were excluded from the study. study protocol was approved by the local ethics committee (Institutional Review Board number: 24661119.7.0000.0091).

Control cases were randomly selected from patients who underwent ECIRS and were matched to those who underwent PCNL during the same period. Matching was based on stone complexity using the Guy's Stone Score (GSS) [10–11], with a ratio of 1:2. The analyzed demographic variables included age, sex, body mass index (BMI), American Society of Anesthesiologists physical status classification (ASA score), comorbidities (diabetes, chronic kidney disease, hypertension), stone diameter, and GSS. The operative and safety outcomes analyzed included operative time, number of accesses, blood transfusion requirement, hemoglobin drop, hospital stay, stone free rate, and complication rates.

Preoperative assessment

The GSS was assessed preoperatively based on findings from computed tomography scans (CT). The stone diameter was defined as the sum of the maximum diameters of all stones. Operative time was measured from the start of cystoscopy to the end of the procedure. Hospital stay was considered from the initiation of anesthesia until patient discharge.

Urine cultures were obtained from all patients at least 30 days prior to surgery. Patients with negative cultures with complex stones started prophylactic antibiotic therapy with oral nitrofurantoin (100 mg, once a day) seven days before surgery. All patients received a third-generation cephalosporin intravenously during the induction of anesthesia. For patients with positive urine cultures, therapeutic antibiotics were administered based on the culture results, starting seven days before the procedure and continued during anesthesia induction.

To reduce the risk of perioperative bleeding, all patients without contraindications received tranexamic acid. Blood transfusions were considered for patients showing signs of refractory hypovolemia. Complications were classified according to the modified Clavien-Dindo classification, with complications rated Clavien$\geq$3 being considered major [12].

Surgical technique

All procedures were performed in the Barts "flank-free" modified supine position under general anesthesia. In the PCNL group, the procedure began with the placement of a 6-Fr ureteral catheter, followed by a retrograde pyelogram and subsequent calyceal puncture under fluoroscopic and ultrasonic guidance. In the ECIRS group, the procedure started with semirigid ureteroscopy, followed by placement of a ureteral access sheath. Renal calyces were accessed using US and fluoroscopy and with the help of the flexible single use ureteroscope (Wiscope®). The tract was dilated up to 30 Fr with Amplatz dilators. If a second or third access was required, the same technique was applied. Nephroscopy was performed with a 26-Fr nephroscope (Karl Storz®, Germany), and stone fragmentation was carried out using an ultrasonic lithotripter (Swiss Lithoclast Master®, EMS, Switzerland). Intraoperative stone-free status was verified using fluoroscopy and flexible nephroscopy in the PCNL group and flexible ureteroscopy in the ECIRS group.

In both groups, a ureteral stent was inserted routinely at the end of the surgery. A 16 Fr nephrostomy tube was placed in case of bleeding, residual stones, solitaire kidney, pelvic injury, or multiple access. An 18 Fr Foley catheter was routinely placed until the first post operative day. Ropivacaine was injected into the tracts at the end of the procedure.

Table 1 Characteristics and demographic variables

	ECIRS ($n=55$)	PCNL ($n=110$)	P value
Gender; n (%)			
Male	22 (40.0)	59 (53.6)	0.099
Female	33 (60.0)	51 (46.4)	
Age (years); mean (SD)			
	54.6 ± 13.8	52.1 ± 13.7	0.397
BMI (kg/m^2); mean (SD)			
	29.2 ± 7.4	28.9 ± 5.1	0.737
ASA Score; n (%)			
I	18 (32.7)	23 (20.9)	0.645
II	28 (50.9)	72 (65.5)	
III	9 (14.4)	15 (13.6)	
GSS; n (%)			
1	9 (16.4)	18 (16.4)	
2	22 (40.0	44 (40.0)	
3	16 (29.1)	32 (29.1)	
4	8 (14.5)	16 (14.5)	
Laterality; n (%)			
Right	30 (54.5)	65 (59.1)	0.578
Stone size (mm); mean (SD)	33.7 ± 15.1	26.2 ± 13.7	0.010
Mean stone density (HU); mean (SD)	994 ± 323.4	1020 ± 351.1	0.641

Data are presented as median (first quartile, third quartile) or number (proportion)

SD: standard deviation; ECIRS: endoscopic combined intrarenal surgery; PCNL: percutaneous nephrolithotomy; BMI: body mass index; ASA: American Society of Anesthesiologists; GSS: Guy's stone score; HU: Hounsfield unit

Table 2 Operative variables

	ECIRS ($n=55$)	PCNL ($n=110$)	P value
Operative time (min); mean (SD)			
	113.4 ± 45.5	114.7 ± 52.3	0.878
Number of accesses; n (%)			
1	46 (83.6)	76 (69.1)	0.073
2	6 (10.9)	29 (26.4)	
3 or more	3 (5.5)	5 (4.5)	
Overall stone-free rate; n (%)	45 (81.8)	62 (56.4)	0.001
Stone free rate complex stones; n (%)	43 (78.2)	46 (41.8)	0.003
Overall complication rate	12 (21.8)	29 (26.4)	0.607
Major complication rate	4 (7.3)	6 (5.4)	0.426

Data are presented as median (first quartile, third quartile) or number (proportion)

SD: standard deviation; ECIRS: endoscopic combined intrarenal surgery; PCNL: percutaneous nephrolithotomy; Major complications: Clavien ≥ 3

Outcome evaluation

A non-contrast CT scan was performed 90 days postoperatively in all cases. The stone free rate (SFR) was defined as the absence of any residual fragments.

Statistical analysis

Continuous variables with a parametric distribution were reported as means and standard deviations, while categorical variables as frequencies. Continuous variables were compared using ANOVA or the Student's t-test for independent groups, while in categorical variables was used the Chi-square or Fisher's exact test. All statistical analyses were performed using SPSS version 29.0 (SPSS Inc., Chicago, IL, USA), with statistical significance set at $p<0.05$.

Results

A total of 165 patients were enrolled in the study, with 55 undergoing ECIRS and 110 undergoing PCNL. Since pairwise case-matching was employed, no significant differences in the Guy's Stone Score (GSS) were observed between the two groups. The mean age of the patients was 53.5 ± 13.7 years, and the mean BMI was 29.1 ± 6.2 kg/m². A total of 72 (43.6%) patients had complex kidney stones (GSS 3 or 4), while 37 patients (22.4%) had diabetes, and 39 (5.4%) had chronic kidney disease. There were no significant differences in the ASA score between the two groups ($p=0.645$). Preoperative stone size was significantly larger in the ECIRS group compared to the PCNL group (3.37 ± 1.51 cm vs. 2.62 ± 1.37 cm; $p<0.001$) (Table 1).

The overall stone-free rate (SFR) was significantly higher in the ECIRS group (81.8%) compared to the PCNL group (56.4%; $p=0.001$). Operative characteristics, including the number of accesses and operative time, were comparable between the two groups (Table 2). The overall complication rate was 24.8%, with no significant difference between the groups (21.8% in the ECIRS group vs. 26.3% in the PCNL group; $p=0.607$). Similarly, major complication rates were comparable (7.3% in the ECIRS group vs. 5.4% in the PCNL group; $p=0.426$) (Tables 2 and 3).

When analyzing SFR and complication rates based on GSS, which considers stone burden and location, patients with GSS 1 and 2 had similar stone-free rates between the groups (83.9% for ECIRS vs. 67.7% for PCNL; $p=0.09$). However, GSS was found to be a significant factor associated with complications. Patients with GSS 1 and 2 had a complication rate of 19.3%, while those with GSS 3 and 4 had a higher complication rate of 31.9% ($p=0.026$). (Table 4)

Table 3 Intra and post-operative complications

Type of complication	*n* (% of total)	ECIRS (*n*=55)	PCNL (*n*=110)
Clavien 1	17 (10.3)	4 (7.3)	13 (11.8)
Pain	15 (9.1)	3 (5.4)	12 (10.9)
Acute kidney injury	1 (0.6)	0 (0)	1 (0.9)
Prolonged postoperative ileus	1 (0.6)	1 (1.8)	0 (0)
Clavien 2	14 (8.5)	4 (7.3)	10 (9.1)
Urinary tract infection	2 (1.2)	0 (0)	2 (1.8)
Severe bleeding (transfusion)	11 (6.6)	3 (5.4)	8 (7.3)
Pleural effusion	1 (0.6)	1 (1.8)	0 (0)
Clavien 3	8 (4.8)	3 (5.4)	5 (4.5)
Stone migration to ureter	4 (2.4)	1 (1.8)	3 (2.7)
Arteriovenous fistula	2 (1.2)	1 (1.8)	1 (0.9)
Ureteral stricture	2 (1.2)	1 (1.8)	1 (0.9)
Clavien 4	2 (1.2)	1 (1.8)	1 (0.9)
Sepsis	2 (1.2)	1 (1.8)	1 (0.9)
TOTAL	**41 (24.8)**	**12 (21.8)**	**29 (26.3)**

Data are presented as number (proportion). $p=0.549$

Table 4 Complications according to the guys stone score

Total of complications	*n* (% of total procedures)	Complications (*n*=41)
GSS 1	27 (16.4)	7 (17.1)
GSS 2	66 (40.0)	11 (16.7)
GSS 3	48 (29.1)	8 (16.7)
GSS 4	24 (14.5)	15 (62.5)

Data are presented as number (proportion). $p=0.026$

Discussion

PCNL in complex cases remains a challenging procedure, often associated with higher complication rates and lower success rates [1–3]. The introduction of ECIRS appears to enhance the quality, efficacy, and safety of treating large kidney stones [7]. To the best of our knowledge, this study is the first matched-pair comparison between patients undergoing PCNL and ECIRS, with success rates confirmed by CT scans. One of the major challenges in comparing these techniques lies in the wide variability of reported PCNL stone-free rates in the literature, which range from 40 to 90%, complicating direct comparisons between PCNL and ECIRS [9].

Several nonrandomized comparative studies have reported conflicting evidence regarding the outcomes of ECIRS versus PCNL, largely due to the lack of standardized criteria and consensus on evaluation methods. However, all these studies agree that the combination of antegrade and retrograde approaches improves success rates, particularly in complex cases [13–17]. A systematic review by Hakin et al. demonstrated a significantly higher one-step stone-free rate (SFR) for ECIRS (OR: 5.14; $p<0.001$), as well as lower rates of auxiliary procedures, fewer complications, and similar operative times and hemoglobin drops compared to PCNL [18].

Our main findings are consistent with the literature, showing a higher SFR in the ECIRS group (81.8% vs. 56.4%; $p=0.001$), especially in complex cases (GSS 3 and 4) where ECIRS had a significant advantage (79.2% vs. 41.7%; $p=0.003$). To the best of our knowledge, this is the first study to specifically assess the influence of stone complexity on surgical outcomes, thereby addressing a critical gap in high-quality data on this topic. Regarding complication rates, our overall complication rate of 20% and major complication rate of 6% are consistent with previous reports in the literature. However, unlike some studies, we found no significant difference in complication rates between the ECIRS and PCNL groups (21.8% vs. 25.5%; $p=0.607$). Although ECIRS may theoretically offer better safety due to the direct visualization during puncture and dilation, this advantage may be limited in complex cases, such as staghorn calculi, where direct visualization is not always feasible [16–19]. The higher complication rates observed in GSS 3 and 4 cases (22.2%) reflect the greater complexity of these cases.

This study has several limitations. First, its retrospective design inherently introduces potential patient selection bias. Furthermore, the relatively small sample size, particularly in the ECIRS group, limits the generalizability of our findings. Despite these limitations, we believe that this study contributes valuable insights to the urological literature. The use of a standardized surgical technique, with few sources of potential bias, the systematic use of CT scans for outcome evaluation, and the matched-pair analysis based on stone complexity strengthen the validity of our results.

To further validate these findings and provide stronger evidence, a prospective, randomized controlled trial would be ideal. Such a study would minimize selection bias, allow for better control of confounding variables, and provide a higher level of evidence regarding the comparative efficacy and safety of ECIRS and PCNL, particularly in complex cases. This would enable more definitive conclusions about the role of ECIRS in the management of large and complex renal stones.

Conclusion

ECIRS is an effective and safe treatment, particularly for large and complex kidney stones. When compared to one-step PCNL, ECIRS offers significantly higher stone-free rates, especially in cases with greater complexity, while maintaining similar complication rates. However, further research, particularly in the form of prospective randomized trials, is needed to confirm these results and to establish

clearer guidelines on the selection of patients for each technique.

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Data availability No datasets were generated or analysed during the current study.

Declarations

Ethical approval All procedures performed in the study were in accordance with the ethical standards of the local research committee and with the 1964 Helsinki Declaration and its later amendments.

Informed consent Informed consent was obtained from all patients.

Competing interests The authors declare no competing interests.

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