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Retrorenal Colon on Dual-Position CT and Its Implications for Safer Percutaneous Nephrolithotomy: A Prospective Observational Study

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Abstract

Background: Colonic injury during percutaneous nephrolithotomy (PCNL), though uncommon, may result in significant morbidity. While computed tomography (CT) is routinely used for preoperative evaluation, the role of positional imaging in assessing colon–kidney relationships remain unclear.

Objective: To describe the prevalence and positional variability of retrorenal colon using dual-position CT and to evaluate its potential implications for percutaneous access planning.

Methods: In this prospective observational study, 100 adult patients undergoing PCNL were evaluated. All patients underwent non-contrast CT in both supine and prone positions. The presence, laterality, and anatomical location of retrorenal colon were documented, along with its relationship to the anticipated access tract. Data were analyzed descriptively.

Results: Retrorenal colon was identified in 9% of patients on prone CT and 8% on supine CT. Positional variation was observed in a subset of patients, including one case identified exclusively in the prone position. Preoperative imaging findings led to modification of the planned access in 8% of cases, most commonly involving avoidance of lower pole puncture. No colonic injuries were observed.

Conclusion: Retrorenal colon is an infrequent but clinically relevant anatomical variant. Dual-position CT demonstrates positional variability in selected patients and may assist in identifying potentially hazardous access trajectories, supporting safer procedural planning. Further studies are required to establish its clinical utility.

Keywords: Percutaneous nephrolithotomy; Retrorenal colon; Computed tomography; Anatomical variation; Access planning

Introduction

Urolithiasis is an increasingly prevalent global health problem, attributed to changing dietary patterns, sedentary lifestyle, and rising metabolic disorders such as obesity and diabetes mellitus. [1,2] Percutaneous nephrolithotomy (PCNL) remains the gold standard for the management of large and complex renal calculi due to its high stone clearance rates. [3] Despite technical advancements, PCNL is associated with complications, including bleeding, infection, and injury to adjacent organs. [4,5] Colonic injury, although uncommon (0.3–1%), can result in serious morbidity. [6–8]

Retrorenal colon, defined as colonic loops positioned posterior to the kidney, is an anatomical variant reported in 6–14% of patients and may increase the

risk of colonic injury during percutaneous access. [9–11] While non-contrast computed tomography (CT) is routinely used for preoperative planning, its role in evaluating positional anatomical relationships remains underexplored. [12–14]

This study evaluates the prevalence and positional variability of retrorenal colon using dual-position CT and its implications for access planning in PCNL.

Materials And Methods

This prospective observational study was conducted in the Department of Urology at a tertiary care center between May 2021 and December 2022. This study was approved by the Institutional Ethics Committee (Approval No: KIMS/ECBMHR/2021/19-01), and written informed consent was obtained from all participants. The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. [15] Adult patients aged between 18 and 70 years who were scheduled to undergo PCNL for renal calculi were eligible for inclusion. Indications for PCNL included stones larger than 20 mm, staghorn calculi, or failure of prior treatment modalities. Patients with a history of prior renal surgery, significant spinal deformities affecting positioning, intra-abdominal masses, ascites, or those unwilling to participate were excluded from the study. All enrolled patients underwent non-contrast computed tomography of the kidney, ureter, and bladder (CT KUB) in both supine and prone positions using a standardized imaging protocol. CT scans were performed using a multidetector CT scanner with standardized acquisition parameters (slice thickness: 3–5 mm, tube voltage: 120 kVp). Radiation dose parameters were not specifically analyzed as part of this study. The scans were performed sequentially during the same session. Images were reviewed by an experienced radiologist who was blinded to intraoperative details. Retrorenal colon was defined as the presence of any segment of colon positioned posterior to the renal parenchyma on axial imaging. The laterality (right or left), anatomical location relative to the upper, mid, or lower pole of the kidney, and its relationship to the anticipated percutaneous access tract were recorded. Initial surgical planning was performed based on standard clinical and imaging parameters, including stone burden, pelvicalyceal anatomy, and surgeon preference. Following detailed review of CT images, cases in which retrorenal colon was identified along or near the anticipated access trajectory were reassessed. Access modification was defined as any change in the planned calyceal puncture site, alteration in the trajectory of access, or change in patient positioning. All PCNL procedures were performed under general anesthesia. Most procedures were conducted in the prone position using fluoroscopic guidance. Retrograde pyelography was routinely performed to delineate the collecting system prior to percutaneous access. Standard techniques for tract dilation and stone fragmentation were employed. The primary outcome measure was the proportion of patients in whom the planned access was modified following CT evaluation. Secondary parameters included operative time, nephrostomy tract length, duration of hospital stay, and postoperative complications classified according to the Clavien–Dindo grading system. [16]

Given the limited number of retrorenal colon cases, data analysis was primarily descriptive. Continuous variables are presented as mean ± standard deviation, while categorical variables are expressed as frequencies and percentages.

Results

A total of 100 patients were included in the study, comprising 45 males and 55 females. The mean age of the cohort was 43.5 ± 11.5 years. The majority of patients presented with unilateral renal calculi, with left-sided stones observed in 63% of cases. The mean body mass index was 23.4 ± 4.4 kg/m². Common comorbidities included hypertension and diabetes mellitus (Table 1). Retrorenal colon was identified in 9 patients on prone CT imaging and in 8 patients on supine CT imaging, corresponding to a prevalence of 9% and 8%, respectively (Figure 1A & 1B). In one patient, retrorenal colon was detected exclusively in the prone position, illustrating positional variability in colonic anatomy. Among the identified cases, the retrorenal colon was more frequently located posterior to the lower pole of the kidney and was predominantly observed on the left side (Table 2). Assessment of the relationship between the colon and the anticipated access tract revealed that in 8 patients, the initially planned access trajectory traversed or was in close proximity to the retrorenal colon (Figure 2A & 2B). Based on these findings, the surgical approach was modified in these cases. Modifications primarily involved shifting the puncture site from the lower pole

Volume 9, Issue 3; May-June 2026; Page No 273-281

to a mid or upper calyceal approach to avoid a potentially hazardous access path. In one patient, the surgical plan was altered to a supine PCNL approach. The mean operative time for the cohort was 76.6 ± 15.9 minutes. The mean nephrostomy tract length was comparable across patients, and the average duration of hospital stay was 2.8 ± 0.5 days. Postoperative complications were observed in 8 patients (8%), all of which were minor (Clavien–Dindo grade I or II) and managed conservatively (Table 3). Importantly, no cases of colonic injury were observed in this series. This study was not designed to evaluate causality between imaging findings and complication prevention. Overall, dual-position CT provided additional anatomical information in a subset of patients, particularly in identifying positional changes in the relationship between the colon and kidney. These findings influenced surgical planning in selected cases, primarily by guiding safer access trajectories.

Discussion

The present study provides a prospective evaluation of the prevalence and positional variability of retrorenal colon in patients undergoing percutaneous nephrolithotomy (PCNL), with a specific focus on its implications for preoperative access planning. The findings demonstrate that retrorenal colon is an infrequent but clinically relevant anatomical variant and that its spatial relationship with the kidney may vary with patient positioning. Importantly, in a subset of patients, this anatomical information contributed to modification of the planned access trajectory, highlighting its potential role in enhancing procedural safety.

The prevalence of retrorenal colon observed in this study (8–9%) is consistent with previously reported imaging-based estimates ranging between 6% and 14%. [9–11] Early anatomical and radiological investigations have established that the colon may lie posterior to the kidney in a minority of individuals, with a higher frequency on the left side and in relation to the lower pole. [10] This distribution is clinically significant, as lower pole access is commonly preferred during PCNL due to its favorable alignment with the renal pelvis and calyceal anatomy. Consequently, the presence of a retrorenal colon in this region may increase the risk of colonic injury during percutaneous access.

Colonic injury during PCNL, although rare, is a well-recognized complication with potentially serious consequences. Reported incidence ranges from approximately 0.3% to 1%, but the associated morbidity—including peritonitis, sepsis, and the need for surgical intervention—can be substantial. [6–8] The risk of such injury is closely related to the anatomical relationship between the kidney and surrounding viscera, particularly the colon. Therefore, accurate preoperative identification of anatomical variations such as retrorenal colon assumes critical importance in minimizing procedural risk.

A key contribution of the present study is the demonstration of positional variability in the relationship between the colon and kidney. In one patient, retrorenal colon was identified exclusively in the prone position, underscoring the dynamic nature of intra-abdominal anatomy. This finding is supported by prior radiological studies that have demonstrated shifts in colonic position with changes in patient posture, attributed to gravitational effects and mesenteric mobility. [13,14] Such positional changes may be particularly relevant in the context of PCNL, where there is a discrepancy between the imaging position (typically supine) and the operative position (commonly prone).

In routine clinical practice, non-contrast computed tomography (CT) is primarily interpreted with a focus on stone-related parameters such as size, location, and density. [12] However, the spatial relationship between the kidney and adjacent structures is equally important in determining the safety of percutaneous access. The findings of this study highlight that structured and deliberate evaluation of colon–kidney relationships can reveal anatomical configurations that may not be immediately apparent during routine assessment. This is particularly relevant in cases where the colon lies along or near the anticipated access tract.

In the present series, preoperative identification of retrorenal colon led to modification of the planned access in 8% of patients. These modifications predominantly involved avoiding lower pole puncture and selecting alternative calyceal access routes, thereby minimizing the risk of colonic injury. In one instance, the surgical plan was altered to a supine PCNL approach. While these observations suggest that detailed anatomical assessment may influence surgical decision-making, it is important to interpret

Volume 9, Issue 3; May-June 2026; Page No 273-281

these findings within the context of the study design. The study was not intended to establish causality or demonstrate superiority of dual-position imaging, but rather to provide descriptive insights into anatomical variability and its potential clinical implications.

The absence of colonic injury in this cohort is a reassuring finding but should be interpreted with caution. Given the low baseline incidence of this complication, the sample size of the present study is insufficient to draw meaningful conclusions regarding the effectiveness of dual-position CT in preventing injury. Furthermore, the lack of a control group limits the ability to compare outcomes between standard and positional imaging strategies. Therefore, while the findings suggest a potential role for dual-position CT in selected cases, they remain hypothesis-generating rather than definitive.

An important consideration in the use of dual-position CT is the associated increase in radiation exposure. CT imaging is widely regarded as the gold standard for the evaluation of urolithiasis due to its high sensitivity and specificity. [12] However, cumulative radiation dose is a recognized concern, particularly in patients requiring repeated imaging. Although advances in low-dose CT protocols have mitigated this issue to some extent, the addition of a second scan in a different position inevitably increases radiation exposure. This raises important questions regarding the risk–benefit balance of routine dual-position imaging.

In addition to radiation concerns, cost implications must also be considered. In many healthcare settings, particularly in low- and middle-income countries, resource constraints may limit the feasibility of additional imaging. Therefore, the routine use of dual-position CT for all patients undergoing PCNL may not be practical or justified. A more rational approach would involve selective use in patients at higher risk of anatomical variation or in cases where the colon appears to be in close proximity to the anticipated access tract on initial imaging.

The findings of the present study support such a selective strategy. Rather than advocating for universal adoption, dual-position CT may be most useful in specific clinical scenarios, such as planned lower pole access, equivocal anatomical relationships on standard imaging, or in patients with factors that may predispose to altered intra-abdominal anatomy. This targeted approach would allow clinicians to obtain additional anatomical information when needed while minimizing unnecessary radiation exposure and cost.

The study has several strengths, including its prospective design and the use of a standardized imaging protocol. The inclusion of both supine and prone CT imaging in the same session allowed for direct comparison of anatomical relationships under different conditions. Additionally, the assessment of how imaging findings influenced surgical planning provides practical insights into the potential clinical utility of positional imaging.

However, several limitations must be acknowledged. The number of patients with retrorenal colon was relatively small, limiting the ability to perform subgroup analyses or identify predictive factors. The study design was descriptive and did not include a control group, precluding comparison with standard imaging practices. Radiation exposure and cost analysis were not formally assessed, which limits the ability to evaluate the broader implications of dual-position imaging. Furthermore, the study was conducted at a single center, which may limit generalizability.

Future research in this area should focus on larger, multicenter studies with comparative designs. Such studies should aim to evaluate whether dual-position imaging leads to measurable improvements in clinically relevant outcomes, including reduction in complication rates, improved procedural success, and cost-effectiveness. Integration of preoperative imaging with intraoperative guidance techniques, such as ultrasound or real-time navigation systems, may further enhance procedural safety and represents an area of potential future development.

From a broader clinical perspective, the findings of this study underscore the importance of comprehensive preoperative planning in PCNL. While technological advancements have significantly improved the safety and efficacy of the procedure, anatomical variations remain an important source of potential complications. Recognition and appropriate management of such variations are essential components of safe surgical practice. In this context, the identification of retrorenal colon and its positional variability represents a small but meaningful step toward more individualized and risk-aware procedural planning.

Volume 9, Issue 3; May-June 2026; Page No 273-281

Conclusion

Retrorenal colon is an infrequent but important anatomical variant encountered in patients undergoing PCNL. Dual-position CT demonstrates positional variability in a subset of patients and may assist in identifying potentially hazardous access trajectories. The findings of this study suggest that structured evaluation of colon–kidney relationships can influence surgical planning in selected cases. However, these observations are descriptive and hypothesis-generating. Further controlled studies are required to determine the clinical value, cost-effectiveness, and safety implications of incorporating positional imaging into routine preoperative assessment for PCNL.

Declarations

1. Acknowledgements: None.
2. Conflict of interest: The authors declare no conflicts of interest.
3. Funding: No funding was received for this study
4. Ethical Statement: This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki and its amendments. The authors are accountable for all aspects of the work. All authors read and approved the final manuscript.
5. Consent for publication: Written informed consent was obtained from the patients for publication.

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Volume 9, Issue 3; May-June 2026; Page No 273-281

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Table 1: Baseline Characteristics of the Study Population (n = 100)

Variable	Value
Age (years), mean ± SD	43.5 ± 11.5
Male	45 (45%)
Female	55 (55%)
Right side stone	37 (37%)
Left side stone	63 (63%)
BMI (kg/m²), mean ± SD	23.4 ± 4.4
Comorbidities*	32 (32%)

Data are presented as mean ± standard deviation or number (percentage).

*Comorbidities include hypertension and/or diabetes mellitus.

Table 2: Distribution and Positional Characteristics of Retrorenal Colon (n = 100)

Variable	Value
Retrorenal colon (supine CT)	8 (8%)
Retrorenal colon (prone CT)	9 (9%)
Positional variation	1 (1%)
Left	8 (88.9%)
Right	1 (11.1%)
Lower pole	7 (77.8%)
Mid/Upper pole	2 (22.2%)

Retrorenal colon defined as colon posterior to renal parenchyma.

Percentages based on n=9 cases.

Volume 9, Issue 3; May-June 2026; Page No 273-281

Table 3: Descriptive Perioperative Outcomes (n = 100)

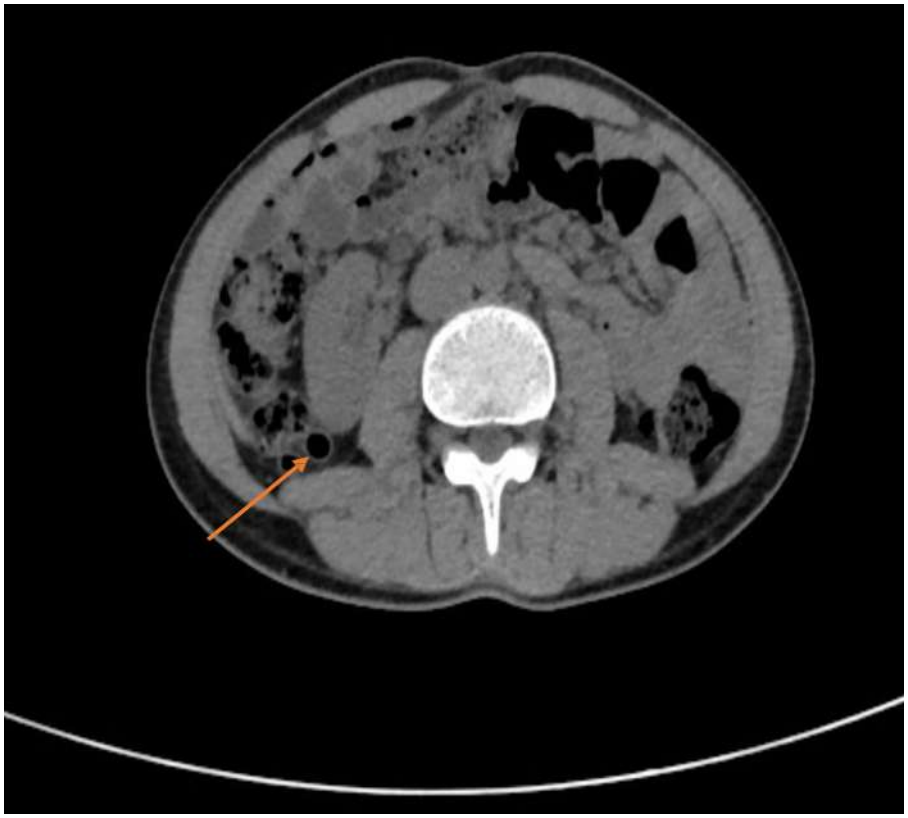
Variable	Value
Operative time (minutes)	76.6 ± 15.9
Nephrostomy tract length (mm)	92.1 ± 6.5
Hospital stay (days)	2.8 ± 0.5
Access modification	8 (8%)
Complications (Clavien–Dindo grade I–II), n (%)	8 (8%)
Colonic injury	0 (0%)

• Data presented as mean ± SD or number (%).

• No inferential statistics performed.

Figure Legends

Figure 1A: Non-contrast CT scan—Right retrorenal colon in supine position.



Volume 9, Issue 3; May-June 2026; Page No 273-281

Figure 1B: Non-contrast CT scan—Right retrorenal colon in prone position

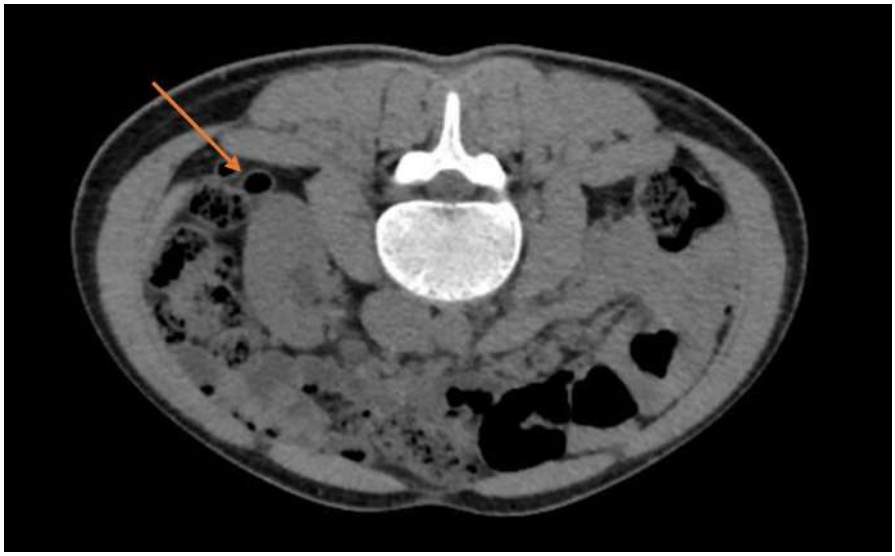
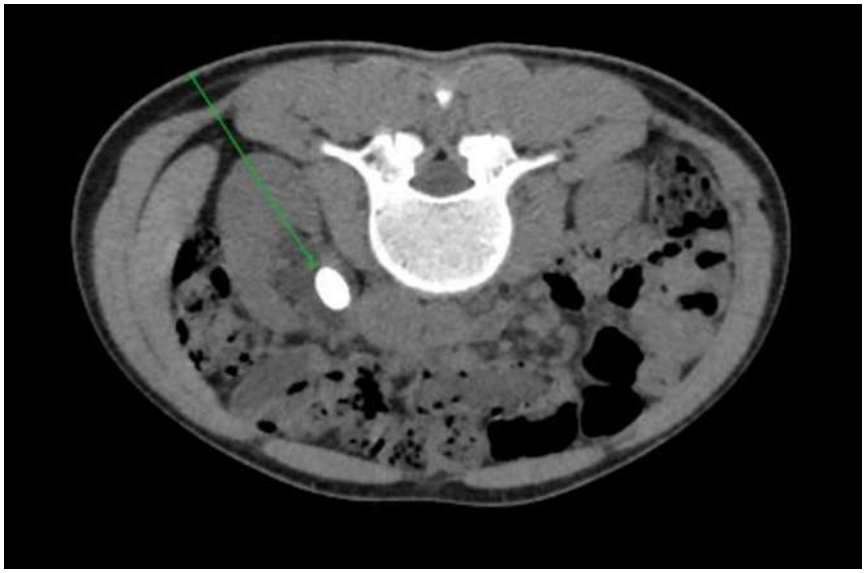
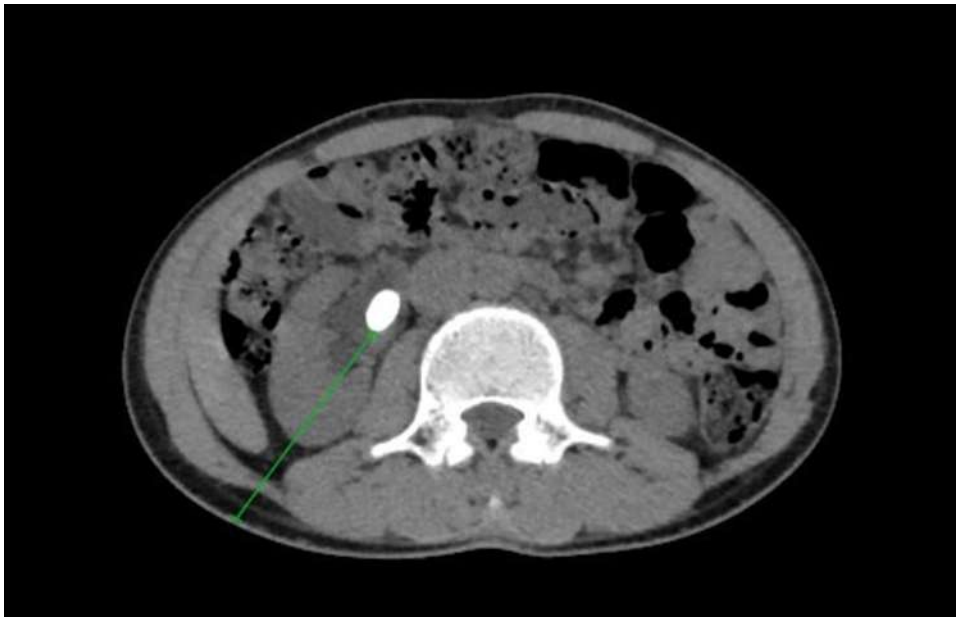


Figure 2A: Prone NCCT showing percutaneous nephrostomy tract length.



Volume 9, Issue 3; May-June 2026; Page No 273-281

Figure 2B: Supine NCCT showing percutaneous nephrostomy tract length.



Volume 9, Issue 3; May-June 2026; Page No 273-281