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Original Article

Surgical Success and Predictive Factors for Residual Stones Following Supine Percutaneous Nephrolithotomy in the Galdakao-Modified Valdivia Position

Galdakao-Modifiye Valdivia Pozisyonunda Supin Perkütan Nefrolitotomi Sonrası Cerrahi Başarı ve Rezidüel Taşları Öngören Faktörler

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ABSTRACT

Objective: Supine percutaneous nephrolithotomy (sPCNL) is widely accepted as a safe and effective treatment for kidney stones. This study aims to assess surgical outcomes and identify predictive factors for residual fragments following sPCNL in the Galdakao-modified Valdivia position (GMV-sPCNL).

Methods: We retrospectively evaluated the clinical data of patients undergoing GMV-sPCNL. The primary outcomes were the stone-free rate (SFR) and the complication rate. Demographic, radiologic, and perioperative parameters were also compared between patients with and without residual stones.

Results: 195 patients [Male:127 (65.1%); Female: 68 (34.9%)] were included. The mean age was 48.6±15.6 years; the mean body mass index (BMI) was 27.4±5 kg/m2. The overall SFR was 83.1%. Residual stones were associated with greater stone burden (number, size, surface area, and volume), longer operative time, and longer hospitalization (p<0.05). Gender, age, BMI, stone laterality, and density were not significantly associated with SFR. The receiver operating characteristic analysis showed that having more than two stones, a stone size ≥26 mm, or a stone volume ≥2639.8 mm3 significantly predicted residual fragments. Stone volume demonstrated the best predictive performance, with sensitivity and specificity of 81.8% and 61.0%, respectively. GMV-sPCNL was associated with a low overall complication rate: 86.2% of patients experienced no or only minor complications, and major complications (Clavien-Dindo ≥3) occurred in just 4.6% of cases.

Conclusions: GMV-sPCNL demonstrates high success rates and an acceptable complication profile. Stone burden parameters such as stone number, stone size, and stone volume are important determinants of surgical success.

Keywords: Galdakao-modified Valdivia position, kidney stones, percutaneous nephrolithotomy, supine position, treatment outcome

ÖZ

Amaç: Supin perkütan nefrolitotomi (sPCNL), böbrek taşlarının tedavisinde güvenli ve etkili bir tedavi yöntemidir. Bu çalışmada, Galdakao-modifiye Valdivia pozisyonunda (GMV-sPCNL) uygulanan sPCNL sonrası cerrahi sonuçların değerlendirilmesi ve rezidüel fragmanları öngören faktörlerin belirlenmesi amaçlanmıştır.

Yöntemler: GMV-sPCNL uygulanan hastalara ait klinik veriler retrospektif olarak incelendi. Çalışmanın birincil sonucu taşsızlık ve komplikasyon oranlarının saptanmasıdır. Rezidü taş varlığına göre hastaların demografik, radyolojik ve perioperatif parametreleri karşılaştırıldı.

Bulgular: Çalışmaya 195 hasta [Erkek: 127 (%65.1)/Kadın: 68 (%34.9)] dahil edildi. Ortalama yaş 48,6 (±15,6) yıl, ortalama beden kitle indeksi (BKİ) 27,4 (±5) kg/m^2 idi. Genel taşsızlık oranı %83,1 olarak saptandı. Rezidü taş varlığı; daha yüksek taş yükü (taş sayısı, boyutu, yüzey alanı ve hacmi), daha uzun operasyon süresi ve uzamış hastanede yatış süresi ile ilişkili bulundu (p<0,05). Cinsiyet, yaş, BKİ, cerrahi tarafı ve taş dansitesi ile taşsızlık arasında anlamlı bir ilişki saptanmadı. Receiver operating characteristic analizinde, taş sayısının 2'den fazla olması, taş boyutunun ≥26 mm ve taş hacminin ≥2639,8 mm^3 olması rezidüel fragmanları anlamlı şekilde öngördü. Taş hacmi, en iyi öngörü performansını göstermiş olup, buna karşılık gelen duyarlılık ve özgüllük değerleri sırasıyla %81,8 ve %61,0 olarak bulunmuştur. GMV-sPCNL hastalarında düşük komplikasyon oranları gözlendi. Hastaların %86,2'sinde hiç komplikasyon görülmedi veya sadece minör olaylar yaşandı. Majör komplikasyon (Clavien-Dindo ≥3) oranı ise %4,6 olarak saptandı.

Sonuçlar: GMV-sPCNL, yüksek taşsızlık ve düşük komplikasyon oranları ile büyük böbrek taşlarında etkili bir tedavi seçeneğidir. Taş yükü parametreleri —taş sayısı, boyutu ve hacmi— cerrahi başarının önemli belirleyicileri olarak saptandı.

Anahtar kelimeler: Galdakao-modifiye Valdivia pozisyonu, böbrek taşları, perkütan nefrolitotomi, supin pozisyon, tedavi sonuçları

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INTRODUCTION

Percutaneous nephrolithotomy (PCNL) is widely recognized as the first-line treatment for complex or large kidney stones[1]. The prone position provides adequate access for renal puncture and facilitates effective instrument handling. However, it also poses several disadvantages, including patient discomfort, increased radiation exposure to the surgeon, the need for repositioning in cases of combined retrograde access, and anesthetic challenges—particularly in obese, elderly, or cardiopulmonary-compromised patients[2].

To address these limitations, Valdivia et al. introduced supine PCNL (sPCNL) in 1998, reporting a large series of 557 patients and demonstrating its safety, patient comfort, and low complication rates[3]. Various sPCNL techniques have gained popularity due to their versatility, allowing simultaneous antegrade and retrograde access, improved ergonomics, and airway access for anesthesia[2,4]. The sPCNL were performed in various positions, such as Valdivia, entire supine position, Galdakao-modified Valdivia, flank-free Barts, or Barts-modified[5].

Across studies, sPCNL was associated with shorter operation time (OT), lower infection rates, and fewer visceral injuries[6,7]. However, there is no consensus regarding the optimal supine technique[5]. The Galdakao-modified Valdivia (GMV) position, which was employed in all cases in our study, is a widely accepted and reliably applicable technique[2]. This study aims to assess the clinical efficacy of sPCNL in the Galdakao modified Valdivia position (GMV-sPCNL) over a 5-year period by analyzing stone-free rates (SFR), postoperative complication rates, and clinical and radiological predictors of residual stone formation. Unlike most previous reports, which primarily compared stone-free and complication rates across different PCNL positions, the present study provides quantitative data on stone characteristics from a relatively large cohort of patients treated in the GMV-sPCNL position and evaluates their predictive performance for residual stones using receiver operating characteristic (ROC) analysis.

MATERIALS and METHODS

A retrospective review involving patients who underwent GMV-sPCNL between January 2019 and May 2025 was performed using records from our institutional PCNL database. This study was conducted in accordance with the principles of the Declaration of Helsinki (Recommendations Guiding Physicians in Biomedical Research Involving Human Subjects, first adopted in Helsinki in 1964 and subsequently amended). The study protocol was reviewed and approved by the Institutional Review Board (IRB) of Marmara University (approval no.: 09.2025.25-0626, date: 18.07.2025).

Patients aged above 18 years who underwent GMV-sPCNL for renal stone management in accordance with established clinical guidelines were included[1]. The exclusion criteria included patients undergoing synchronous bilateral endoscopic stone surgery, patients with current UTIs, anatomical or functional urinary tract abnormalities (e.g., ureteropelvic junction obstruction, horseshoe kidney, vesicoureteral reflux), immunocompromised patients, and patients younger than 18 years.

In all cases, surgical indications and stone parameters—including number, size, Hounsfield units (HU), volume, and surface area—were assessed using computed tomography (CT). Stone size was based on the longest axis of the largest stone when multiple stones were present. Stone volume and surface measurements were obtained through 3D reconstruction of axial CT scans using 3D-DOCTOR software (Able Software Corp., Lexington, MA, USA). Postoperative residual fragments that are unlikely to cause renal colic or require further medical or interventional treatment were defined as clinically insignificant residual fragments. In previous studies, stone-free status has most commonly been defined by accepting residual fragments measuring 2-4 mm as clinically insignificant[8-10]. Patients were considered stone-free in our study if follow-up CT imaging at one month postoperatively revealed either no stones or only clinically insignificant residual fragments smaller than 3 mm, a threshold that is commonly used in previous studies[8,9,11].

All GMV-sPCNL procedures were performed by two endourologists with over five years of experience and extensive backgrounds in sPCNL (>200 cases) and flexible ureterorenoscopy (>400 cases). All patients underwent a standardized preoperative and perioperative surgical protocol. Urine cultures were obtained from all patients prior to the procedure. Those with sterile urine cultures received prophylactic ceftriaxone within 30 minutes prior to the operation. Patients with UTIs were managed with appropriate antibiotics for at least seven days and underwent surgery only after sterile urine cultures were obtained. Renal access was achieved using ultrasound, fluoroscopy, or both.

SFR and Clavien-Dindo (CD) complications were evaluated for the entire cohort. Patients were categorised into two groups: those with postoperative residual stones and those without. Demographic data, stone characteristics, and perioperative and postoperative outcomes were compared between the two groups.

Statistical Analysis

No formal a priori power analysis was performed because the study was retrospective in design. However, the sample size of 195 patients is comparable to or larger than those reported in similar studies, and provides sufficient statistical power for the analyses performed[8]. Additionally, a post-hoc power analysis was performed using G*Power 3.1. Within the family of t-tests, the "Means: Wilcoxon-Mann-Whitney test (two groups)" option was selected to perform non-parametric comparisons between the residual-stone and stone-free groups. Effect sizes were calculated from group-specific means and pooled standard deviations. Using a two-sided α=0.05, achieved power (1-β) values were calculated. Statistical analyses were conducted using SPSS (IBM, version 25). The distribution patterns of the variables were explored using visual approaches, such as histograms and probability plots, and through statistical assessments, including the Kolmogorov-Smirnov and Shapiro-Wilk tests. For normally distributed data, values were reported as mean ± standard deviation, and comparisons were carried out using the independent samples t-test. In cases of non-normal distribution, the data were summarized using median and interquartile range, with the Mann-Whitney U test employed for between-group comparisons. Categorical variables were assessed using either the chi-square test or Fisher's exact test, depending on the data structure. For paired samples, the Wilcoxon signed-rank test was utilized. The correlation between variables was determined using Spearman's rank correlation method. To assess the diagnostic performance of different predictors for residual stones, ROC curve analysis was performed. Statistical significance was set at p<0.05.

RESULTS

The cohort of 195 patients who underwent GMV-sPCNL had a mean age of 48.6±15.6 years and a mean body mass index (BMI) of 27.4±5.0 kg/m^2. Most patients were male (65.1%) and had American Society of Anesthesiologists (ASA) scores of 1 or 2. Multiple stones were present in 63.1% of the cohort, with the median diameter of the largest stone and the median volume being 25 (21.8-32) mm and 2927 (1364-7561) mm^3, respectively.

Postoperative evaluation revealed stone-free status in 162 of 195 patients (SFR =83.1%). No statistically significant differences were observed between the groups regarding age (p=0.559), BMI (p=0.729), or the stones' maximum and mean HU (p=0.069 and p=0.110). However, the residual stone group had a significantly higher number of stones (p=0.005), larger stone size (p=0.022), volume (p=0.005), and surface area (p=0.032). Post hoc power analysis demonstrated that the significant differences in stone-related parameters were supported by adequate statistical power, with achieved 1-β (statistical power) values of 0.86 for stone number, 0.84 for maximal stone size, 0.91 for stone volume, and 0.93 for stone surface area. Additionally, the residual stone (+) group had significantly longer OT (p<0.001) and a longer hospital stay (p=0.012) (Table 1).

No statistically significant differences were observed between the groups with respect to gender, ASA score, diabetes mellitus, side of surgery, or pre- and postoperative urinary drainage methods (p>0.05). Residual stones occurred more frequently when multiple stones were present (p=0.014). Postoperative Foley catheter use was more frequent in residual stone-positive patients (p = 0.019) (Table 2).

ROC analysis (Figure 1) revealed that stone number area under the curve [(AUC): 0.647, p=0.008] and largest stone size (AUC: 0.626, p=0.022) were significantly associated with residual stones; cut-off points were identified to aid clinical assessment. Similarly, Figure 2 shows that stone volume (AUC =0.689, p=0.005) and stone surface area (AUC =0.643, p=0.036) are important variables, supported by their respective thresholds. These AUC values indicate a fair discriminatory ability of the evaluated stone parameters to predict residual stones. Additionally, significant positive correlations were observed between stone number and OT (r=0.244, p=0.001), stone size and OT (r=0.222, p=0.002), and OT and hospital stay duration (r=0.162, p=0.023).

In the majority of patients (86.2%) undergoing GMV-sPCNL, no complications occurred; when complications did occur, they were mild (CD grade 1). Only 9 patients (4.6%) experienced CD grade ≥3 complications, whereas 26 patients (13.3%) experienced CD grade ≥2 complications (Table 3). No statistically significant differences in infection rates were observed between the groups (p=0.892). Hemoglobin levels decreased significantly postoperatively, from 14.64±9.11 g/dL to 13.54±8.65 g/dL, and hematocrit levels decreased from 38.99±5.40% to 38.82±5.50% (p<0.001). However, no significant differences were found between the groups (p=0.304 and p=0.108, respectively). Blood transfusions were required in 11 patients (5.6%) because of a drop in hemoglobin levels. Three patients (1.5%) required postoperative intensive care unit (ICU) follow-up. One elderly patient (0.6%) with cardiac and neurological comorbidities developed a postoperative hematoma and sepsis and died during ICU follow-up.

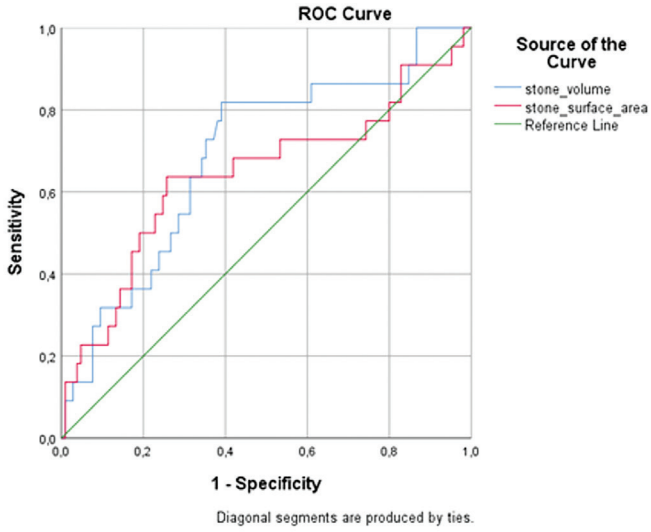

Figure 2. ROC curves for stone volume and stone surface area in predicting residual stone.

Receiver operating characteristic (ROC) analyses were performed for stone volume and stone surface area to evaluate their ability to predict residual stone formation. Stone volume demonstrated an AUC of 0.689 (p=0.005; 95% CI: 0.567-0.811), while stone surface area showed an AUC of 0.643 (p=0.036; 95% CI: 0.497-0.788). The optimal cut-off for stone volume was ≥2639.8 mm^3, corresponding to a sensitivity of 81.8% and specificity of 61.0%. For stone surface area, the optimal cut-off was ≥1250.2 mm^2, with 68.2% sensitivity and 58.1% specificity.

AUC: Area under the curve, CI: Confidence interval

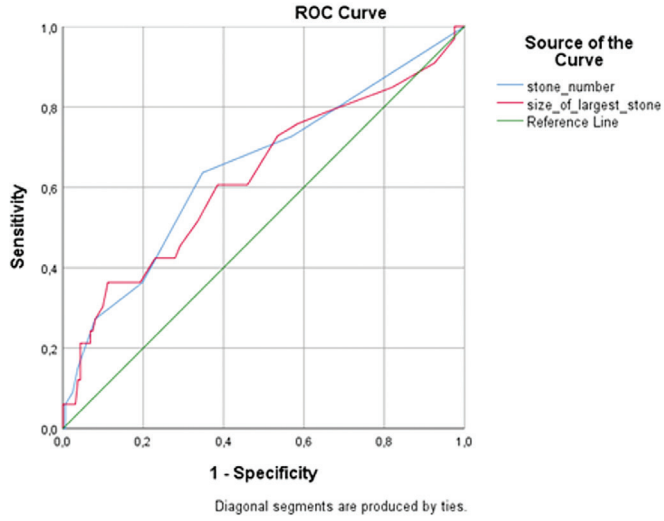

Figure 1. ROC curves for stone number and largest stone size in predicting residual stone.

Receiver operating characteristic (ROC) curves were generated to assess the diagnostic accuracy of stone number and size of the largest stone in predicting the presence of residual stone. The area under the curve (AUC) for stone number was 0.647 (p=0.008; 95% CI: 0.537-0.757), and for the size of the largest stone was 0.626 (p=0.022; 95% CI: 0.513-0.740). The optimal cut-off value for stone number was >2, with a sensitivity of 68.2% and specificity of 66.7%. For the largest stone size, the best cut-off was ≥26 mm, yielding 60.6% sensitivity and 61.5% specificity.

CI: Confidence interval

Table 1. Comparison of continuous parameters by residual stone status.

Variable	Supine PCNL patients N=195	Residual stone (-) n=162 (83.1%)	Residual stone (+) n=33 (16.9%)	p-value
Age (years)	48.6 (±15.6)	48.3 (±16.0)	50.0 (±14.0)	0.559
BMI (kg/m^2)	27.4 (±5.0)	27.4 (±5.1)	27.7 (±4.4)	0.729
Stone number	2 (1-3)	2 (1-3)	3 (1-5)	**0.005**
Size of largest stone (mm)	25 (21.8-32)	25 (21-30.5)	28 (23.5-42)	**0.022**
Stone volume (mm^3)	2927 (1364.3-7561)	2471 (1332.8-6141.6)	5296 (3349.3-12797.6)	**0.005**
Stone surface area (mm^2)	1157.2 (671.2-2671.9)	1121.1 (662-2199.3)	2711.5 (654.5-5448.2)	**0.032**
HU max	1268 (1020.5-1464.5)	1292.5 (1058.5-1491)	1204 (815-1388)	0.069
HU mean	1089.5 (825.8-1207.5)	1100 (846-1216)	980 (635-1124.5)	0.110
Operation time (min)	120 (90-180)	120 (90-150)	180 (122.5-230)	**0.000**
Length of stay (days)	2 (2-5)	2 (2-4.3)	3 (2-7)	**0.012**

Continuous variables are presented as mean (± standard deviation) or median (interquartile range) according to their distribution. The independent samples t-test was used for normally distributed variables, and the Mann-Whitney U test was used for non-normally distributed variables. A p-value of <0.05 was considered statistically significant.

BMI: Body mass index, HU: Hounsfield unit, mm: Millimeter, mm^2: Square millimeter, mm^3: cubic millimeter, min: Minute, IQR: Interquartile range

Table 2. Comparison of categorical parameters by residual stone status.

Variable	Supine PCNL patients n=195	Residual stone (-) n=162 (83.1%)	Residual stone (+) n=33 (16.9%)	p-value
Gender				
Male	127 (65.1%)	101 (62.3%)	26 (78.8%)	0.071
Female	68 (34.9%)	61 (37.7%)	7 (21.2%)	
ASA score				
ASA 1	91(46.7%)	79 (48.8%)	12 (36.4%)	0.086
ASA 2	94 (48.2%)	73 (45.1%)	21 (63.6%)	
ASA 3	10 (5.1%)	10 (6.2%)	0 (0.0%)	
Diabetes mellitus				
No	157 (80.5%)	133 (82.1%)	24 (72.7%)	0.222
Yes	38 (19.5%)	29 (17.9%)	9 (27.3%)	
Multiple stones				
No	72 (36.9%)	66 (40.7%)	6 (18.2%)	**0.014**
Yes	123 (63.1%)	96 (59.3%)	27 (81.8%)	
Surgery side				
Left	108 (55.4%)	86 (53.1%)	22 (66.7%)	0.153
Right	87 (44.6%)	76 (46.9%)	11 (33.3%)	
Amplatz sheath size				
12/16	42 (21.5%)	37 (22.8%)	5 (15.2%)	0.123
16/20	118 (60.5%)	99 (61.1%)	19 (57.6%)	
20/24	29 (14.9%)	23 (14.2%)	6 (18.2%)	
26/30	6 (3.1%)	3 (1.9%)	3 (9.1%)	
Pre-op urinary diversion				
None	159 (81.5%)	134 (82.7%)	25 (75.8%)	0.292
DJ stent	24 (12.3%)	20 (12.3%)	4 (12.1%)	
Nephrostomy	12 (6.2 %)	8 (4.9%)	4 (12.1%)	
Post-op urinary drainage				
None	53 (27.2%)	47 (29.0%)	6 (18.2%)	0.055
Nephrostomy	21 (10.8%)	16 (9.9%)	5 (15.2%)	
DJ stent	102 (52.3%)	87 (53.7%)	15 (45.5%)	
Nephrostomy + DJ stent	19 (9.7%)	12 (7.4%)	7 (21.2%)	
Post-op Foley catheter Use				
No	149 (76.4%)	129 (79.6%)	20 (60.6%)	**0.019**
Yes	46 (23.6%)	33 (20.4%)	13 (39.4%)	

Categorical variables are presented as frequency and percentage. The chi-square test or Fisher's exact test was used for group comparisons, as appropriate. A p-value of <0.05 was considered statistically significant.

ASA: American Society of Anesthesiologists, DJ Stent: Double-J ureteral stent, HU: Hounsfield unit

DISCUSSION

The sPCNL procedure has long been recognized as a safe and effective treatment for complex kidney stones[1, 12]. Various sPCNL techniques are currently used, each offering distinct advantages for surgical access and patient positioning[5]. GMV-sPCNL was highly effective, yielding an SFR of 83.1% in a cohort with a notable stone burden, underscoring the technique's efficacy and potential for clinical success. Additionally, the low complication rates support its safety profile. ROC analyses revealed that patients with more than two stones (>2) or with a largest stone diameter ≥26 mm were at higher risk of residual fragments. Among the evaluated variables, stone

Table 3. Comparison of postoperative outcomes by residual stone status.				
Variable	**Supine PCNL patients n=195**	**Residual stone (-) n=162 (83.1%)**	**Residual stone (+) n=33 (16.9%)**	**p-value**
Urinary tract infection				
No Yes	173 (88.7) 22 (11.3)	144 (88.9%) 18 (11.1%)	29 (87.8%) 4 (12.2%)	0.892
Hemoglobin decrease (g/dl)	0.9 (0.1-1.6)	1 (0.2-1.6)	0.6 (0.1-1.4)	0.304
Hematocrit decrease (%)	2 (0-4.1)	1.9 (0.35-3.9)	1 (0.2-1.6)	0.108
Clavien-Dindo complications				
No CD-1 CD-2 CD-3 CD-4 CD-5	121 (62.1%) 48 (24.6) 17 (8.7%) 5 (2.6%) 3 (1.5%) 1 (0.5%)	102 (63.8%) 41 (24.7%) 14 (8.4%) 3 (1.9%) 1 (0.6%) 1 (0.6%)	19 (57.5%) 7 (21.2%) 3 (9.1%) 2 (6.1%) 2 (6.1%) 0 (0.0%)	0.140
Intensive Care Unit Admission				
No Yes	192 (98.5%) 3 (1.5%)	161 (99.4%) 1 (0.6%)	31 (93.9%) 2 (6.1%)	0.075

Data are presented as frequency (percentage) for each group. Differences between groups were evaluated using Pearson's chi-square test or Fisher's exact test, as appropriate. A p-value<0.05 was considered statistically significant.

CD: Clavien-Dindo classification, PCNL: Percutaneous nephrolithotomy

volume with a cut-off value of ≥2639.8 mm^3 predicted residual stone formation with a sensitivity of 81.8% and a specificity of 61.0%.

SPCNL has been shown to achieve favorable SFR across different patient positioning techniques. In a study using Giusti's position, a modification of GMV-sPCNL, Batratanakij et al.[6] reported an SFR of 86.2% among patients with a mean stone size of 31.8 (±11.7) mm. Similarly, Babaoff et al.[13] documented an SFR of 81.4%. Ahmed et al.[9] observed a 75.4% SFR in cases with a mean stone size of 28.34 (±10.02) mm using the split-leg modified lateral supine position. Using GMV-sPCNL, Kannan et al.[14] reported an 86.7% success rate in patients with stones averaging 24±4 mm. In another study, Jones et al.[15] achieved a 70% SFR in patients treated with the modified supine approach; the average stone size was 22.9 (±13.5) mm.

Melo et al.[10] compared complete supine, Valdivia, and GMV-sPCNL and reported SFRs ranging from 49% to 58%, without significant differences among positions. Studies in sPCNL patients have also reported success rates exceeding 90%[12,16]. In a meta-analysis, Li et al.[7] achieved an SFR of 78.1% for all sPCNL patients, regardless of position. Similarly, Lachkar et al.[8] reported, across 45 studies, a pooled SFR of 71.85% for sPCNL in patients with a mean stone size of approximately 2 cm. Consistent with previous reports, this study demonstrated a notable SFR of 83.1% among patients with a median stone size of 25 mm (range, 21.8-32 mm) who underwent GMV-sPCNL.

It is also important to note that the definition used for stone-free status can significantly influence the reported SFR values across studies. There is no universally accepted definition of "stone-free status" in endourological stone management[17]. Although the complete absence of residual fragments is the most objective indicator of success, such an approach would require consideration of clinically insignificant fragments that are unlikely to cause symptoms or require further intervention. Previous studies have used various size thresholds (e.g., ≤2 mm to ≤4 mm) to define stone-free status[7,9,10]. Because of the heterogeneity and lack of standardization in defining stone-free status across studies, including meta-analyses, it is not possible to draw definitive conclusions regarding the clinical significance of different cut-off values reported in studies[7,8]. Therefore, in the present study, we adopted the widely accepted threshold of ≤3 mm to define clinically insignificant residual fragments and compared our findings with those of other studies.

Stone burden remains the most influential factor in determining stone-free outcomes after PCNL. Higher

stone number, size, and complexity are consistently associated with lower success rates[18-20]. Specifically, patients with multiple stones or greater stone burden exhibit significantly reduced SFR (74% vs. 45% and 69% vs. 47%, respectively; p<0.001)[21]. Several studies have identified stone size, stone number, volume, and surface-area as predictors of SFR[19, 20, 22]. In the present study, ROC analysis showed that patients with multiple stones (>2) or with a maximum stone diameter ≥26 mm were less likely to be stone-free; a stone volume ≥2639.8 mm^3 predicted residual stone formation with high sensitivity (81.8%). Additionally, increased stone size was correlated with longer OT, reflecting greater surgical complexity[19]. Conversely, factors such as gender, age, BMI, laterality, and stone density did not appear to influence surgical success in our cohort[19, 21].

A significant difference in OT was observed between the two positions, favoring sPCNL with 103.9 (±42.6) minutes over the prone approach with 116.3 (±38.9) minutes (p=0.016), mainly because patient repositioning was not required[6]. However, notable variations exist in the reported OT across different sPCNL studies. These discrepancies can partly be attributed to differences in how OT is defined. Some studies begin timing at anesthesia induction, patient positioning or initiation of PCNL, and end at completion of PCNL or placement of a double-J catheter or nephrostomy[13, 23, 24]. In an sPCNL meta-analysis, the mean OT was reported as 80.76 minutes[8]. Another meta-analysis reported a wide range of OT, from 43 to 114 minutes across different studies[7]. In our study, OT was measured from induction of anesthesia to recovery from anesthesia, yielding a median duration of 120 minutes (range, 90-180 minutes), which is slightly longer than previously reported but remains within an acceptable clinical range. This difference may be attributed to the higher stone burden and complexity of our cohort (median stone volume 2927 (1364.3-7561) mm^3 and multiple stones in 63.1% of patients), to differences in time-measurement methodology, or to a combination of the two. Notably, patients with residual stones had significantly longer OT than stone-free patients, consistent with their higher stone burden and increased surgical complexity.

In patients with a high stone burden and complex renal stones, multi-tract access during PCNL is considered an effective and safe option[25]. Previous studies have reported that patients undergoing multi-tract PCNL generally present with a higher stone burden and may experience a slightly higher rate of minor complications[26]. In our study, multi-tract access was performed in only 7 patients (3.7%), all of whom had large or multiple stones. Stone-free status was achieved in four of these cases. However, the limited number of patients who underwent multi-tract PCNL precluded meaningful statistical comparisons of SFR, stone burden, OT, or complication rates. Because our data were collected retrospectively, we cannot draw definitive conclusions for our cohort; nevertheless, prospective studies based on predefined criteria—such as stone number and total stone volume—would provide more robust evidence to guide decision-making in this area.

In addition to high success rates, sPCNL has been associated with low complication rates. Kiss et al.[27] documented an overall complication rate of 9.55% and noted that there were no CD grade 4 or 5 complications. Hoznek et al.[4] observed complication rates for CD grades 1 and 2 of 10.6% and 8.5%, respectively. Abu-Ghanem reported a complication rate of 21.7%[19]. Lachkar et al.[8] reported an overall complication rate of 15.58%, while the rate of major complications was only 4.04%. In a meta-analysis by Li et al.[7], the overall complication rate was 16.1% 7. Jones et al.[15] reported an 8% complication rate and a 2.6% requirement for blood transfusion. Liu et al.[12] calculated a mean intraoperative hemoglobin decrease of 1.04 g/dL without the need for transfusion, whereas Ahmed et al.[9] recorded a transfusion rate of 14.7% due to bleeding. Babaoff et al.[13] found a postoperative hemoglobin drop of 1.7 (±1.5 g/dL and a transfusion rate of 7.1%. In a meta-analysis by Lachkar et al.[8], the mean decrease in hemoglobin was 1.68 g/dL, with a transfusion rate of 4.92%. In patients who underwent GMV-sPCNL, the rates of minor complications (CD grade 1-2) and major complications (CD grade ≥3) were 19.5% and 7.3%, respectively[28]. In the present study, the rate of major complications (CD grade ≥3) was 4.6%. Hemoglobin decreased by approximately 1.1 g/dL and erythrocyte transfusion was required in 5.6% of patients, which aligns with the findings in current literature and confirms an acceptable safety profile for GMV-sPCNL.

A randomized study of patients undergoing flexible ureteroscopy found no association between postoperative Foley catheterization and complications or fever; to our knowledge, no comparable data exist for sPCNL[29]. In our routine practice, urethral Foley catheters are generally not used after sPCNL; however, in complex or prolonged cases, surgeons may prefer to place a catheter to ensure adequate drainage and to minimize postoperative discomfort and complications. Therefore, the higher catheterization rate observed among patients with residual stones in our series likely reflects their greater stone burden, greater surgical complexity, and longer OT.

Reported Infectious complications, such as fever and UTI, vary among studies of sPCNL. Postoperative fever occurred in 10% of patients in Liu et al.[12]'s study, compared with 33% in the cohort described by Batratanakij et al.[6], who also reported a UTI rate of 11.5%. In our study, the UTI rate was 11.3%, which is comparable to findings from previous studies.

Hospital stays in sPCNL patients are generally short, although reported values vary across studies. Hoznek et al.[4] and Jones et al.[15] reported average hospital stays of 3.4±1.9 days and 2.0±2.1 days, respectively. Lachkar et al.[8], in a meta-analysis, reported a mean hospitalization duration of 4 days, whereas Li et al.[7] found a range from 1.43 to 8.4 days. Median hospital stay was 2 days (2-4.3) in the stone-free group and 3 days (2-7) in patients with residual fragments. These findings suggest that sPCNL generally allows for a short hospitalization period, even in patients with higher stone complexity.

Study Limitations

This study has some limitations. The retrospective design and single-center setting may restrict the applicability of the results to broader populations. Furthermore, the study focused primarily on perioperative parameters affecting surgical success; therefore, long-term outcomes such as the need for secondary interventions were not assessed. In addition, the lack of data on short- and long-term postoperative changes in renal function represents a limitation of the present study. Prospective, multicenter studies with long-term follow-up are needed to confirm and extend these findings.

CONCLUSION

sPCNL performed in the GMV achieves high SFR, even in patients with a significant stone burden. It is a safe and effective technique with acceptable complication rates. Patients with residual stones were observed to have a higher number of stones and increased stone size, volume, and surface area. Preoperative assessment of these parameters helps classify patients at higher risk for residual stones. In such patients, surgical strategies such as multiple access tracts or adjunctive procedures may be considered to optimize stone clearance and minimize the need for re-intervention.

Ethics

Ethics Committee Approval: The study protocol was reviewed and approved by the Institutional Review Board (IRB) of Marmara University, School of Medicine (approval no.: 09.2025.25-0626, date: 18.07.2025).

Informed Consent: This study was conducted retrospectively using previously collected and anonymized data from the PCNL Database; therefore, obtaining written informed consent from participants was not required.

Footnotes

Author Contributions

Surgical and Medical Practices: G.O., E.G., Y.T., T.E.S., Concept: G.O., K.C., T.E.S., Design: G.O., K.C., T.E.S., Data Collection and/or Processing: G.O., E.G., Y.T., Analysis or Interpretation: G.O., K.C., Literature Search: G.O., Writing: G.O., T.E.S.

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