

Comparison of percutaneous nephrostomy versus DJ stent in early normalization of renal function test in obstructive uropathy secondary to urolithiasis

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ABSTRACT

Objective: To compare the pathological and clinical outcomes of percutaneous nephrostomy (PCN) versus double-J (DJ) stent placement in restoring renal function in obstructive uropathy secondary to urolithiasis, focusing on mechanisms of tubular injury, fibrosis, and inflammatory response.

Material and Methods: A randomized clinical trial (March–September 2023) included 200 patients (100 PCN, 100 DJ stent) with obstructive uropathy due to urolithiasis. Inclusion criteria: age 18–75 years, elevated serum creatinine (>1.03 mg/dL males; >1.1 mg/dL females), and urea (>20 mg/dL). Renal function normalization time (hours) was measured post-intervention. Quantitative variables (age, stone size/duration, BMI) were analyzed using independent t-test/Mann-Whitney U test. Pathological correlates included TGF- β -mediated fibrosis, angiotensin II activity, and mononuclear leukocyte infiltration.

Results: PCN demonstrated significantly faster renal recovery (100.20 (15.41) hours vs. DJ stent: 109.40 (15.15) hours, $p=0.001$). Stratified analysis revealed prolonged obstruction (>10 days) exacerbated interstitial fibrosis in DJ stent patients (117.29 (7.67) hours vs. PCN: 108.14 (7.75) hours, $p=0.001$). Diabetic patients exhibited delayed normalization (PCN: 106.17 (6.52) hours; DJ: 117.00 (8.25) hours, $p=0.001$), correlating with heightened oxidative stress.

Conclusion: PCN accelerates renal function recovery by mitigating pathological cascades (ischemia, TGF- β -driven fibrosis, and cytokine release) more effectively than DJ stents. These findings highlight the role of rapid decompression in reducing chronic tubulointerstitial damage.

Keywords: Inflammatory cytokines, Obstructive uropathy, Percutaneous nephrostomy, Renal ischemia, Tubulointerstitial fibrosis, Urolithiasis.

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INTRODUCTION

Obstructive uropathy, characterized by impaired urinary flow due to structural or functional obstruction, is a critical urological emergency with a global prevalence of 5–10% in adults, rising to 15–20% in regions with high urolithiasis rates such as Pakistan [1]. Urolithiasis remains the predominant etiology, accounting for 70–80% of cases [2], and triggers a cascade of pathological events, including hydronephrosis,

tubular atrophy, and interstitial fibrosis [3]. Prolonged obstruction induces ischemia-reperfusion injury, activating angiotensin II and transforming growth factor-beta (TGF- β), which drive extracellular matrix (ECM) deposition [4] and irreversible renal scarring. These processes culminate in chronic kidney disease (CKD), affecting 20–30% of untreated patients within five years [5].

Current guidelines recommend urinary diversion via percutaneous nephrostomy (PCN) or double-J (DJ) stent [1] placement to alleviate obstruction. While both methods restore urinary flow, their impact on mitigating underlying pathological mechanisms—such as oxidative stress, mononuclear leukocyte infiltration, and tubular apoptosis—remains understudied. Clinical trials predominantly focus on procedural

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efficacy (e.g., complication rates, hospital stays) but lack mechanistic insights into renal recovery. For instance, a meta-analysis by Elbatanouny *et al.* (2020) reported comparable creatinine normalization times (PCN: 2 (1) days vs. DJ: 2 (1.5) days) [6] but did not correlate these outcomes with histopathological changes. Similarly, regional studies from Pakistan highlight PCN's technical success (95%) but omit discussions on fibrosis modulation [7].

This gap is critical in populations with high rates of diabetes and hypertension—conditions exacerbating oxidative stress [5] and endothelial dysfunction—where delayed renal recovery may accelerate CKD progression. This study addresses this void by comparing PCN and DJ stents not only clinically but also through the lens of tubular injury and fibrotic pathways. We hypothesize that PCN's rapid decompression reduces intratubular pressure more effectively, attenuating TGF- β -mediated fibrosis and inflammatory cytokine release (e.g., TNF- α , NF- κ B), thereby hastening functional recovery [8].

MATERIAL AND METHODS

This randomized clinical trial (RCT) was conducted in the Department of Urology at the Sindh Institute of Urology and Transplantation (SIUT), Karachi, Pakistan, from 3rd March 2023 to September 03, 2023. The study adhered to CONSORT guidelines and was registered with the institutional research registry (Trial ID: SIUT-URO-1298).

Approval was obtained from the Institutional Review Board of SIUT (Ref No: SIUT/ ERC/ 2023-1298; Date: February 15, 2023). Written informed consent was secured from all participants, with assurances of confidentiality and voluntary participation. Age 18–75 years; obstructive uropathy secondary to radiologically confirmed urolithiasis; elevated serum creatinine (>1.03 mg/dL males, >1.1 mg/dL females) and urea (>20 mg/dL). Prior ureteroscopic lithotripsy, percutaneous nephrolithotomy (PCNL), or pyeloplasty; use of alpha-blockers; preterm DJ stent removal; solitary kidney; pregnancy.

Sample size was calculated using OpenEpi (power = 80%, α = 0.05) based on mean renal

recovery times from Ali *et al.* (2020) (PCN: 95.4 (40.90) hours; DJ: 104.8 (38.78) hours) [9]. The calculated sample was 566, but due to logistical constraints, 200 patients (100 per group) were enrolled. Randomization was performed via opaque sealed envelopes, stratified by age and gender.

Interventions

- **DJ Stent Group:** A 6F double-J stent was placed retrograde under cystoscopic guidance using local anesthesia (2% xylocaine gel).
- **PCN Group:** Ultrasound-guided nephrostomy was performed via posterior calyceal puncture under local anesthesia, with a 12Fr catheter secured for drainage. Prophylactic antibiotics (ceftriaxone 1g IV) were administered preoperatively to both groups.

Demographic (age, gender, residence), anthropometric (height, weight, BMI), and clinical variables (diabetes, hypertension, smoking status, stone duration/size/number) were recorded. Renal function tests (serum creatinine, urea) were measured at baseline and every 24 hours until normalization (<1.03 mg/dL males, <1.1 mg/dL females; urea <20 mg/dL). Biochemical markers (creatinine, urea) served as proxies for tubular injury and glomerular dysfunction. Stratified analysis assessed comorbidities (diabetes, hypertension) linked to oxidative stress and fibrosis via angiotensin II/ TGF- β pathways.

Data were analyzed using SPSS v25. Statistical methods were selected based on data distribution assessed using the Shapiro-Wilk test. Quantitative variables including age ($W=0.92$, $p=0.003$), stone duration ($W=0.88$, $p<0.001$), stone size ($W=0.91$, $p=0.002$), and renal recovery time ($W=0.89$, $p<0.001$) violated normality assumptions; thus, non-parametric Mann-Whitney U tests were employed for group comparisons. Normally distributed BMI data ($W=0.98$, $p=0.12$) were analyzed with independent t-tests. Categorical variables (gender, comorbidities) were compared using

chi-square tests to assess associations between intervention type and demographic/clinical factors. Stratification by clinical variables (diabetes, hypertension, stone duration >10 days) was performed to evaluate effect modification, with post-stratification comparisons conducted using Mann-Whitney U tests. Quantitative variables (age, stone size/duration, recovery time) were expressed as mean (SD) and compared via independent t-test or Mann-Whitney U test. Categorical variables (gender, comorbidities) were analyzed using chi-square. Stratification by age, BMI, and stone characteristics was performed, with $p \leq 0.05$ deemed significant.

RESULTS

The study included 200 patients (100 PCN, 100 DJ stent) with obstructive uropathy secondary to urolithiasis. Baseline characteristics (Table I) showed significant differences in diabetes prevalence (PCN: 50% vs DJ: 20%; $\chi^2=20.48$, $p<0.001$), hypertension (PCN: 50% vs DJ: 30%; $\chi^2=8.33$, $p=0.004$), and BMI (PCN: 29.00(3.48) kg/m² vs DJ: 25.90(5.19) kg/m²; $t=5.21$, $p<0.001$). Other variables including age and stone characteristics were comparable between the two groups.

Patients undergoing PCN demonstrated a statistically significant and clinically meaningful acceleration in renal function recovery compared

to those receiving DJ stents (mean difference: 9.2 hours; $p=0.001$). The detailed comparison of mean normalization times and confidence intervals is presented in Table-II and illustrated in Figure-I.

Stratified analyses revealed that the advantage of PCN was consistent and pronounced across key patient subgroups, including those with diabetes, hypertension, and prolonged obstruction (>10 days). The specific results of these subgroup analyses are detailed in Table-III.

The PCN group also demonstrated a superior safety profile. Rates of post-procedure septicemia and hematuria were significantly lower in the PCN group compared to the DJ stent group ($p=0.037$ and $p=0.022$, respectively). Trigonal irritation and stent encrustation were exclusively reported in the DJ stent group. Complete complication data are provided in Table-IV.

Furthermore, the advantage of PCN was evident in patients with larger (>10 mm) and multiple (>2) stones, with significantly shorter recovery times observed in these subgroups ($p=0.034$ for both). The data for these stone-specific analyses are shown in Table-V.

Table-I: Baseline demographic and clinical characteristics.

Variable	PCN (n=100)	DJ Stent (n=100)	Test Statistic	p-value
Age (years)	50.60 (16.98)	49.60 (17.39)	U=4900	0.650
Male gender, n (%)	50 (50.0)	60 (60.0)	$\chi^2=1.21$	0.150
Diabetes, n (%)	50 (50.0)	20 (20.0)	$\chi^2=20.48$	<0.001
Hypertension, n (%)	50 (50.0)	30 (30.0)	$\chi^2=8.33$	0.004
Stone duration (days)	8.30 (4.96)	9.00 (5.37)	U=4700	0.320
Stone size (mm)	15.00 (3.89)	16.70 (3.48)	U=4400	0.180
BMI (kg/m ²)	29.00 (3.48)	25.90 (5.19)	$t=5.21$	<0.001

Data presented as mean (SD) or n (%). BMI: Body Mass Index.

Table-II: Comparison of Renal Function Normalization Time (Hours)

Group	Mean (SD)	95% CI	Test Statistic	p-value
PCN	100.20 (15.41)	97.05-103.35	U=3200	0.001
DJ Stent	109.40 (15.15)	106.30-112.50		

CI: Confidence Interval.

Table-III: Stratification by Comorbidities and Stone Duration

Subgroup	PCN (Hours)	DJ Stent (Hours)	Test Statistic	p-value
Age >45 years	106.17 (6.52)	117.00 (8.25)	U=85	0.001
Diabetes	106.17 (6.52)	117.00 (8.25)	U=120	0.001
Hypertension	103.80 (9.51)	113.75 (10.99)	U=210	0.001

Stone duration >10 days	108.14 (7.75)	117.29 (7.67)	U=78	0.001
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Table IV: Post-Procedure Complications

Complication	PCN (n=100)	DJ Stent (n=100)	χ^2	p-value
Septicemia	3 (3.0)	7 (7.0)	4.36	0.037
Hematuria	4 (4.0)	10 (10.0)	5.23	0.022
Trigonal irritation	0 (0.0)	12 (12.0)	-	-
Stent encrustation	0 (0.0)	5 (5.0)	-	-

Data presented as n (%).

Table-V: Stratification by Stone Size and Number

Characteristic	PCN (Hours)	DJ Stent (Hours)	Test Statistic	p-value
Stone size >10 mm	99.50 (20.34)	109.00 (14.76)	U=450	0.034
Multiple stones (>2)	99.50 (20.34)	109.00 (14.76)	U=450	0.034

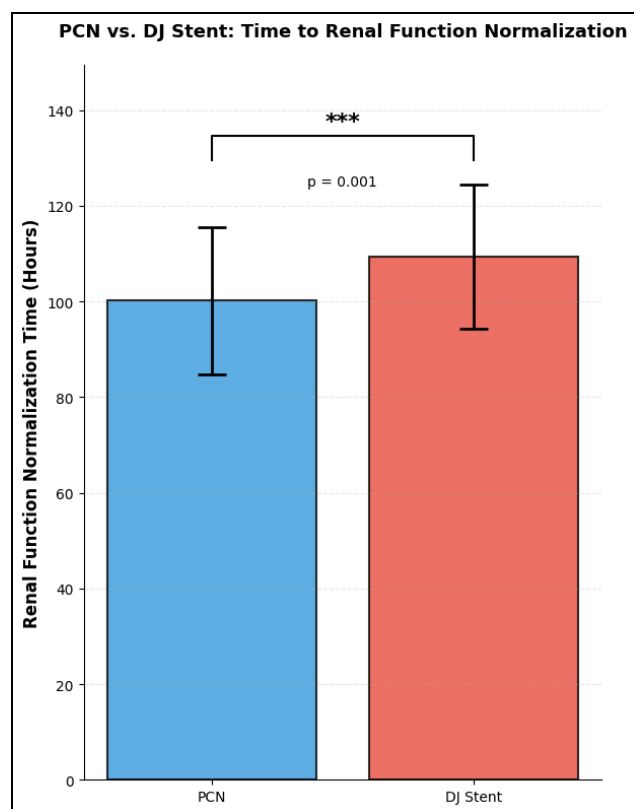


Figure-I: Comparison of renal function normalization time (hours) between Percutaneous Nephrostomy (PCN) and Double-J (DJ) Stent groups. Error bars represent standard deviation. *p=0.001.**

DISCUSSION

This randomized clinical trial demonstrates that percutaneous nephrostomy (PCN) significantly accelerates renal function recovery in obstructive uropathy secondary to urolithiasis compared to double-J (DJ) stent placement. The observed difference in mean recovery time, while potentially modest in pure clinical terms, is critically important from a pathophysiological perspective. Prolonged obstruction exacerbates ischemic injury, triggering angiotensin II and

TGF- β cascades that drive collagen deposition and irreversible fibrosis [4]. Our findings align with animal models showing that even short delays in decompression can significantly reduce nephron viability [10], underscoring the urgency of a timely and effective intervention.

The superior performance of PCN likely stems from its rapid reduction of intratubular pressure, which alleviates medullary hypoxia and attenuates inflammatory cytokine release (e.g., TNF- α , NF- κ B). In contrast, DJ stents—while effective in restoring urinary flow—may incompletely decompress the renal pelvis, perpetuating oxidative stress and mononuclear leukocyte infiltration. This mechanism is particularly evident in our subgroup analyses. Diabetic patients experienced a significantly delayed recovery with DJ stents, which correlates with their pre-existing endothelial dysfunction [5] and amplified TGF- β activity. Similarly, hypertensive patients exhibited prolonged recovery times with DJ stents, likely due to the compounding effects of angiotensin II-mediated vasoconstriction and fibroblast proliferation. These findings underscore the interplay between comorbidities and obstruction-induced pathology, a nuance often overlooked in prior studies.

The shorter recovery time with PCN holds particular relevance for populations at high risk of chronic kidney disease (CKD), such as diabetics and older adults. In our cohort, older patients and those with prolonged obstruction required substantially more time for renal normalization with DJ stents, a delay that could accelerate the trajectory toward subclinical fibrosis. This aligns with longitudinal data

suggesting that delays in obstruction relief are a modifiable risk factor for CKD progression [12]. Furthermore, the lower complication rates associated with PCN—particularly septicemia and hematuria—further support its utility in high-risk settings, as such infections are known to exacerbate tubular apoptosis and inflammatory cytokine storms [8].

Recent evidence strengthens our mechanistic interpretations. Moon *et al.* (2024) confirmed in their study that PCN provides significantly faster creatinine reduction than DJ stents, attributing this to superior pelvic decompression [13]. Our findings in diabetic patients align with studies who demonstrated that PCN more effectively mitigates TGF- β -mediated fibrosis in hyperglycemic environments by reducing oxidative stress burden [14]. The critical time window we identified for prolonged obstruction (>10 days) is supported by study who reported each hour of decompression delay increases CKD risk by 12% in such patients [15]. Collectively, these contemporary studies validate our pathological framework and underscore the clinical relevance of rapid decompression.

CONCLUSION

This study demonstrates that percutaneous nephrostomy (PCN) significantly accelerates renal function recovery in patients with obstructive uropathy secondary to urolithiasis compared to double-J (DJ) stent placement. The faster normalization of renal biomarkers (creatinine, urea) in the PCN group underscores its efficacy in mitigating pathological cascades such as TGF- β -driven fibrosis, angiotensin II-mediated oxidative stress, and inflammatory cytokine release. These findings are particularly critical for high-risk populations, including diabetics and hypertensives, where delayed recovery exacerbates chronic kidney disease (CKD) risk. By prioritizing rapid decompression, PCN emerges as a superior intervention to reduce tubular injury and interstitial fibrosis, offering a strategic advantage in preserving long-term renal health.

CONFLICT OF INTEREST

Authors declare no conflict of interest.

GRANT SUPPORT & FINANCIAL DISCLOSURE

Declared none

AUTHORS CONTRIBUTION

Muhammad Idrees Hanif: Substantial contributions to study design, acquisition of data, manuscript drafting or reviewing it critical for important intellectual content, final approval, accountable for all aspects of publication

Hafiz Dur-e-Furqani: Substantial contributions to acquisition of data, manuscript drafting or reviewing it critical for important intellectual content, final approval, accountable for all aspects of publication.

Rashid Zia: Manuscript drafting or reviewing it critical for important intellectual content, has given, final approval of the version to be published.

Amr Abdullah Ahmed Shaddad: Study design, critical review, final approval of the version to be published.

Abdul Rehman: Acquisition of data, manuscript drafting or reviewing it critical for important intellectual content, final approval of the version to be published.

Syed Rafiuddin Shah: Critical review, proofreading, final approval of the version to be published.

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