

# Insights and outcomes of day-case percutaneous nephrolithotomy: results of a systematic review and single-arm meta-analysis

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## Abstract

**Background:** Traditionally performed as an inpatient procedure, day-case or ambulatory percutaneous nephrolithotomy (PCNL) has emerged in recent years as a promising alternative offering the potential to reduce hospital admissions and healthcare costs, without compromising patient outcomes.

**Objectives:** Conduct a systematic review and meta-analysis to critically evaluate the efficacy, safety and overall outcomes of day-case PCNL

**Design:** The systematic review was conducted in line with PRISMA guidelines (Preferred Reporting Items for Systematic reviews and Meta-Analyses).

**Data sources and methods:** We conducted a comprehensive search of MEDLINE, Embase, Scopus, Web of Science, CENTRAL and Cochrane Databases from inception until January 2025 (CRD42024584357). The PICO statement for this systematic review is as follows: in patients with renal stones, what are the outcomes of day-case PCNL (intervention) compared with inpatient PCNL (comparator)? The authors included studies with more than 50 adult patients evaluating day-case PCNL (postoperative hospital stay  $\leq$  24 h) written in the English language.

**Results:** From an initial literature search of 2122 articles, 16 studies were identified, from which 3133 patients were included. A variety of standard, mini and ultra-mini techniques were used, with the majority opting for tubeless (61%) or totally tubeless PCNL (16%). The mean stone size was  $21.5 \pm 13.5$  mm, with five studies including patients with renal structural abnormalities (3.6%). The pooled mean stone-free rate (SFR) was 90% (95% CI: 0.859–0.931), with a readmission rate of 3.2% (95% CI: 0.018–0.046). The overall complication rate was 10.7% (95% CI: 0.078–0.137), with most complications classified as minor with Clavien–Dindo Grade I–II (9.1%) and III–IV (1.6%). The quality assessment of the included literature revealed that all studies were of moderate to high quality.

**Conclusion:** Day-case PCNL represents a safe and viable approach that has seen a growing adoption over recent years, driven in part by post-pandemic healthcare trends. Our review underscores its efficacy, marked by favourable outcomes and a low incidence of complications and readmissions. Moreover, detailed planning is paramount in order to establish clear criteria for potential surgical candidates and indications for inpatient admission, as well as a thorough follow-up plan.

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## Plain language summary

### Study examining the current literature and whether it is safe for patients to go home the same day after kidney stone surgery?

1. **Aims and Purpose of the Research** This study explored whether people who have a specific kidney stone surgery—called percutaneous nephrolithotomy (PCNL)—can safely go home the same day, rather than staying overnight in the hospital. This same-day approach is known as “day-case PCNL.” Before starting the research, we expected that with the right patient selection, same-day discharge could be safe and effective. Our aim was to combine data from existing studies to see how often the surgery was successful, how many patients needed to return to the hospital, and what kinds of side effects occurred.

2. **Background of the Research** This research matters because kidney stones are common, and PCNL is often used to treat large or complicated cases. Traditionally, patients are admitted to hospital after surgery, but hospitals are looking for ways to reduce inpatient stays and improve efficiency. If day-case PCNL is proven to be safe, it could benefit many patients by freeing up hospital beds, lowering healthcare costs, and allowing people to recover more comfortably at home.

3. **Methods and Research Design** We carried out a systematic review and meta-analysis, meaning we collected and analyzed data from multiple high-quality studies. We searched six medical databases and reviewed over 2,000 articles, ultimately including 16 studies with more than 3,100 adult patients who had day-case PCNL. We looked at how effective the procedure was, how often complications happened, and how many patients needed to return to the hospital after going home.

4. **Results and Importance** Our findings showed that about 90 percent of patients were successfully treated, just over 3 percent needed to return to the hospital, and around 10 percent experienced complications—most of which were mild and manageable. No deaths were reported. These results suggest that day-case PCNL is generally safe and effective for many patients, even some with more complex conditions.

**Keywords:** ambulatory, day case, outcomes, percutaneous nephrolithotomy, safety

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## Introduction

Since the pioneering work of Fernstorm and Jöhansson in 1976,<sup>1</sup> percutaneous nephrolithotomy (PCNL) has established itself as the gold standard for managing complex and large renal calculi, particularly those exceeding 2 cm in size.<sup>2–4</sup>

Traditionally performed as an inpatient procedure, day-case or ambulatory PCNL has emerged in recent years as a promising alternative offering the potential to reduce hospital admissions, lower healthcare costs, and enhance patient satisfaction.<sup>5</sup> This evolution has been driven in part by broader healthcare trends prioritizing shorter hospital stays, minimizing costs and improving convenience for patients. However, the paradigm shift towards

performing PCNL as an outpatient procedure has also been facilitated by the advent of miniaturized instrumentation, improvements in lasers and nephrostomy-free surgical techniques.<sup>6–8</sup>

Individual studies have demonstrated the safety and efficacy of day-case PCNL, however, there remains a paucity of large-scale pooled data regarding its broader implementation and to delineate optimal patient selection criteria.<sup>5</sup> While recent meta-analyses by Calvillo-Ramirez et al. (day-case PCNL patients,  $n=994$ ) and Du et al. (day-case PCNL patients,  $n=1956$ ) have provided important insights into this approach, our study sought to evaluate a larger and more focused day-case cohort to better characterize outcomes in real-world practice.<sup>9,10</sup>

In addition, the heterogeneity in patient selection, surgical techniques and post-operative management across institutions further complicates the generalizability of existing data.

Thus, this systematic review and single-arm meta-analysis seeks to critically evaluate the efficacy, safety and overall outcomes of day-case PCNL. By synthesizing the available evidence, this review aims to elucidate the role of day-case PCNL within contemporary renal stone management and to identify potential areas for further investigation and clinical standardization.

## Methods

### Study design

This systematic review and meta-analysis were conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines.<sup>11</sup> The review was registered prospectively with PROSPERO (CRD42024584357).

### Search strategy

A comprehensive search of MEDLINE (via PubMed), Embase (via Ovid), Scopus, Web of Science, Cochrane Database of Systematic Reviews (CDSR) and Cochrane Central Register of Controlled Trials (CENTRAL) was conducted from the inception of each database until 15th January 2025. We also hand-searched the references of all review articles identified by our search strategy and screened unpublished 'grey' literature including conference abstracts.

Our search terms included (not limited to) 'percutaneous nephrolithotomy', 'PCNL', 'day case', 'ambulatory' and 'outpatient' and medical subject headings (MeSH) terms included 'nephrolithotomy, percutaneous' and 'ambulatory surgical procedures'. The specific search strategy that we used is available in Supplemental Item 1.

### Eligibility criteria

Inclusion criteria:

1. Studies where patients underwent day-case PCNL, defined as same-day discharge or within 24 h post-operatively.

2. Adult patients
3. Sample size of at least  $\geq 50$  patients
4. Randomized controlled studies, cohort studies and case-control studies
5. English language

Exclusion criteria:

1. Studies where patients underwent inpatient PCNL that is, greater than 24h admission post-operatively
2. Paediatric patients
3. Case reports, reviews and conference abstracts
4. Active urinary tract infection
5. Prior renal surgery
6. Retrograde intrarenal surgery (RIRS) and/or studies where patients underwent either PCNL or RIRS alone, and data pertaining to PCNL could not be individually identified

Abstracts were screened by two authors (SS and SL), with disagreements resolved by mutual agreement and discussion with senior author (BKS). Full-text screening was performed by the same authors, with conflicts handled using the same method. Title, abstract and full-text screening were conducted using Covidence systematic review software. In addition, the risk of bias for each included study was independently assessed by two authors (SS and SL) using the RoB-2 or the ROBINS-I tools, with results of this assessment included in Supplemental Item 2.<sup>12-14</sup>

### Data extraction and outcome measures

For baseline characteristics, we extracted the following: patient demographics, incidence of comorbidities (hypertension and diabetes), incidence of pre-existing renal/urological conditions and pre-operative ASA classification. We also extracted operative characteristics detailing the technical aspects of the PCNL procedures undertaken in each study. Finally, several post-operative outcomes were extracted including stone-free rate (SFR), ED visit rate, readmission rate and complication rates. Data were initially extracted by one reviewer (SS) and subsequently independently validated by a second reviewer (SL). Any discrepancies identified during this validation process were resolved through discussion, with input from a third author (BKS) if consensus could not be reached.

### Statistical analysis

Pooled means and proportions of our data were analysed using a random-effects, generic inverse variation method of DerSimonian and Laird, which assigns the weight of each study based on its variance.<sup>15</sup> The heterogeneity of effect size estimates across the studies was quantified using the  $Q$  statistic and  $I^2$  ( $p < 0.10$  was considered significant) with a value of  $I^2$  of 0%–25% indicating insignificant statistical heterogeneity, 26%–50% low heterogeneity, and 51%–100% high heterogeneity.<sup>16</sup> When conducting this analysis, if the mean and standard deviation (SD) were unavailable, the median was converted to a mean using the recommended formulas illustrated in the Cochrane Handbook for Systematic Reviews of Interventions.<sup>17</sup> A leave-one-out sensitivity analysis was conducted by excluding studies in which means and standard deviations were estimated from medians and interquartile ranges, to test the robustness of the pooled effect estimates. Finally, data analysis was performed using Open Meta Analyst software (CEBM, Brown University, Providence, Rhode Island, USA).

## Results

### Study selection and patient characteristics

The initial literature search yielded 2122 potentially relevant articles. Following the removal of duplicates, abstract and full-text screening, sixteen unique studies involving 3471 patients were included in this systematic review and meta-analysis.<sup>6,18–32</sup> PRISMA flowchart of the study selection process is depicted in Supplemental Item 3. From the studies selected, there were three randomized controlled trials (RCTs),<sup>6,19,26</sup> three prospective cohort studies<sup>18,25,29</sup> and ten retrospective cohort studies.<sup>20–25,27,28,30–32</sup> It should be noted that of the 3471 patients, we have included only 3133 in our subsequent analysis; 338 patients across five studies<sup>3,6,19,26,28</sup> did not meet our strict definition of day-case PCNL (i.e. planned/underwent same day discharge or discharge within 24 h post-operatively). Specifically, patients were excluded from Basiri et al. (planned 3-day admission cohort), and from Bechis et al., Kumar et al., Agrawal et al., and Roberts et al., where inpatient and outpatient data were reported separately but only day-case data met the inclusion criteria. This exclusion was necessary to preserve the integrity of pooled estimates for day-case procedures, although it may limit the generalizability of the

findings to the broader PCNL populations. The baseline characteristics for all included studies are detailed in Table 1.

### Assessment of risk of bias

The results of the quality assessment for all included studies are shown in Supplemental Item 2. Overall, all observational studies assessed using the ROBINS-I tool were assessed to be at moderate risk, with each study scoring as low or moderate risk across the various domains. Similarly, all randomized controlled trials assessed using the RoB-2 tool were determined to be of some concern, with most domains rated as low risk or some concern. Notably, Kumar et al. was considered high risk for bias arising from the randomization process, as the study mentioned randomization but lacked details on sequence generation and treatment allocation.

### Clinical characteristics

The included studies recorded a range of baseline clinical characteristics as reported as pooled values in Table 2. Seven studies<sup>18,20,26–29,31</sup> reported on rates of hypertension (48.0%) and diabetes (23.4%). In addition, five studies<sup>20,21,24,28,29</sup> permitted patients with more significant comorbidities to undergo day-case PCNL, with 20.3% of patients in these studies classed ASA 3 or 4. From these five, three studies<sup>20,21,24</sup> recorded a 3.6% incidence of renal structural abnormalities including horseshoe kidneys. Finally, nine studies<sup>18,20–24,29,31,32</sup> included patients with partial or complete staghorn calculi to undergo day-case PCNL, accounting for 9.7% of their cumulative patient cohort.

### Operative characteristics

Seven studies<sup>6,19–21,23,24,26</sup> performed only standard or maxi-PCNL (sheath size 22–30Fr), three studies<sup>18,27,31</sup> conducted only mini-PCNL (sheath size 14–20Fr) and Chen et al. performed ultra-mini-PCNL (sheath size 13Fr). The remaining five studies<sup>25,28–30,32</sup> implemented a mixture of both standard and mini-PCNL procedures. Tubeless PCNL (ureteric stent insertion without concomitant nephrostomy insertion) was undertaken in the majority of studies, with three studies<sup>22,26,27</sup> performing almost all cases with ‘totally tubeless’ technique (no stent or nephrostomy inserted). In addition, two papers utilized ECIRS

**Table 1.** Basic characteristics of included studies.

Study	Year	Country	Study type	Total patients/ <i>n</i>	Day-case* PCNL patients/ <i>n</i>	Male** patients/ <i>n</i> (%)	Age**, mean $\pm$ SD /years	PCNL type
Agrawal et al.	2008	India	RCT	202	101	NR	33 $\pm$ 9.3	Standard
Beiko et al.	2015	Canada	Retrospective	50	50	26 (52)	56 $\pm$ 14.8	Standard
Kumar et al.	2016	India	RCT	113	56	33 (59)	36 $\pm$ 13.3	Standard
Fahmy et al.	2017	Egypt	Retrospective	162	162	103 (64)	42 $\pm$ 13	Standard
Bechis et al.	2018	USA	Retrospective	97	60	27 (45)	55 $\pm$ 2.0	Standard
Wu et al.	2019	China	Retrospective	86	86	48 (56)	52 $\pm$ 12	Mini
Basiri et al.	2020	Iran	RCT	200	98	70 (71)	45 $\pm$ 12.8	Standard
Aarthy et al.	2021	India	Prospective	70	70	NR	45 $\pm$ 10.7	Mini
Chen et al.	2021	China	Retrospective	358	358	254 (71)	60 $\pm$ 11.7	Ultra mini
Hosier et al.	2022	Canada	Retrospective	118	118	57 (48)	57 $\pm$ 15.3	Standard
Roberts et al.	2022	USA	Retrospective	175	134	61 (46)	56 $\pm$ 15.4	Standard or mini
Zhu et al.	2022	China	Retrospective	205	205	126 (72)	52 $\pm$ 12.4	Standard or mini
Thakker et al.	2023	USA	Retrospective	107	107	55 (51)	59 $\pm$ 13.4	Standard or mini
Kannan et al.	2023	India	Prospective	166	166	98 (59)	46 $\pm$ 11.5	Standard or mini
Rosen et al.	2023	USA	Prospective	1267	1267	605 (48)	57 $\pm$ 17.8	Standard or mini
Nikoufar et al.	2024	Canada	Retrospective	95	95	60 (63)	61 $\pm$ 13	Mini

\*Number of patients who underwent day-case PCNL or were planned for day-case PCNL, depends on study type.  
\*\*Please note that the data referring to the number/percentage of male patients and age refers only to the cohort of patients in each study who underwent day-case PCNL only. The number of patients in these cohorts is noted in column 6.  
*n*, number of participants; NR, not reported; PCNL, percutaneous nephrolithotomy; RCT, randomized controlled trial; SD, standard deviation.

(endoscopic combined intrarenal surgery), where ECIRS was the preferred modality.<sup>25,29</sup> Finally, the mean stone size was 21.5  $\pm$  13.5 mm with stones as large as 80 mm reported.<sup>24</sup> Other procedural details, including positioning, multi-tract PCNL incidence and mean operating room (OR) time, are noted in Table 3.

#### Post-operative outcomes

As illustrated in Table 4, studies implemented different protocols regarding same-day and overnight stay, resulting in varying discharge rates. Five studies<sup>19,21,24,27,28</sup> successfully discharged all patients on the same day as the procedure, while the remaining studies discharged  $\geq 85\%$  patients within 24 h post-procedure.

As a measure of procedural success, the pooled SFR across fifteen studies was 90% (95% CI: 0.858–0.931,  $I^2=93\%$ ,  $n=2967$ ) (Figure 1(a)) and for the seven studies<sup>6,18,20,25,27,28,31</sup> that measured CSC (complete stone clearance that is no residual stones), the pooled CSC SFR was 83% (95% CI: 0.725–0.924),  $I^2=97\%$ ,  $n=657$ ) (Figure 1(b)). Despite consistent reporting of SFR as a primary outcome, there was significant variation in SFR assessment methodology across studies, as shown in Supplemental Item 4. This variation observed in SFR modality and timing precluded further meaningful subgroup analysis.

Furthermore across fourteen studies, the pooled readmission rate was 3.2% (95% CI: 0.018–0.046,  $I^2=73\%$ ,  $n=1700$ ) (Figure 2(a)). The

**Table 2.** Pooled clinical characteristics of included studies.

Patient characteristics	Day-case PCNL patients* (n=3133)
Demographic characteristics	
Age, mean ± SD/years	53.7 ± 16.3
Male, n (%)	1623 (51.8)
BMI, mean ± SD/kg/m <sup>2</sup>	28.5 ± 8.2
Comorbidities	
Hypertension n/N (%)	848/1768 (48.0)
Diabetes n/N (%)	414/1768 (23.4)
Renal/urological abnormalities	
Renal structural abnormalities n/N (%)	26/719 (3.6)
Horseshoe kidney n/N (%)	2/719 (0.3)
Hydronephrosis n/N (%)	194/765 (25.4)
Stone characteristics	
Stone size, mean ± SD /mm	21.5 ± 13.5
Unilateral stones n/N (%)	595/618 (96.3)
Bilateral stones n/N (%)	23/618 (3.7)
Staghorn n/N (%)	249/2566 (9.7)
ASA classification	
ASA 1–2 n/N (%)	2306/2893 (79.7)
ASA 3 n/N (%)	581/2893 (20.1)
ASA 4 n/N (%)	6/2893 (0.2)
*Notably, all data in this table refer only to patients who were planned for or underwent day-case PCNL in the selected studies. Total patients across all studies; n=3471, only relevant day-case PCNL patients; n=3133. ASA, American Society of Anesthesiologists; N, total number of day-case PCNL participants across all studies; PCNL, percutaneous nephrolithotomy; SD, standard deviation.	

authors conducted further subgroup analysis assessing the impact of different PCNL types (standard/mini/ultra-mini). Studies conducting standard PCNL resulted in a pooled readmission rate of 3.9% (95% CI: 0.015–0.063,  $I^2=70\%$ ,  $n=645$ ), mini-/ultra-mini-PCNL had a rate of 2.0% (95% CI: 0–0.042,  $I^2=60\%$ ,  $n=609$ ) and studies employing both standard and mini-PCNL described a readmission rate of 5.1% (95% CI: 0–0.102,  $I^2=87\%$ ,  $n=446$ ) as noted in Figure

2(b). Emergency department (ED) visit rates were also reported in seven studies, with an overall pooled rate of 12% (95% CI: 0.061–0.178,  $I^2=88\%$ ,  $n=726$ ).

### Complications

The pooled overall complication rate across all studies was 10.7% (95% CI: 0.078–0.137,  $I^2=88\%$ ,  $n=3133$ ) (Figure 3(a)). Further subgroup analysis was conducted to delineate differences in complication rates between PCNL types, as noted in Figure 3(b) with no significant difference identified. Fourteen studies further classified complications ( $n=218$ ) using the Clavien–Dindo classification with the majority being minor Grade I–II (85%) managed with conservative or medical treatment. The breakdown of complications by Clavien–Dindo grade is as follows: grade I 55%, grade II 30%, grade III 13% and grade IV 2%. The most common complication included post-operative fever and infection, accounting for 27% ( $n=58$ ), with twelve cases progressing to sepsis and requiring intravenous antibiotics. This was closely followed by mild to severe haematuria at 23% ( $n=50$ ), with six patients receiving blood transfusions and a further six requiring renal angioembolization for arterial pseudoaneurysm. Across all sixteen studies, there were a total of four grade IV complications. Hosier et al. reported one NSTEMI initially managed with medical management and subsequent coronary artery bypass grafting. Rosen et al. reported three unspecified grade IV complications without further details of these complications. No deaths were reported in any of the selected studies. Further detail regarding complications and management is summarized in Table 5. Finally, sensitivity analysis excluding studies with estimated means and SDs showed no substantial change in the pooled effect estimates or heterogeneity across SFR, readmission and complication rates.

### Discussion

In the aftermath of the Covid-19 pandemic, the traditional inpatient model for PCNL has been increasingly challenged by the ascendancy of ambulatory PCNL as institutions seek to maximize efficiency without compromising patient outcomes. To our knowledge, this study reports the largest pooled cohort of day-case PCNL patients ( $n=3133$ ), and successfully demonstrates

**Table 3.** Operative characteristics of included studies.

Study (N=3133)*	PCNL type	Tubeless (stented, no PCN)/n	Totally tubeless (no stent or PCN)/n	Prone position/n	Supine position/n	Multi-tract/n	Total OR time, mean $\pm$ SD or median (range) /mins	Stone size, mean $\pm$ SD or median (range) /mm
Agrawal et al.	Standard	101	0	NR	NR	0	NR	38.0 (10–57)**
Beiko et al.	Standard	47	2	50	0	NR	NR	19.6 (7–60)
Kumar et al.	Standard	0	56	56	0	3	41 $\pm$ 11.6	30.2 $\pm$ 4.6
Fahmy et al.	Standard	34	0	162	0	14	94	51.0 $\pm$ 36.9**
Bechis et al.	Standard	53	0	NR	NR	10	135 $\pm$ 7	25.8 $\pm$ 27
Wu et al.	Mini	51	0	NR	NR	8	64 $\pm$ 23.8	33.0 $\pm$ 18.3
Basiri et al.	Standard	0	0	98	0	1	NR	36.3 $\pm$ 20.3
Aarthy et al.	Mini	18	4	60	10	6	80 $\pm$ 19.7	24.8 $\pm$ 4.9
Chen et al.	Ultra mini	11	341	NR	NR	0	NR	14.6 $\pm$ 6.2
Hosier et al.	Standard	116	2	118	0	4	104 (32–210)	24.0 $\pm$ (7–80)
Roberts et al.	Standard or mini	127	2	95	39	1	153 $\pm$ 37.4	18.5 $\pm$ 6.1
Zhu et al.	Standard or mini	NR	NR	205	0	60	75 $\pm$ 30.4	63.2 $\pm$ 64**
Thakker et al.	Standard or mini	NR	NR	107	0	NR	90 $\pm$ 32.1	15.5 (7–26)
Kannan et al.	Standard or mini	148	0	83	83	20	51 $\pm$ 12.8	24.0 $\pm$ 4.0
Rosen et al.	Standard or mini	1256	NR	>90%	<10%	114	92.70 (25–305)	31.6 (1.2–17)
Nikoufar et al.	Mini	9	86	95	0	3	64 (38–135)	16.0 (10–25)

\*Notably, all data in this table refer only to patients who were planned for or underwent day-case PCNL in the selected studies. Total patients across all studies;  $n=3471$ , only relevant day-case PCNL patients;  $n=3133$ .

\*\*These measurements refer to stone burden and are in  $\text{mm}^2$ , rather than stone size in mm as reported by the other studies.

N, total number of day-case PCNL patients; NR, not reported; OR, operating room; PCN, percutaneous nephrostomy; PCNL, percutaneous nephrolithotomy; SD, standard deviation.

that, with appropriate selection criteria, day-case PCNL is a safe and feasible strategy, yielding favourable outcomes and reduced healthcare burdens.

In line with recent studies, our analysis affirms the efficacy of day-case PCNL, evidenced by a pooled SFR of 90%. This aligns with rates reported in contemporary literature, such as Meng Gao *et al.*, who reported similarly high success rates for day-case PCNL.<sup>33</sup> The consistency in these findings suggests that day-case PCNL achieves equivalent outcomes to traditional inpatient procedures, provided that patient selection and surgical techniques are carefully tailored.

The pooled readmission rate of 3.2% and complication rate of 10.7% also underscore the safety of day-case PCNL. Comparatively, Gassman *et al.* reported slightly higher readmission rates, likely attributable to differing patient populations and procedural characteristics.<sup>34</sup> Calvillo-Ramirez *et al.* also noted low complication rates in their analysis, further validating the safety of day-case PCNL in reducing post-operative morbidity.<sup>9</sup>

Several studies<sup>18,22,29,32</sup> documented reasons for failed day-case discharge. The most common causes were minor Clavien–Dindo grade I–II complications, such as pain, haematuria, fever, electrolyte disturbances, and hypotension.

**Table 4.** Post-operative outcomes of included studies.

Study	Same-day post-op discharge/ <i>n</i> (%)	<24 h post-op discharge/ <i>n</i> (%)	Stone-free rate/%		ED visit rate/%	Readmission rate/%	Complication rate/%
			Residual fragments*	CSC			
Agrawal et al.	NR	87 (86)	100	100	NR	0	4.0
Beiko et al.	50 (100)	—	92.0	—	12.0	4.0	18.0
Kumar et al.	51 (91)	55 (98)	96.4	—	NR	7.1	19.6
Fahmy et al.	146 (90)	NR	89.5	—	3.1	1.2	14.2
Bechis et al.	43 (72)	60 (100)	97.2	72.2	18.3	10.0	20.0
Wu et al.	42 (49)	82 (95)	90.7	84.9	NR	2.3	11.6
Basiri et al.	98 (100)	—	71.4	—	NR	9.2	9.2
Aarthy et al.	64 (91)	NR	91.4	91.4	NR	8.6	8.6
Chen et al.	NR	326 (91)	94.7	—	NR	0.6	7.8
Hosier et al.	118 (100)	—	83.3	—	17.5	5.3	17.5
Roberts et al.	134 (100)	—	56.3	41.0	25.4	13.4	21.6
Zhu et al.	142 (69)	175 (85)	88.8	—	NR	1.5	11.2
Thakker et al.	53 (50)	107 (100)	NR	NR	4.7	2.8	3.7
Kannan et al.	NR	146 (88)	94.6	94.6	NR	NR	3.0
Rosen et al.	1247 (98)	NR	88.6	—	NR	NR	2.7
Nikoufar et al.	95 (100)	—	92.6	87.4	7.4	2.1	19.0

\*Papers had varying definitions for stone-free rates with the majority of studies defining it as patients with residual stones <3mm in size. See Supplemental Table 5 for further details.

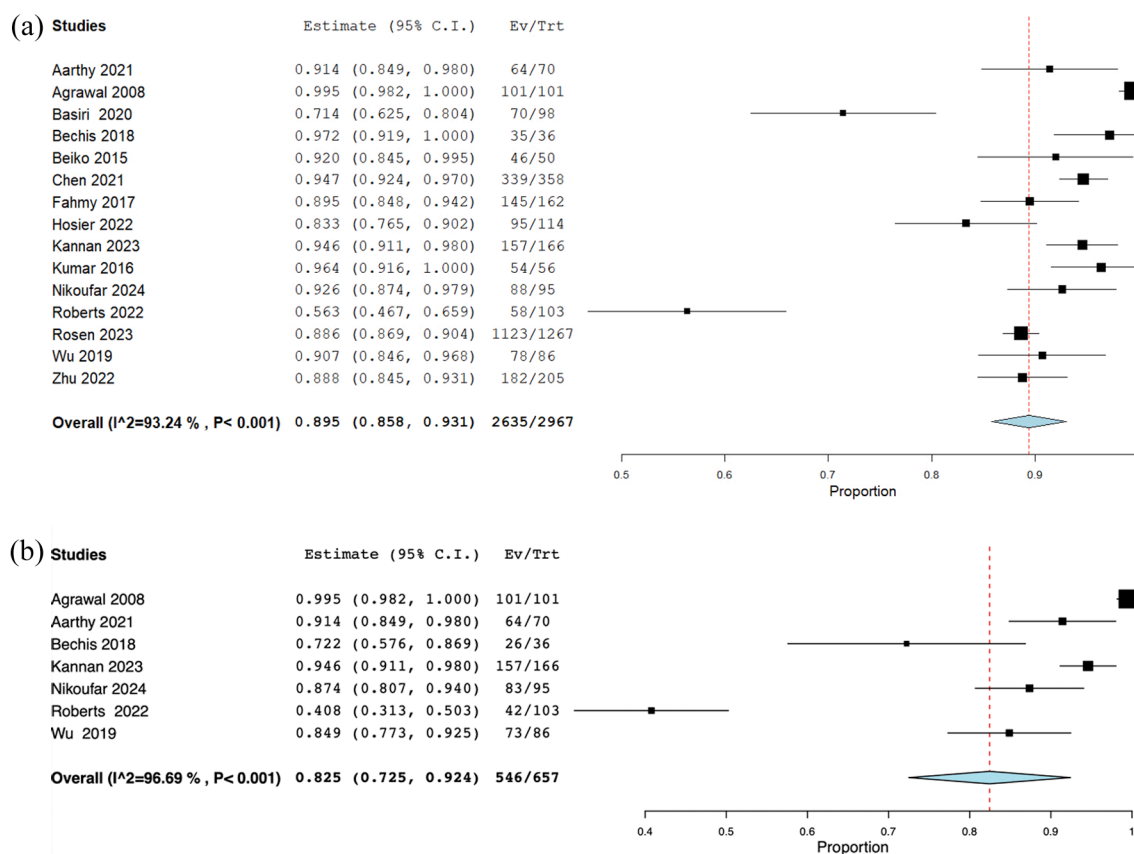
CSC, complete stone clearance that is no residual fragments; ED, emergency department; NR, not reported.

However, non-clinical barriers also emerged as significant factors. Zhu et al. reported that 23.3% of patients declined discharge despite meeting clinical criteria, primarily due to anxiety about potential post-operative complications. Moreover, Bechis et al. found that among the seventeen patients who were not discharged as planned, six remained for social reasons, such as inability to arrange transport or inadequate home support. These findings highlight the need for day-case units to screen for non-clinical barriers to discharge, including assessments of social support and discharge logistics – particularly when expanding pathways to more complex or vulnerable patient populations.

Patient selection remains a critical determinant of day-case PCNL success. Prior reviews, such as

the study by Jones et al., have noted the importance of excluding patients with congenital anomalies, staghorn calculi, larger stone sizes and multiple morbidities. In addition, EAU 2024 guidelines emphasize selecting low-risk patients with ASA scores  $\leq 2$ , favourable stone and anatomical characteristics.<sup>2,5</sup> The majority of included studies applied similar restrictions in order to achieve optimal outcomes with day-case PCNL. However, evidence from our review and external studies suggests that day-case PCNL can safely be performed in more complex patients.

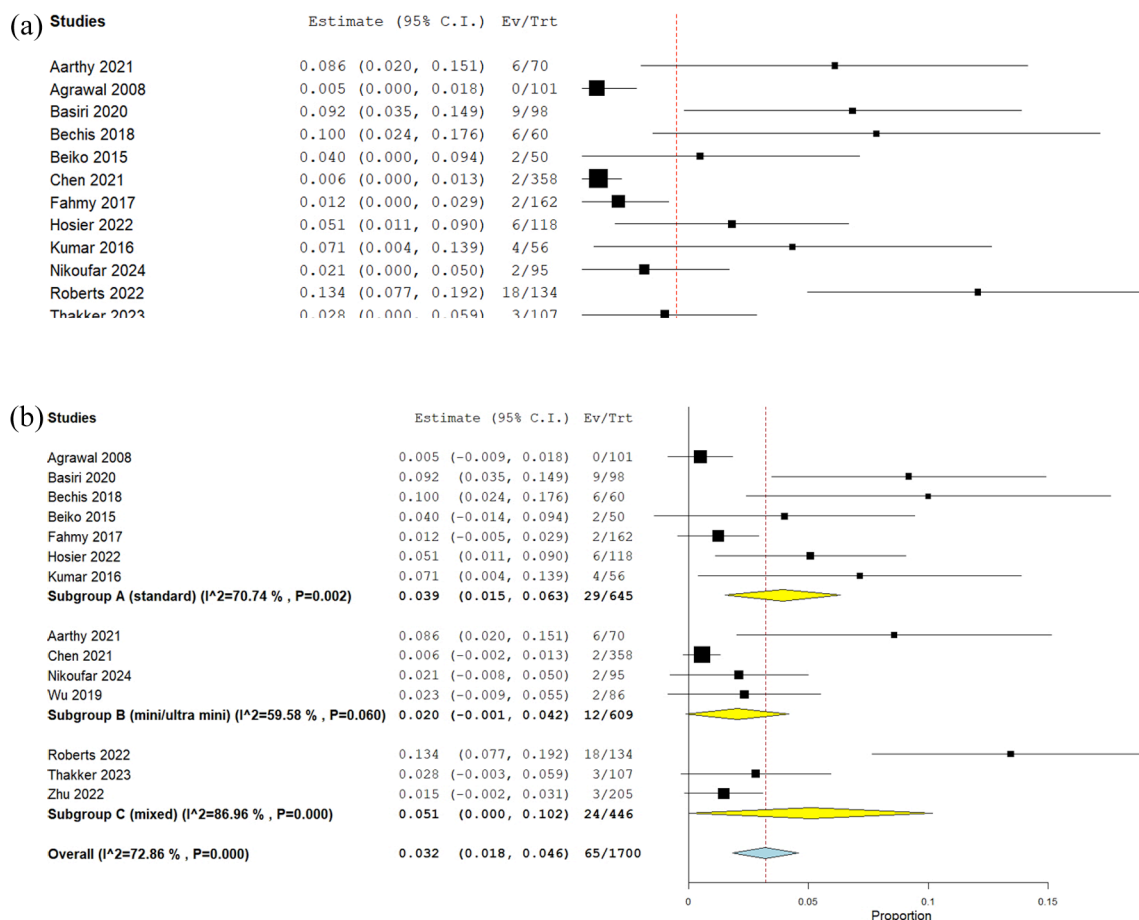
Our post hoc analysis of nine studies<sup>18,20–24,29,31,32</sup> that included staghorn stones (9.7% of the cohort) supports this, showing comparable SFRs and complication rates to those of less complex cases. Patients with staghorn calculi achieved a



**Figure 1.** (a) Pooled stone-free rate. (b) Pooled complete stone clearance rate.

pooled SFR of 90% (95% CI: 0.879–0.934,  $I^2=75\%$ ,  $n=2376$ ), which aligns closely with the overall pooled stone-free rate reported in this review. In addition, this value compares favourably with the 84.8% SFR reported by Zhu *et al.*<sup>35</sup> in their study of multi-tract day-case PCNL for the treatment of complex renal stones. Of the included studies, Rosen *et al.* included the highest number of patients with staghorn calculi ( $n=79$ ) and routinely pre-treated these patients up to a week prior with oral antibiotics before ambulatory surgery. In addition, they noted that staghorn calculi were more likely to require transfer to the hospital and require a second-look post-operatively. In addition, Bechis *et al.* and Beiko *et al.* successfully demonstrated the feasibility of day-case PCNL in multiple patients ( $n=23$ ) with renal structural abnormalities including horseshoe kidneys.<sup>20,21</sup> These findings cautiously suggest that with experienced surgical teams, careful preoperative planning and standardized protocols, day-case PCNL could be safely extended to more complex patient populations, challenging the traditional boundaries of its use.

There was notable heterogeneity in the surgical techniques employed across the sixteen studies. Miniaturized techniques – particularly mini- and ultra-mini-PCNL – have been reported in the literature to be associated with reduced renal trauma, lower postoperative pain and shorter hospital stays due to smaller tract dilation.<sup>36</sup> However, this review observed no differences in readmission or complication rates between studies utilizing miniaturized and standard techniques. This is consistent with findings from Calvillo-Ramirez *et al.*, who reported no significant differences in complication or transfusion rates between standard and mini-PCNL cohorts. In terms of drainage technique, most patients ( $n=1971$ ) underwent tubeless PCNL, and three studies employed totally tubeless approaches. Kumer *et al.* noted the benefits of tubeless PCNL, including reduced analgesic requirement, blood loss and faster return to normal activity. However, broader conclusions regarding the drainage technique or tract size remain limited by substantial heterogeneity in stone burden, patient comorbidities, perioperative protocols and inconsistent stratification of



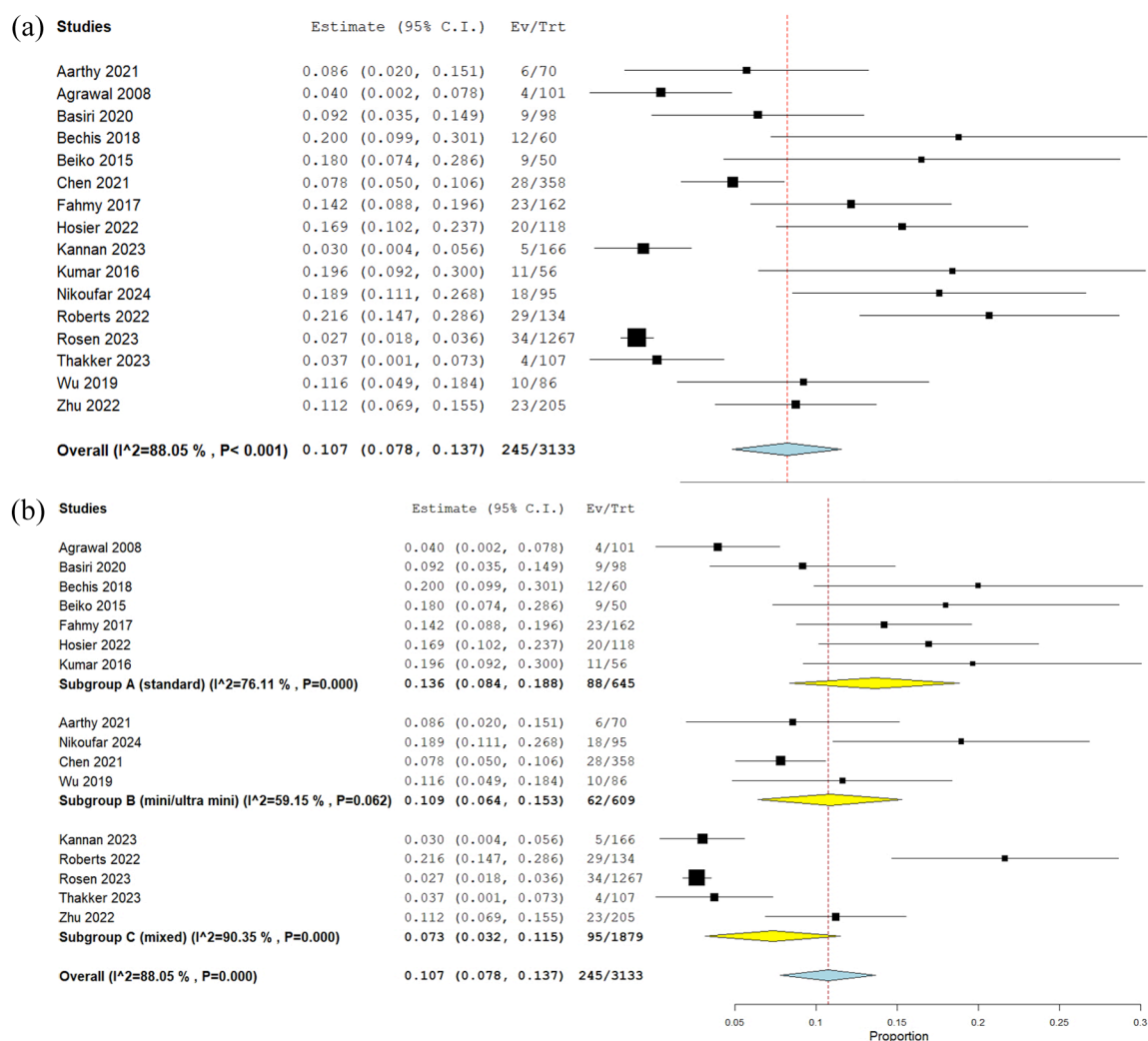
**Figure 2.** (a) Pooled readmission rate. (b) Subgroup analyses of standard, mini/ultra-mini and mixed cohorts for readmission rate.

these variables across studies. Finally, Kannan et al. compared supine and prone positioning directly with no clear superiority identified, although prone positioning appears to be preferential in patients with complex anatomy or larger stone burden.

The economic advantages of day-case PCNL are significant. Thakker et al. highlighted the comparative cost-effectiveness of day-case PCNL, reporting lower overall expenditures when compared with inpatient procedures. In particular, they noted that day-case PCNL translated to advantageous operating margins through decreased bed occupancy and shorter post-operative monitoring periods.<sup>30</sup> These findings are consistent with the contemporary literature – as Krocak et al. report, outpatient PCNL substantially reduces healthcare costs by minimizing inpatient bed occupancy and shortening post-operative monitoring.<sup>37</sup> However, it is important to acknowledge that not all

institutions have the infrastructure, staffing or perioperative pathways required to safely support ambulatory surgery. Furthermore, while day-case PCNL is assumed to offer improved patient convenience and satisfaction due to earlier discharge and home recovery, these assumptions remain largely unverified – none of the studies in this review assessed patient-reported outcomes, such as quality of life or patient satisfaction. Echoed by a recent meta-analysis by Du et al., this lack of data on quality-of-life outcomes and patient satisfaction represents a significant gap in the literature. Future research should prioritize evaluating the impact of day-case PCNL on patient-reported outcomes to ensure a more comprehensive understanding of its benefits.

Despite this review representing the largest pooled cohort of day-case PCNL patients, several limitations must be acknowledged. First, the heterogeneity in surgical techniques (e.g., standard, mini-,



**Figure 3.** (a) Pooled complication rate. (b) Subgroup analyses of standard, mini/ultra-mini and mixed cohorts for complication rate.

and ultra-mini-PCNL), drainage techniques and patient positioning across studies introduces variability that complicates direct comparison of outcomes. To make more robust conclusions regarding surgical technique, further studies that directly compare these approaches in the day-case setting are needed.

Second, inconsistent definitions of outcomes, particularly SFR, limit the generalizability of our conclusions. The authors observed significant heterogeneity in the assessment and definition of SFR as recorded in Supplemental Item 4. Two studies assessed SFR endoscopically intra-operatively, with the remainder using post-operative X-ray, CT or ultrasound days, weeks or months following the procedure. In addition, definitions for SFR varied significantly, with papers defining

SFR as the absence of residual fragments  $< 2$ ,  $< 3$ ,  $< 4$  and  $< 5$  mm, respectively, as well as six studies that reported CSC. This heterogeneity undermines comparability and underscores the need for standardized outcome definitions across institutions. Similarly, ED visit rates were inconsistently reported across the studies, with only seven studies commenting on this outcome – further underscoring the need for uniform outcome reporting following PCNL.

Additionally, the predominance of retrospective cohort studies in our analysis also raises the potential for selection and reporting bias. Only three randomized controlled trials were included, highlighting the need for more prospective, high-quality evidence. Moreover, few studies addressed long-term outcomes, such as stone recurrence

**Table 5.** Summary of all post-operative complications.

Complication	Frequency/n (%) (N= 3022)	Management
Clavien–Dindo Grade I		
Flank pain/stent colic	41 (1.36)	Conservative
Fever	3 (0.10)	Conservative
Haematuria	34 (1.13)	Conservative
Perirenal haematoma	9 (0.30)	Conservative
Urine leakage	9 (0.30)	Conservative
Hypokalaemia	4 (0.13)	Conservative
Urinary retention	4 (0.13)	Conservative
Extruded stent	1 (0.03)	Conservative
Ovarian vein thrombosis	1 (0.03)	Conservative
Cellulitis	1 (0.03)	Conservative
Unspecified Grade I	11 (0.36)	—
Clavien–Dindo Grade II		
Fever (non-specific)	26 (0.86)	Oral antibiotics
Haematuria	10 (0.33)	Hospitalization; 6 received blood transfusion
Sepsis	11 (0.36)	Intravenous antibiotics
UTI	11 (0.36)	Oral antibiotics
Pyelonephritis	3 (0.10)	Intravenous antibiotics
Wound cellulitis	2 (0.07)	Oral antibiotics
DVT	1 (0.03)	Medical
Unspecified Grade II	11 (0.36)	-
Clavien–Dindo Grade III		
Severe haematuria secondary to arterial pseudoaneurysm	6 (0.20)	Renal artery embolization
Pleural effusion	3 (0.10)	Chest drain insertion
Tract site abscess	3 (0.10)	Incision and drainage
Urosepsis	1 (0.03)	Required stent insertion
Misplaced stent	1 (0.03)	Endoscopic removal
Perirenal haematoma	1 (0.03)	Renal artery embolization
Unspecified Grade III	12 (0.40)	—
Clavien–Dindo Grade IV		
NSTEMI	1 (0.03)	Medical
Unspecified Grade IV	3 (0.10)	—
DVT, deep vein thrombosis; N, total number of day-case PCNL patients; NSTEM, non-ST-elevated myocardial infarction; PCNL, percutaneous nephrolithotomy; UTI, urinary tract infection.		

rates or functional renal recovery, limiting the ability to assess the durability of day-case PCNL outcomes.

Finally, from a methodological standpoint, although study screening was conducted independently by two reviewers with consensus and senior author adjudication for disagreements, a limitation is that inter-rater reliability was not formally quantified.

Finally, future research should address key gaps in the literature, particularly focusing on complex patient populations and underexplored outcomes. While this review demonstrates the feasibility of day-case PCNL in selected patients with staghorn calculi, further multi-centre, randomized controlled trials are necessary to standardize protocols and identify optimal patient selection criteria for these groups. In addition, future studies should evaluate long-term outcomes, such as recurrence rates and renal function preservation, to ensure that the safety and efficacy observed in the immediate post-operative period in complex stone patients are sustained over time. Moreover, studies such as Thakker *et al.* have emphasized the cost-saving potential of day-case PCNL – however, further granular financial analyses are needed to quantify savings across diverse health-care systems, including comparisons of direct and indirect costs. Finally, none of the studies in this review explicitly evaluated patient-reported outcomes or quality of life. Given the increasing emphasis on patient-centred care, future research should prioritize these measures to better understand the broader benefits of day-case PCNL. Assessing post-operative pain, functional recovery and patient satisfaction will be critical to fully establishing day-case PCNL as a standard of care.

## Conclusion

Day-case PCNL represents a safe and increasingly viable approach, with growing adoption in recent years, driven in part due to broader post-pandemic healthcare trends. Our comprehensive review underscores its efficacy, favourable outcomes and a low incidence of complications and readmissions. Rigorous pre-operative planning remains essential in establishing criteria for suitable surgical candidates; however, increasing evidence indicates the opportunity for extended patient criteria, including patients with renal abnormalities and complex stone burdens. Future

research should standardize protocols and explore long-term quality-of-life analyses.

## Declarations

*Ethics approval and consent to participate*

Not applicable.

*Consent for publication*

Not applicable.

*Author contributions*

**Shreehari Suresh:** Data curation; Formal analysis; Investigation; Methodology; Writing – original draft; Writing – review & editing.

**Sylvia Ling:** Formal analysis; Methodology; Writing – original draft; Writing – review & editing.

**Dilip K. Vankayalapati:** Formal analysis; Writing – original draft; Writing – review & editing.

**Sherwin M. Ganegoda:** Formal analysis; Writing – original draft; Writing – review & editing.

**Bhaskar Somani:** Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Writing – original draft; Writing – review & editing.

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*Availability of data and materials*

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## Supplemental material

Supplemental material for this article is available online.

## References

1. Fernström I and Johansson B. Percutaneous pyelolithotomy: a new extraction technique. *Scand J Urol Nephrol* 1976; 10: 257–259.
2. EAU. EAU guidelines. In: *EAU annual congress*, Paris, 2024. EAU.
3. Assimos D, Krambeck A, Miller NL, et al. Surgical management of stones: American Urological Association/Endourological Society Guideline, PART II. *J Urol* 2016; 196: 1161–1169.
4. de la Rosette J, Assimos D, Desai M, et al. The Clinical Research Office of the Endourological Society Percutaneous Nephrolithotomy Global Study: indications, complications, and outcomes in 5803 patients. *J Endourol* 2011; 25: 11–17.
5. Jones P, Bennett G, Dosis A, et al. Safety and efficacy of day-case percutaneous nephrolithotomy: a systematic review from European society of uro-technology. *Eur Urol Focus* 2019; 5: 1127–1134.
6. Agrawal MS, Agrawal M, Gupta A, et al. A randomized comparison of tubeless and standard percutaneous nephrolithotomy. *J Endourol* 2008; 22: 439–442.
7. Crook TJ, Lockyer CR, Keoghane SR, et al. Totally tubeless percutaneous nephrolithotomy. *J Endourol* 2008; 22: 267–271.
8. Jones P, Bennett G, Aboumarzouk OM, et al. Role of minimally invasive percutaneous nephrolithotomy techniques-micro and ultra-mini PCNL (<15F) in the pediatric population: a systematic review. *J Endourol* 2017; 31: 816–824.
9. Calvillo-Ramirez A, Angulo-Lozano JC, Acevedo-Rodriguez JE, et al. Comparative outcomes of day-case percutaneous nephrolithotomy versus conventional inpatient surgery: a systematic review and meta-analysis. *Urology* 2024; 195: 214–226.
10. Du K, Uy M, Cheng A, et al. Comparing ambulatory to inpatient percutaneous nephrolithotomy: systematic review and meta-analysis. *BjU Int* 2025; 135: 380–389.
11. Moher D, Liberati A, Tetzlaff J, et al. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS Med* 2009; 6: e1000097.
12. Sterne JA, Hernán MA, Reeves BC, et al. ROBINS-I: a tool for assessing risk of bias in non-randomised studies of interventions. *BMJ* 2016; 355: i4919.
13. Sterne JAC, Savović J, Page MJ, et al. RoB 2: a revised tool for assessing risk of bias in randomised trials. *BMJ* 2019; 366: 14898.
14. McGuinness LA and Higgins JPT. Risk-of-bias VISualization (robvis): an R package and Shiny web app for visualizing risk-of-bias assessments. *Res Synthesis Methods* 2020; 12: 55–61.
15. DerSimonian R and Laird N. Meta-analysis in clinical trials. *Control Clin Trials* 1986; 7: 177–188.
16. Higgins JP, Thompson SG, Deeks JJ, et al. Measuring inconsistency in meta-analyses. *BMJ* 2003; 327: 557–560.
17. Higgins JPT, Thomas J, Chandler J, et al. (eds). *Cochrane handbook for systematic reviews of interventions version 6.5*, Cochrane, www.cochrane.org/handbook (2024, accessed August 2024).
18. Aarthy P, Thangarasu M, Prakash JS, et al. Safety and efficacy of mini-percutaneous nephrolithotomy as daycare procedure: a prospective observational study. *African J Urol* 2021; 27: 9.
19. Basiri A, Arab D, Pakmanesh H, et al. An overnight stay versus three days admission after uncomplicated percutaneous nephrolithotomy: a randomized clinical trial. *Urol J* 2020; 17: 352–357.
20. Bechis SK, Han DS, Abbott JE, et al. Outpatient percutaneous nephrolithotomy: the UC San Diego health experience. *J Endourol* 2018; 32: 394–401.
21. Beiko D, Elkoushy MA, Kokorovic A, et al. Ambulatory percutaneous nephrolithotomy: what is the rate of readmission? *J Endourol* 2015; 29: 410–414.
22. Chen Q, Cao Y, Xia L, et al. The retrospective experience of day-surgery semi tubeless ultra-mini percutaneous nephrolithotomy. *Transl Androl Urol* 2021; 10: 654–661.
23. Fahmy A, Rhashad H, Algebaly O, et al. Can percutaneous nephrolithotomy be performed as an outpatient procedure? *Arab J Urol* 2017; 15: 1–6.
24. Hosier GW, Visram K, McGregor T, et al. Ambulatory percutaneous nephrolithotomy is safe and effective in patients with extended selection criteria. *Can Urol Assoc J* 2022; 16: 89–95.
25. Kannan D, Quadri M, Sekaran PG, et al. Supine versus prone percutaneous nephrolithotomy (PCNL): a single surgeon's experience. *Cureus* 2023; 15: e41944.
26. Kumar S, Singh S, Singh P, et al. Day care PNL using 'Santosh-PGI hemostatic seal' versus standard PNL: a randomized controlled study. *Cent European J Urol* 2016; 69: 190–197.
27. Nikoufar P, Hodhod A, Hadi RA, et al. Safety and efficacy of ambulatory tubeless

- mini-percutaneous nephrolithotomy in the management of 10-25-mm renal calculi: a retrospective study. *Can Urol Assoc J* 2024; 18(10): 341–347.
28. Roberts JL, Sur RL, Flores AR, et al. Understanding causes for admission in planned ambulatory percutaneous nephrolithotomy. *J Endourol* 2022; 36: 1418–1424.
  29. Rosen DC, Drescher MR, Arias Villela NL, et al. Advancements in performance of percutaneous nephrolithotomy in ambulatory surgery centers: outcomes and lessons from 1250+ cases. *Urology* 2024; 184: 26–31.
  30. Thakker PU, Mithal P, Dutta R, et al. Comparative outcomes and cost of ambulatory PCNL in select kidney stone patients. *Urolithiasis* 2022; 51: 22.
  31. Wu X, Zhao Z, Sun H, et al. Day-surgery percutaneous nephrolithotomy: a high-volume center retrospective experience. *World J Urol* 2020; 38: 1323–1328.
  32. Zhu H, Liu B, Karagöz MA, et al. Reasons and risk factors for delayed discharge after day-surgery percutaneous nephrolithotomy. *BMC Urol* 2022; 22: 209.
  33. Gao M, Zeng F, Zhu Z, et al. Day care surgery versus inpatient percutaneous nephrolithotomy: a systematic review and meta-analysis. *Int J Surg* 2020; 81: 132–139.
  34. Gassmann K, Gupta K, Khargi R, et al. Review of efficacy and safety of same-day discharge after percutaneous nephrolithotomy. *Am J Clin Exp Urol* 2024; 12: 8–17.
  35. Zhu H, Zhao Z, Cheng D, et al. Multiple-tract percutaneous nephrolithotomy as a day surgery for the treatment of complex renal stones: an initial experience. *World J Urol* 2021; 39: 921–927.
  36. Kallidonis P, Tsaturyan A, Lattarulo M, et al. Minimally invasive percutaneous nephrolithotomy (PCNL): techniques and outcomes. *Turk J Urol* 2020; 46: S58–S63.
  37. Krocak T, Pace KT, Andonian S, et al. Ambulatory percutaneous nephrolithotomy in Canada: a cost-reducing innovation. *Can Urol Assoc J* 2018; 12: 427–429.

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