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Impact of Menopausal Status on Outcomes of Prone Percutaneous Nephrolithotomy for Staghorn Stones

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Abstract

Background

Menopause has been associated with an increased risk of kidney stone formation; however, its impact on surgical outcomes in women undergoing percutaneous nephrolithotomy (PCNL) for complex stones remains unclear. This study aimed to compare surgical success, perioperative outcomes, and complication rates between premenopausal and menopausal women undergoing percutaneous nephrolithotomy for staghorn stones.

Methods

Female patients who underwent prone PCNL for staghorn kidney stones between January 2024 and January 2026 were retrospectively analyzed. Patients were divided into premenopausal (n=81) and menopausal (n=75) groups. Demographic characteristics, perioperative parameters, complication rates, and residual stone outcomes were compared between groups. Multivariable logistic regression analysis was performed to identify independent predictors of residual stone formation.

Results

A total of 156 patients were included. Age and body mass index were significantly higher in the menopausal group ($p<0.001$ and $p=0.0003$, respectively). Operative parameters, including stone burden, stone density, operative time, nephroscopy time, and fluoroscopy time, were comparable between groups. Residual stone rates were 38.3% in the premenopausal group and 22.7% in the menopausal group, with borderline statistical significance ($p=0.053$). In multivariable analysis, menopausal status was independently associated with a lower risk of residual stone formation (OR 0.36; 95% CI 0.15–0.82; $p=0.016$), while stone burden was identified as the strongest independent predictor (OR 1.08 per 100 units; 95% CI 1.02–1.13; $p=0.008$). Overall and major complication rates did not differ significantly between groups.

Conclusions

Menopausal status did not adversely affect complication rates or postoperative recovery following prone PCNL for staghorn kidney stones. Although residual stone rates were lower in menopausal patients, stone burden remained the primary determinant of surgical success. Menopause should not be considered a limiting factor for PCNL in women with staghorn stones.

INTRODUCTION

Menopause is a physiological transitional period in a woman’s life characterized by the cessation of fertility and accompanied by hormonal and physiological remodeling, and variability in the age of menopause has been reported among different countries (1). The regulatory effects of estrogens on vascular reactivity and endothelial function may create a basis for cardiovascular and microcirculatory

changes in the menopausal period to be reflected in clinical outcomes (2). Modulation of immune responses through estrogen receptors represents one of the biological mechanisms underlying increased susceptibility to infections after menopause (3). In the menopausal period, the development of hypertension and vascular remodeling via the renin–angiotensin system constitutes another axis that may influence comorbidity burden and perioperative risk profiles in surgical patients (4). Urinary tract infections are commonly encountered in women during the menopausal period (5). The menopausal period has been associated with an increased risk of kidney stone formation, and several cohorts have reported a rise in stone risk following menopause (6). Kidney stones affect approximately 7% of women during their lifetime, and the incidence of urolithiasis increases after menopause (7). In the surgical management of kidney stones, indications for interventional treatment approaches in large and complex stones have been defined in international guidelines (8). Staghorn kidney stones are complex calculi that often fill the renal pelvis and calyces, are frequently associated with infection, and may contain a high proportion of struvite; their pathogenesis and management strategies emphasize the importance of infection control. Moreover, they are observed twice as frequently in women compared to men (9). Although PCNL provides high efficacy in reducing stone burden in these stones, it represents a clinical scenario in which complications such as bleeding, fever/sepsis, and residual stones may be encountered more frequently (10).

This study aimed to compare surgical success, perioperative outcomes, and complication rates between premenopausal and menopausal women undergoing percutaneous nephrolithotomy for staghorn stones.

MATERIALS AND METHODS

Ethical approval

This retrospective study was approved by the İzmir City Hospital Non-Interventional Ethics Committee (03 December 2025; Decision No: 2025/631).

Study design and patient selection

Female patients who underwent prone percutaneous nephrolithotomy for staghorn kidney stones between January 2024 and January 2026 were retrospectively reviewed. Patients were categorized according to menopausal status into two groups: premenopausal (n=81) and menopausal (n=75). Menopausal status was determined based on patient history and medical records. Patients were classified as menopausal if they had experienced at least 12 consecutive months of amenorrhea not attributable to pregnancy, lactation, hormonal treatment, or other pathological causes. Women who reported regular menstrual cycles or had menstruation within the preceding 12 months were classified as premenopausal. Patients with a history of surgical menopause or those receiving hormone replacement therapy were excluded from the analysis.

Preoperative evaluation

Before surgery, patients underwent clinical assessment including medical history and physical examination. Laboratory evaluation consisted of complete blood count, serum creatinine, coagulation parameters, serum electrolytes, liver function tests, and hepatitis markers. Chest radiography and electrocardiography were performed as part of the routine anesthetic evaluation. Stone characteristics, including size, number, location, and anatomical relationships, were assessed using plain urinary system radiography and computed tomography(CT). Surgery was performed only after confirmation of sterile urine cultures, and preoperative antibiotic therapy was administered in all patients.

Surgical technique

All procedures were carried out under general anesthesia using a prone percutaneous nephrolithotomy approach. Following ureteral catheter placement with cystoscopy in the lithotomy position, patients were repositioned prone. Under fluoroscopic guidance, contrast was injected and percutaneous access to the collecting system was obtained using a Chiba needle. After guidewire placement, tract dilation was performed and an Amplatz sheath was introduced. Stone fragmentation was achieved with a pneumatic lithotripter, and fragments were removed using a nephroscope. A nephrostomy tube was placed at the end of the procedure and removed between postoperative days 1 and 3 according to the patient's clinical course.

Stone-free status was defined as the presence of residual fragments smaller than 4 mm on CT performed one month after surgery and was considered surgical success. Postoperative complications were graded according to the Clavien-Dindo classification, with grades ≥3 regarded as major complications.

Statistical analysis

Statistical analyses were conducted using SPSS software. Data distribution was evaluated with the Kolmogorov–Smirnov test. Continuous variables not showing normal distribution were expressed as median values with interquartile ranges and compared using the Mann–Whitney U test. Categorical variables were presented as frequencies and percentages and analyzed with the chi-square or Fisher's exact test when appropriate. Multivariable logistic regression analysis was used to identify independent predictors of residual stone formation, and results were reported as odds ratios with 95% confidence intervals. Statistical significance was defined as $p < 0.05$.

RESULTS

A total of 156 patients were analyzed, of whom 81 were premenopausal and 75 were menopausal. The sociodemographic and clinical characteristics of the groups are presented in Table 1. Age and body mass index (BMI) were significantly higher in the menopausal group ($p<0.001$ and $p=0.0003$, respectively). No statistically significant differences were observed between the groups with respect to stone burden, stone density, operative time, nephroscopy time, or fluoroscopy time (Table 1).

Residual stone rates were 38.3% (31/81) in the premenopausal group and 22.7% (17/75) in the menopausal group, with the difference reaching a borderline level of statistical significance (p=0.053). In multivariable logistic regression analysis, menopausal status was independently associated with a lower risk of residual stone formation (OR 0.36; 95% CI 0.15–0.82; p=0.016). In addition, as shown in Table 2, each 100-unit increase in stone burden was identified as an independent predictor of residual stone formation (OR 1.08; 95% CI 1.02–1.13; p=0.008).

Postoperative complication rates were similar between the groups, as summarized in Table 3. The incidence of any complication was 35.8% (29/81) in the premenopausal group and 40.0% (30/75) in the menopausal group (p=0.708). Major complication rates (Clavien-Dindo grade ≥3) were 6.2% (5/81) and 10.7% (8/75) in the premenopausal and menopausal groups, respectively (p=0.469). No significant difference was observed between the groups regarding the need for blood transfusion (p=0.434) (Table 3).

The distribution of complication grades according to the Clavien-Dindo classification is summarized in Table 4. Grade 0 complication rates were 63.0% in the premenopausal group and 60.0% in the menopausal group, with no statistically significant difference between the groups (p=0.74). A similar distribution was observed across the other complication grades (Table 4). The median nephrostomy removal time was 2 days (interquartile range [IQR], 2–3) in both groups, with no significant difference observed (p=0.88). Length of hospital stay was also comparable between the premenopausal and menopausal groups (p=0.14).

DISCUSSION

In this study, the impact of menopausal status on perioperative outcomes in women undergoing prone PCNL for staghorn kidney stones was evaluated, and menopause was not found to significantly increase complication rates. These findings suggest that menopausal status alone is not an unfavorable prognostic factor for PCNL. While the relationship between menopause and kidney stones has primarily been evaluated in terms of stone formation risk in the literature, data focusing on surgical outcomes are limited; therefore, the present study provides insight into the clinical implications of menopausal status in staghorn stone surgery.

In the menopausal period, estrogen deficiency–related alterations in immune modulation may contribute to increased susceptibility to infections (3). From a clinical perspective, urinary tract infections represent a substantial source of morbidity and healthcare utilization in menopausal women, particularly with the accumulation of additional risk factors (5). Menopause-related changes in the vaginal ecosystem facilitate colonization with Enterobacteriaceae, which plays a key role in the pathogenesis of recurrent urinary tract infections (11,12). Although estrogen-based therapies targeting vaginal flora have been shown to improve microbial composition and alleviate symptoms, infection management in staghorn stone surgery primarily relies on ensuring sterile urine cultures and implementing appropriate perioperative antibiotic strategies (13). Previous studies have demonstrated that stone and renal pelvic

urine cultures are more reliable predictors of post-PCNL infectious complications, including sepsis, than bladder urine cultures alone (14). In this context, the requirement for sterile urine cultures prior to surgery in all patients may partly explain the comparable rates of infection-related complications observed between premenopausal and menopausal groups in our cohort. Thus, despite the theoretical biological mechanisms linking menopause to increased infection risk, a standardized preoperative infection control protocol may mitigate this risk and contribute to favorable surgical outcomes following PCNL (10,11). Risk factors for severe bleeding complications following PCNL in staghorn stones have been investigated, with stone characteristics and hydronephrosis degree being highlighted; the similarity in stone density and burden between groups in our series is consistent with comparable bleeding outcomes (15). Large reviews on PCNL complications indicate that bleeding and infection are the most frequent and clinically relevant complications; similarly, major complication rates in our study were acceptable and comparable between groups (10). Comprehensive analyses on the prevention and management of complications underscore the importance of surgical experience, patient selection, and procedural standardization; our single-center standardized approach may represent an advantage in this regard (16). Residual stones are clinically important because even small fragments may be associated with stone growth, infection, and the need for reintervention over time. Therefore, differences in residual stone rates represent a key finding of our study. However, this difference suggests that menopausal status is not an absolute determinant of surgical success but should be evaluated in interaction with patient selection and intraoperative strategies. In this context, menopause should be considered not as a limiting factor for surgery but as a patient characteristic to be taken into account during clinical planning. Cohort data reporting increased stone risk after menopause support the clinical relevance of stone disease in this population; however, surgical success appears to be more closely related to stone complexity and surgical strategies (6). Epidemiological data on urolithiasis emphasize changes in risk factors and the importance of metabolic profiles over time; the higher BMI observed in the menopausal group in our study is consistent with this perspective (17). Nevertheless, existing evidence indicates that increased body mass index alone does not compromise percutaneous nephrolithotomy outcomes in patients with staghorn stones, and the higher BMI observed in menopausal patients in our cohort is unlikely to have influenced surgical success or complication rates (18).

In multivariable analysis, the independent association between menopausal status and a lower risk of residual stones may be explained by more conservative and structured surgical goals, tract selection, and controlled intraoperative decision-making in menopausal patients. Nevertheless, the absence of stone composition analysis and anatomical complexity scores such as the Guy’s stone score limits the quantitative assessment of anatomical variation influencing residual stone rates, and findings should be interpreted accordingly. Guidelines recommend balancing stone-free goals and safety in complex stones and adopting staged approaches when necessary; the strong association between residual stone risk and stone burden in our logistic regression analysis is consistent with these recommendations (19).

In our study, stone burden emerged as the strongest independent predictor of residual stones, while the infection-related nature and complex anatomical distribution of staghorn stones remain key factors limiting surgical success (9).

Limitations

The retrospective and single-center design limits the exclusion of surgeon and technical heterogeneity. Stone composition and anatomical complexity scores (e.g., Guy's stone score) could not be evaluated. Although residual stone assessment was standardized using CT, intraoperative quantitative assessment of stone clearance was not performed.

CONCLUSION

In women undergoing prone PCNL for staghorn kidney stones, menopausal status did not adversely affect complication rates or postoperative recovery indicators. A lower residual stone rate was observed in menopausal patients, and menopausal status was independently associated with a reduced risk of residual stones in multivariable analysis; however, stone burden emerged as the strongest determinant of residual stones. In clinical practice, menopausal status should not be considered an exclusion criterion for PCNL; instead, safe and effective outcomes should be pursued through standardized surgical approaches focused on patient-specific risk factors, stone burden, and infection control.

Abbreviations

PCNL: Percutaneous nephrolithotomy

BMI: Body mass index

CT: Computed tomography

Declarations

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Ethics approval and consent to participate:

This retrospective study was approved by the İzmir City Hospital Non-Interventional Ethics Committee (03 December 2025; Decision No: 2025/631). Due to the retrospective nature of the study, the requirement for informed consent was waived.

Consent for publication:

Not applicable.

Availability of data and materials:

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests:

The authors declare that they have no competing interests.

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FY, AY: Drafted the manuscript.
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Tables

Table 1. Comparison of Selected Sociodemographic and Clinical Characteristics According to Age Group

Variables	Group 1	Group 2	p
Number of patients (n)	81	75	–
Body mass index (kg/m²)	25.7 (22–29.4)	29.4 (25.8–32.5)	0.0003
Age (years)	39 (35–45)	60 (54–64)	<0.001
Stone burden (mm²)	453 (340–980)	559 (385–970)	0.35
Hounsfield unit (HU)	1000 (800–1200)	950 (800–1120)	0.55
Hemoglobin decrease (g/dL)	1.4 (0.9–2.3)	1.4 (0.7–2.3)	0.91
Residual stone	31/81 (38.3%)	17/75 (22.7%)	0.053
Operative time (min)	90 (70–110)	95 (75–115)	0.41
Nephroscopy time (min)	45 (30–60)	40 (30–60)	0.51
Fluoroscopy time (s)	81 (45–109)	80 (48–116)	0.96
Nephrostomy removal time (days)	2 (2–3)	2 (2–3)	0.88
Length of hospital stay (days)	3 (3–4)	4 (3–4)	0.14

Footnote: Continuous variables are presented as median (interquartile range, IQR) and categorical variables as number (%). Continuous variables were compared using the Mann–Whitney U test, and categorical variables using the chi-square or Fisher's exact test.

Table 2. Multivariable Logistic Regression Analysis for Residual Stone Formation

Variable	OR	95% CI	p
Menopause (vs premenopausal)	0.36	0.15–0.82	0.016
Body mass index (per 1 unit)	0.93	0.86–1.00	0.058
Stone burden (per 100 units)	1.08	1.02–1.13	0.008
Stone density (HU, per 100 units)	1.03	0.91–1.17	0.61
Operative time (per 10 min)	1.08	0.98–1.19	0.12
Metabolic syndrome	1.12	0.62–2.01	0.70
Previous stone surgery	1.29	0.69–2.41	0.42
Preoperative creatinine	1.44	0.58–3.55	0.43

Footnote: OR = odds ratio; CI = confidence interval. The model was constructed using two-sided tests, and p values <0.05 were considered statistically significant.

Table 3. Comparison of Postoperative Complication Rates

Complications	Group 1	Group 2	P
Any complication	29/81 (35.8%)	30/75 (40.0%)	0.708
Major complication (Clavien ≥3)	5/81 (6.2%)	8/75 (10.7%)	0.469
Need for blood transfusion	18/81 (22.2%)	12/75 (16.0%)	0.434
Need for DJ stent due to urine leakage	5/81 (6.2%)	8/75 (10.7%)	0.469

Footnote: Complications were graded according to the Clavien-Dindo classification. Categorical variables were compared using the chi-square or Fisher's exact test.

Table 4. Distribution of Clavien-Dindo Complication Grades

Clavien-Dindo grade	Premenopausal (n=81)	Menopausal (n=75)	P
Grade 0	52 (63.0%)	45 (60.0%)	0.74
Grade 1	4 (4.9%)	2 (2.7%)	0.68
Grade 2	20 (25.9%)	20 (26.7%)	0.91
Grade 3	5 (6.2%)	6 (8.0%)	0.66
Grade 4	0 (0%)	2 (2.7%)	0.23

Footnote: Grade 0 indicates the absence of complications. Major complications were defined as Clavien-Dindo grade ≥3.