

Prone Versus Supine Percutaneous Nephrolithotomy: A Retrospective Comparative Cohort Study of Perioperative Outcomes and Initial Supine Adoption Experience

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Abstract

Background: Percutaneous nephrolithotomy (PCNL) is standard treatment for large renal calculi. Prone PCNL remains established, while supine PCNL offers anesthetic advantages; comparative data during initial institutional adoption remain limited, particularly from Indian centers.

Objective: To compare perioperative outcomes between prone and supine PCNL, our initial supine adoption experience.

Methods: This single-center retrospective cohort study at a tertiary care center included 167 patients: 84 prone (Group A), 83 supine (Group B). All underwent CT urography preoperatively. Primary outcomes were stone-free rate, operative time, hospital stay, and Clavien-Dindo grade complications.

Results: Supine patients had marginally higher BMI (27.6 ± 3.7 vs 27.3 ± 2.8 kg/m²; $p=0.457$). Prone stones were larger (median 3.4 vs 2.6 cm; $p<0.001$) with higher Guy's Stone Scores ($p=0.002$). Lower/inferior calyceal puncture predominated in both groups (73.8% prone, 96.4% supine). Stone-free rates were comparable (84.5% vs 83.1%; $p=0.836$). Operative time was longer in prone patients (97.0 vs 60.0 min; $p<0.001$); fluoroscopic dose was higher in supine patients (57.10 vs 43.95 mGy; $p<0.001$). Hospital stay was shorter with supine PCNL (2 vs 3 days; $p<0.001$); Grade 1 Complications were more frequent in Prone Group (19.0 vs 4.8 %; $p=0.007$) renal vascular injury requiring angioembolization occurred in two patients per group, all resolved without nephrectomy, plus one conservative liver injury. In the propensity-matched sensitivity analysis ($n=35$), operative time remained longer in the prone group and radiation dose remained higher in the supine group, although residual covariate imbalance persisted.

Conclusion: Supine PCNL achieves stone clearance and safety comparable to prone PCNL, with shorter hospital stay. Larger prospective, complexity-matched studies are warranted.

1. INTRODUCTION

Percutaneous nephrolithotomy (PCNL) is the standard treatment for large and complex renal calculi, with the European Association of Urology and American Urological Association recommending PCNL for stones > 20 mm and staghorn calculi [1–4] .

Despite its efficacy, the prone position carries recognized anesthetic risks including hemodynamic instability during turning, airway compromise, raised intraocular pressure, and relative contraindication in respiratory insufficiency, morbid obesity, or orthopedic limitations [5]. Supine (modified Valdivia) PCNL, described by Valdivia-Uria et al. in 1987 [6] and refined into the Galdakao-modified supine Valdivia (GMSV) position by Ibarluzea et al [7] [8].

Several positional modifications for supine PCNL have been described, including the Barts flank-free, complete supine, Calcutta, and intermediate-supine positions [9, 10]. Sabnis et al. confirmed that supine PCNL is feasible across most clinical scenarios, particularly for musculoskeletal abnormalities precluding prone positioning [11]. Systematic reviews report broadly comparable stone-free rates

between positions [12, 13], with supine PCNL offering shorter preparation time and lower radiation exposure at experienced centres [14]. Recent Indian studies have demonstrated comparable safety and efficacy [15, 16]. This study addresses real-world initial institutional adoption of GMSV supine PCNL in a centre with established prone PCNL expertise, with comparison against a historical prone cohort and assessment of perioperative outcomes, radiation exposure, and complications.

2. METHODS

2.1 Design, Setting, and Population

This single-centre retrospective comparative cohort study was conducted at the Department of Urology in a tertiary care center, as per STROBE guidelines [17]. Ethics Committee approval was obtained; data were anonymised and consent waived given the retrospective design. The prone cohort (Group A) comprised patients treated from January 2021 through December 2023, whereas the supine cohort (Group B) comprised the first 83 consecutive eligible supine PCNL procedures performed from January 2024 through December 2025. All five participating surgeons had experience of more than 200 prone PCNL procedures. The authors confirm the availability of, and access to, all original data reported in this study. The author/s have not used AI and AI-assisted technologies, including large language learning models, in the preparation of the manuscript. The author/s confirm that they have reviewed the manuscript and take/s full responsibility for the contents in the article.

2.2 Eligibility and Preoperative Evaluation

Patients aged ≥ 18 years with renal calculi ≥ 20 mm on preoperative imaging undergoing elective PCNL were eligible. Exclusions were uncorrected coagulopathy and incomplete records. All patients underwent complete blood count, renal function tests, coagulation profile, urine culture, and CT urography for stone size, location, collecting system anatomy, and access planning. Stone complexity was graded using the Guy's Stone Score [18]; hydronephrosis was graded 0–3.

2.3 Operative Technique — Positioning

All patients underwent cystoscopy in the lithotomy position for ureteric catheter placement, followed by retrograde pyelography using dilute contrast in ratio of 1:3 (Contrast : Normal Saline). Anaesthetic technique was determined by preoperative anaesthetic assessment and patient factors; For prone PCNL, the patient was repositioned on a radiolucent table with chest/pelvic bolsters and pressure points padded. For supine PCNL, the patient was transitioned without repositioning to the GMSV position [7]: ipsilateral flank elevated 20–25 degrees on a gel pad, ipsilateral limb extended, contralateral limb flexed. All patients underwent ureteric catheterization and retrograde pyelography for collecting-system opacification and access guidance. The definitive stone treatment was performed only percutaneously.

2.4 Operative Technique- Access and Fragmentation

Fluoroscopic guidance was used throughout. In the prone group, access was obtained using the bull's-eye or triangulation technique per stone location and surgeon preference; in the supine group, the triangulation technique only was used. An 18-G needle and 0.035-inch hydrophilic or Zebra guidewire were used, with a safety guidewire maintained throughout dilatation using Amplatz dilators. Prone dilatation was to 24–28 Fr (Amplatz dilatation); supine dilatation was to 24–26 Fr according to stone burden, access requirements, and surgeon preference.

Nephroscopy used a 22 Fr rigid instrument, with a 16.5 Fr flexible nephroscope for inaccessible fragments. Fragmentation employed a pneumatic lithotripter, ultrasonic lithotripter under continuous gravity irrigation, with clearance confirmed endoscopically and fluoroscopically. A Double J stent, nephrostomy tube, or both were placed per surgeon.

In our institution, PCNL was routinely performed using a 22-Fr nephroscope; consequently, a minimum tract dilatation of 24 Fr was used.

2.5 Access Tract Selection

Puncture site was selected according to stone location and anatomical accessibility.

2.6 Outcomes and Statistical Analysis

Nephrostomy tubes were removed after confirming satisfactory drainage, absence of significant haematuria or urinary leak, and clinical stability. Operative time spanned from initial cystoscopy to final drain placement. Stone clearance was assessed at 4–6 weeks using NCCT KUB; Stone-free status was defined as the absence of residual fragments > 4 mm on NCCT KUB at 4–6 weeks. Radiation exposure was recorded directly from the integrated C-arm radiation log as cumulative air kerma (mGy).

Complications were graded by Clavien-Dindo classification [19]; renal vascular injuries managed by angioembolization were classified as Grade IIIa. Double J Stent Removal was decided in follow-up based on clearance of stone on NCCT and need of subsequent procedure for clearance. DJ stents removed between 4–6 weeks post-operatively.

Fever was defined as a temperature > 38.5°C. Extra-Analgesia Requirement was considered patient requiring I.V. Diclofenac, Tramadol, Fentanyl Patch for pain management.

Analysis used SPSS v26.0. Shapiro-Wilk tested normality. Non-normal continuous variables were compared by Mann-Whitney U (median, IQR); normal variables by independent t-test (mean +/- SD). Categorical variables were compared by chi-square or Fisher's exact test. Fisher's's exact test when any expected cell count < 5. Significance was set at $p < 0.05$.

3. RESULTS

3.1 Baseline Patient Characteristics

A total of 167 patients were included: 84 prone, 83 supine (Table 1). Median age was 45(38–54) vs 38(28.5–54) years ($p = 0.036$); median BMI was marginally higher in the prone group without significance (26.50(25.0–28.5) vs 27.35(25.68–29.13) ; $p = 0.457$). Males predominated in the prone group (77.4% vs 61.4%; $p = 0.030$). Diabetes was significantly more prevalent in the supine group (33.7% vs 10.7%; $p < 0.001$); hypertension, CKD, culture positivity, and laterality did not differ.

Table 1
Baseline Patient Characteristics

Variable	Prone PCNL (n = 84)	Supine PCNL (n = 83)	p-value	Test
Age (years), Median (IQR)	45(38–54)	38(28.5–54)	0.036	MWU
BMI (kg/m ²), Median (IQR)	27.35(25.68–29.13)	26.50(25.0–28.5)	0.457	MWU
Male sex, n (%)	65 (77.4%)	51 (61.4%)	0.030	FE
Diabetes mellitus, n (%)	9 (10.7%)	28 (33.7%)	< 0.001	χ^2
Hypertension, n (%)	14 (16.7%)	22 (26.5%)	0.136	FE
Chronic kidney disease, n (%)	20 (23.8%)	18 (21.7%)	0.854	FE
Pre-operative culture positive, n (%)	14 (16.7%)	9 (10.8%)	0.370	FE
Stone laterality: Left, n (%)	43 (51.2%)	48 (57.8%)	0.438	χ^2
Anaesthesia				
General	84 (100%)	77(92.8%)		
Spinal	0 (0%)	6(7.2%)		
MWU = Mann-Whitney U; χ^2 = Pearson chi-square; FE = Fisher's exact. Data are median (IQR) or n (%).				

3.2 Stone Characteristics

Prone patients had significantly larger stones (median 3.4 vs 2.6 cm; $p < 0.001$), higher Guy's Stone Scores ($p = 0.002$); density was comparable ($p = 0.828$) as shown in Table 2. There was no significant difference in hydronephrosis grade between groups ($p = 0.550$);

Table 2
Showing Stone Characteristics

Variable	Prone PCNL (n = 84)	Supine PCNL (n = 83)	p-value	Test
Stone size (cm), median (IQR)	3.4 (3.0–3.8)	2.6 (1.9–3.4)	< 0.001	MWU
Stone density (HU), median (IQR)	1067 (982–1180)	1078 (911–1286)	0.828	MWU
Guy’s Stone Score, median (IQR)	2.0 (2.0–2.0)	1.0 (1.0–2.0)	0.002	MWU
GSS Grade 1, n (%)	20 (23.8%)	45 (54.2%)	0.550	MWU
GSS Grade 2, n (%)	53 (63.1%)	26 (31.3%)		
GSS Grade 3, n (%)	10 (11.9%)	11 (13.3%)		
GSS Grade 4, n (%)	1 (1.2%)	1 (1.2%)		
Hydronephrosis grade, Median (IQR)	0 (0–1)	0 (0–1)	0.002	χ²
Grade 0 – None	45 (53.6%)	41 (49.4%)		
Grade 1 – Mild	29 (34.5%)	30 (36.1%)		
Grade 2 – Moderate	10 (11.9%)	12 (14.5%)		
Grade 3 – Severe	0	0		
Stone location, n (%)			0.002	χ²
Pelvis only	34 (40.5%)	28 (33.7%)		
Inferior / lower calyx only	28 (33.3%)	26 (31.4%)		
Middle calyx only	10 (11.9%)	1 (1.2%)		
Multi-calyceal / staghorn	12 (14.3%)	28 (33.7%)		
IQR = interquartile range; HU = Hounsfield units; GSS = Guy’s Stone Score; MWU = Mann-Whitney U.				

3.3 Operative Outcomes

Operative outcomes are in Table 3 and Fig. 1. Stone-free rates were comparable (71/84, 84.5% prone vs 69/83, 83.1% supine; $p = 0.836$). Treatment failures predominantly involved residual fragments in patients with larger or multi-calyceal stone burden. Operative time was significantly longer in the prone group (median 97.0 vs 60.0 min; $p < 0.001$); fluoroscopic dose was higher in the supine group (median 57.10 vs 43.95 mGy; $p < 0.001$).

Table 3
Showing Operative Outcomes

Variable	Prone PCNL (n = 84)	Supine PCNL (n = 83)	p-value	Test
Operative time (min), median (IQR)	97.0 (92.8–103.2)	60.0 (50.0–80.0)	< 0.001	MWU
Fluoroscopy dose (mGy), median (IQR)	43.95 (37.03–52.38)	57.10 (52.00–65.95)	< 0.001	MWU
Number of access punctures, median (IQR)	1.0 (1.0–1.0)	1.0 (1.0–1.0)	0.774	MWU
Access approach, n (%)			0.117	FE
Infracostal	78 (92.9%)	82 (98.8%)		
Supracostal	6 (7.1%)	1 (1.2%)		
Primary Puncture site, n (%)			< 0.001	χ^2
Lower calyx	62 (73.8%)	80 (96.4%)		
Middle calyx	16 (19.0%)	3 (3.6%)		
Upper calyx	6 (7.1%)	0 (0.0%)		
Tract dilatation (Fr), n (%)			< 0.001	χ^2
24 Fr	40 (47.6%)	40 (48.2%)		
26 Fr	30 (35.7%)	43 (51.8%)		
28 Fr	14 (16.7%)	0 (0.0%)		
Stone-free rate, n (%)	71 (84.5%)	69 (83.1%)	0.836	FE
Nephrostomy tube placed, n (%)	75 (89.3%)	58 (69.9%)	0.002	χ^2
Double-J stent placed, n (%)	68 (81.0%)	52 (62.7%)	0.010	FE
Pre-operative Hb (g/dL), mean $\pm$ SD *	13.6 $\pm$ 1.2	12.91 $\pm$ 1.50	—	
Post-operative Hb (g/dL), mean $\pm$ SD *	12.8 $\pm$ 1.2	12.11 $\pm$ 1.41	—	
Haemoglobin drop (g/dL), mean $\pm$ SD *	0.81 $\pm$ 0.29	0.81 $\pm$ 0.36	0.571	MWU
IQR = interquartile range; MWU = Mann-Whitney U; FE = Fisher's exact; χ^2 = Pearson chi-square. Fluoroscopy dose in mGy from integrated C-arm log. AE = angioembolisation.				

Primary Puncture site distribution differed significantly ($p < 0.001$): in the prone group, the lower/inferior calyx was accessed in 62 (73.8%), middle calyx in 16 (19.0%), and upper calyx in 6 (7.1%), the latter for

selected complex configurations. In the supine group, lower/inferior calyceal access predominated (80/83, 96.4%) with middle calyceal access in 3 (3.6%).

Tract dilatation in the prone group ranged from 24–28 Fr (24 Fr 47.6%, 26 Fr 35.7%, 28 Fr 16.7%); the supine group was confined to 24–26 Fr (24 Fr 48.2%, 26 Fr 51.8%; $p < 0.001$). Nephrostomy (89.3% vs 69.9%; $p = 0.002$) and DJ stent (81.0% vs 62.7%; $p = 0.010$) placement were more frequent in the prone group. The mean Hb Decrease was similar in both group and the difference was not statistically significant.

3.4 Postoperative Outcomes and Complications

Postoperative outcomes are presented in Table 4. Hospital stay was significantly shorter in the supine group than in the prone group (median 2.0 vs 3.0 days; $p < 0.001$). Grade I complications occurred in 16 (19.0%) prone and 4 (4.8%) supine patients ($p = 0.007$), Grade II complications in 0 (0.0%) and 2 (2.4%) patients ($p = 0.246$), and Grade IIIa complications in 2 (2.4%) patients in each group ($p = 1.000$). No Grade IIIb–V complications occurred. Renal vascular injury occurred in two patients in each group, with both Grade IIIa cases in each group classified accordingly. One supine patient had a perinephric collection in association with renal vascular injury.

Table 4
Postoperative Outcomes and Complications

Variable	Prone PCNL (n = 84)	Supine PCNL (n = 83)	p-value	Test
Hospital stay (days), median (IQR)	3.0 (3.0–3.0)	2.0 (2.0–3.0)	< 0.001	MWU
Nephrostomy removal (POD), median (IQR) ‡	1.0 (1.0–2.0)	1.0 (1.0–2.0)	0.448	MWU
Per-Urethral Catheter Removal (POD), median (IQR)	2.0 (2.0–2.3)	2.0 (2.0–3.0)	0.579	MWU
Clavien Dindo Complication n (%)				
Clavien-Dindo Grade 0	66 (78.6%)	75 (90.4%)		
Clavien-Dindo Grade I	16 (19.0%)	4 (4.8%)	0.007	FE
Clavien-Dindo Grade II	0	2 (2.4%)	0.246	FE
Clavien-Dindo Grade IIIa	2 (2.4%)	2 (2.4%)	1.000	FE
Clavien-Dindo Grade IIIb-V	0 (0.0%)	0 (0.0%)		
Post-operative fever (> 38.5°C), n (%)	5 (6.0%)	4 (4.8%)	1.000	FE
Septic Shock, n (%)	0 (0.0%)	1 (1.2%)	0.497	FE
Extra analgesia requirement, n (%)	11 (13.1%)	2 (2.4%)	0.018	FE
Perinephric collection, n (%)	0 (0.0%)	1 (1.2%)	0.497	FE
Blood transfusion, n (%)	0 (0.0%)	0 (0.0%)		
Renal vascular injury requiring AE, n (%)	2 (2.4%)	2 (2.4%)	1.000	FE
Liver injury (conservative), n (%)	0 (0.0%)	1 (1.2%)	0.497	FE
IQR = interquartile range; POD = post-operative day; FE = Fisher's exact; MWU = Mann-Whitney U. ‡ Nephrostomy removal reported only for patients with nephrostomy placed (Prone n = 75; Supine n = 58). AE = angioembolisation. Extra analgesia = analgesic beyond standardised institutional protocol. For patients experiencing multiple postoperative events, the highest applicable Clavien–Dindo grade was assigned as the overall complication grade; individual complications were reported separately and were not considered mutually exclusive.				

Subcapsular liver haematoma due to tract injury (Grade II) was managed conservatively with full recovery. The patient was managed with clinical observation and serial haemoglobin monitoring. Ultrasonography after nephrostomy removal showed only a minimal residual collection, and the patient was discharged on postoperative day 3. No bowel injury, septic shock, or mortality occurred. Extra analgesia was significantly higher in the prone group (13.1% vs 2.4%; $p = 0.018$).

3.5 Propensity-Matched Analysis

Propensity-score matching using age, sex, BMI, diabetes, hypertension, CKD, stone size, Guy's Stone Score, and hydronephrosis grade yielded 35 matched pairs (70 patients) using 1:1 nearest-neighbour matching without replacement with a caliper of 0.2 SD of the logit propensity score. Matching substantially reduced measured baseline imbalance, although small residual imbalances remained for age, stone size, Guy's Stone Score, and hydronephrosis grade. In the matched cohort, operative time remained significantly longer in the prone group than in the supine group (median 99 vs 60 min; $p < 0.001$), while cumulative air kerma remained higher in the supine group (median 45.4 vs 59.1 mGy; $p < 0.001$) as shown in Fig. 1. Hospital stay remained shorter in the supine group (median 2 vs 3 days; $p = 0.041$). Stone-free rates were 80.0% (28/35) in the prone group and 65.7% (23/35) in the supine group, with no significant paired difference ($p = 0.227$). Given the residual covariate imbalance and the sequential temporal allocation of treatment, the matched analysis was considered a sensitivity analysis rather than evidence of causal equivalence between positions.

4. DISCUSSION

This study presents our institutional experience with prone PCNL followed by an initial supine adoption phase. Key findings: comparable stone-free rates; longer prone operative time; higher supine fluoroscopic dose during our adoption phase; shorter supine hospital stay; and comparable complication rates, with renal vascular injuries requiring angioembolization in both groups.

4.1 Stone-Free Rate

Stone-free rates in our series — 84.5% prone and 83.1% supine — were comparable and consistent with contemporary literature. The CROES study reported an overall SFR of 75.7% [2]; Cheng et al. reported pooled SFRs of 85.1% and 83.7% across 12 studies [13]; Mondal et al. and Bansal et al. reported comparable Indian data (85.0–90.0%) [15, 16]. Our findings are comparable to contemporary studies. Treatment failures were predominantly associated with larger or multi-calyceal stone burden, consistent with the established relationship between complexity and clearance.

The marginally higher, non-significant BMI in the supine group ($p = 0.457$) likely reflects institutional preference for supine positioning in patients with elevated body habitus, given its recognised anaesthetic advantages [5, 11]. Operative time was significantly longer in the prone group (97.0 vs 60.0 min; $p < 0.001$); Mondal et al. and Bansal et al. reported similar supine time advantages [15, 16], though the dominant confound here is greater stone burden in the prone cohort (addressed in the propensity-matched sensitivity analysis). Anaesthetic technique differed between groups, with spinal anaesthesia used exclusively in a small subset of supine procedures. This may have influenced postoperative analgesic requirements and length of stay.

Puncture site distribution differed significantly between approaches. Upper calyceal access was used in 6 prone patients (7.1%) for complex configurations, exploiting the wider working field and greater nephroscope excursion. In the supine group, lower/inferior calyceal access predominated (96.4%) with

no upper calyceal puncture required, reflecting the GMSV position's ergonomics, where the extended ipsilateral limb favours lower calyceal entry. Choudhury et al. similarly found inferior calyceal access sufficient for upper-pole clearance [9]; this was our preferred strategy, not a limitation.

Tract dilatation ranged from 24–28 Fr in the prone group, with 28 Fr required in 14 (16.7%) with larger stone burden, whereas the supine group required only 24–26 Fr ($p < 0.001$), reflecting stone burden rather than a position-specific limitation. No blood transfusions occurred in either group.

The higher fluoroscopic dose in the supine group (57.10 vs 43.95 mGy; $p < 0.001$) is directionally opposite to findings from established supine centres [14] and may be attributed to our initial adoption phase: our prone practice benefited from an ingrained fluoroscopic routine, whereas initial supine cases required additional screening time for the altered orientation. Novaes et al. documented this pattern during early adoption [23], and expert centres report doses equivalent to or lower than prone PCNL once established [14]. Bhatti et al. and Sahare et al. reported similarly acceptable outcomes during initial supine experiences [24, 25].

Hospital stay was significantly shorter with supine PCNL (median 2 vs 3 days; $p < 0.001$), facilitated by earlier mobilisation, consistent with De La Rosette et al.'s European data [26]. This finding may reflect differences in postoperative recovery pathways and anaesthetic practice, in addition to the potential effects of patient positioning. Renal vascular injury requiring angioembolization occurred in two patients per group (2.4% each; $p = 1.000$); all four succeeded without nephrectomy. Published haemorrhage-angioembolization rates range 0.8–1.5% [2, 27]; the 2.4% rate observed in each group was higher, although the small number of events precludes meaningful comparative inference. Absence of bowel injury is consistent with CT data showing the colon lies further from the kidney supine [28] and our routine tract inspection; Bhardwaj et al. reported similarly [22]. However, the sample size was insufficient to draw conclusions regarding differences in visceral injury risk between positions. Extra analgesia was significantly higher in the prone group (13.1% vs 2.4%; $p = 0.018$), consistent with Bansal et al.'s lower supine VAS scores [16].

To address residual confounding, we performed propensity score matching this analysis is therefore a partial rather than definitive control for confounding. The persistence of differences in operative time and radiation dose after matching suggests that factors beyond measured stone complexity may have contributed; however, residual confounding and temporal effects cannot be excluded. Hospital stay and complication rate no longer differed significantly, most plausibly reflecting loss of power at $n = 35$ per group.

Limitations

Limitations include: Retrospective single-centre design, Small Sample Size.

5. CONCLUSION

Supine PCNL provides stone clearance and perioperative outcomes comparable to prone PCNL while offering advantages such as shorter hospital stay and reduced postoperative analgesic requirement. Both approaches demonstrated acceptable safety profiles, with major complications, including renal vascular injury requiring angioembolization, occurring infrequently and managed successfully without mortality or nephrectomy. The longer operative time observed in the prone cohort may have been influenced by its greater stone burden and complexity, although temporal and technical confounding cannot be excluded. Similarly, the higher radiation exposure may reflect the early adoption phase and differences in fluoroscopic workflow rather than a fixed limitation. These findings suggest that supine PCNL can be safely introduced into an established prone-based practice without compromising stone-free outcomes or patient safety, provided access technique and tract planning are individualised to stone anatomy. Wider adoption may be facilitated by structured training in supine positioning. Larger prospective, complexity-matched studies with standardised follow-up imaging are warranted to confirm these findings and define the comparative role of positioning in contemporary PCNL practice.

Declarations

Author Contribution

Conceptualization: D.P.B., A.J.M.P., J.S.S.; Methodology: D.P.B., A.J.M.P., J.S.S.; Data acquisition: D.P.B., A.J.M.P.; Formal analysis and statistical analysis: D.P.B., A.J.M.P., J.S.S.; Literature search: D.P.B., A.J.M.P., J.S.S.; Clinical studies: D.P.B., A.J.M.P., J.S.S.; Writing – original draft: D.P.B., A.J.M.P., J.S.S., A.S.S.; Writing – review and editing: D.P.B., A.J.M.P., J.S.S., M.S., S.C.N., A.S.S.; Supervision: A.J.M.P. All authors approved the final manuscript and agree to be accountable for all aspects of the work.

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Data Availability

Data available upon request to corresponding author

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Figures

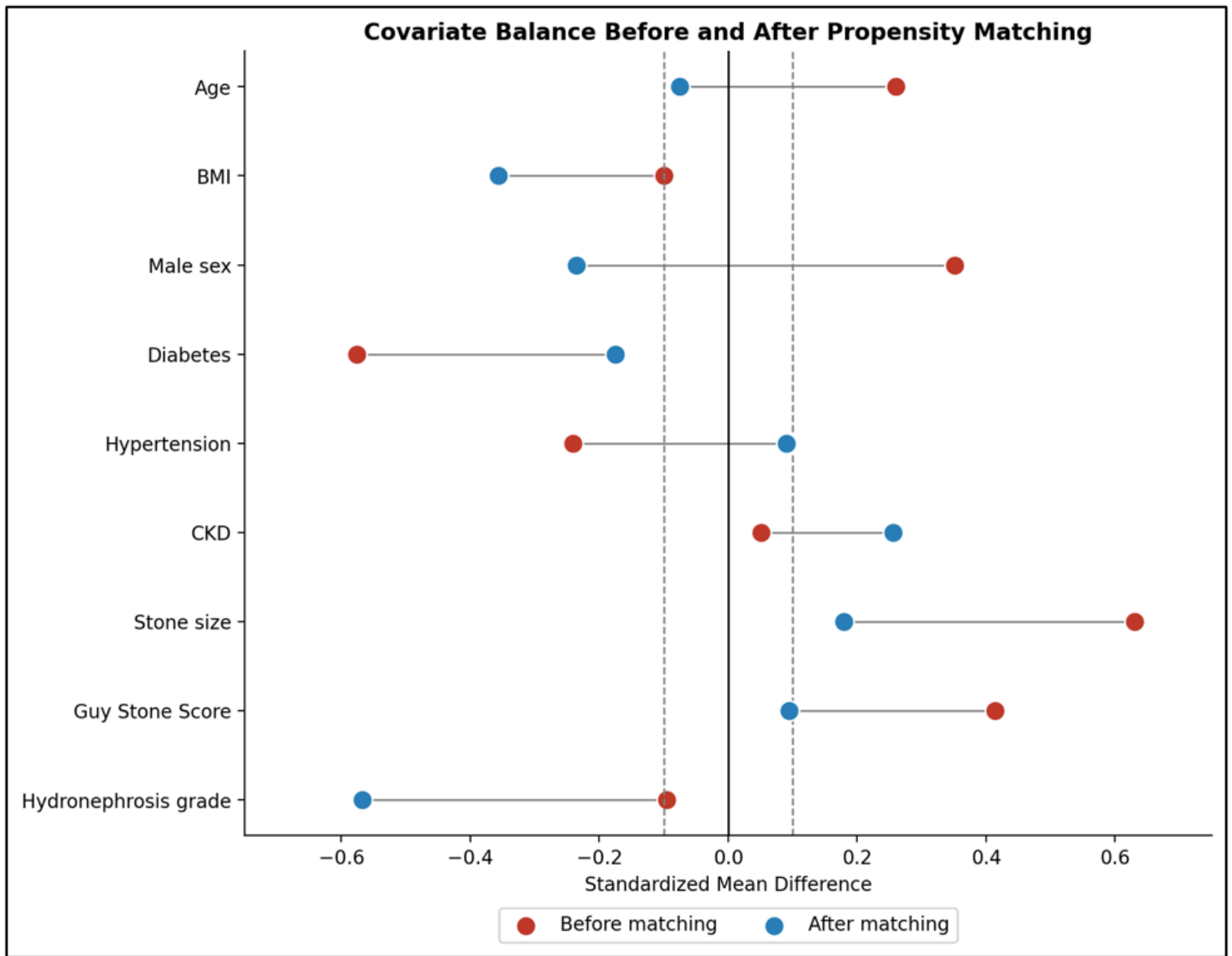


Figure 1

Covariate balance before and after 1:1 propensity score matching (Love plot). Standardised mean differences (SMD) for age, BMI, sex, diabetes, hypertension, CKD, stone size, Guy's Stone Score, and hydronephrosis grade are shown before matching (red) and after matching (blue). The dashed lines denote the conventional $|SMD| = 0.1$ threshold for adequate balance. Balance improved for several covariates (age, hypertension, Guy's Stone Score).