International Journal of Medicine
pISSN 1468-3814 | eISSN 2667-7008
https://theinternationalmedicine.com/

Original Researcher Article DOI: 10.61336/im/26-06-158

ROLE OF THIN-SLICE COMPUTED TOMOGRAPHY IN DISTINGUISHING DISTAL URETERAL CALCULI FROM PELVIC PHLEBOLITHS.

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Received: 07-05-2026
Revised: 26-05-2026
Accepted: 09-06-2026
Published: 25-06-2026

Abstract

Background: Differentiating distal ureteral calculi from pelvic phleboliths on non-contrast computed tomography (CT) remains challenging because of their close anatomical location and overlapping imaging characteristics. Thin-slice CT may improve lesion characterization through evaluation of specific morphologic and attenuation-based features. ***Objective:*** To evaluate the diagnostic utility of thin-slice CT criteria in distinguishing distal ureteral stones from pelvic phleboliths. ***Materials and Methods:*** Materials and Methods: This prospective observational analytical study was conducted at Sree Mookambika Institute of Medical Sciences between August 2025 and January 2026 and included 36 distal ureteral stones and 78 pelvic phleboliths evaluated using thin-slice non-contrast CT imaging. Parameters analysed included lesion size, shape, mean attenuation value, central lucency, profile analysis, soft tissue rim sign, and comet-tail sign. Statistical analysis was performed using the Mann–Whitney U test and Chi-square test, with $p < 0.05$ considered statistically significant. ***Results:*** Both vertical and transverse diameters were greater in ureteral stones compared with phleboliths (6.45 ± 1.42 mm vs 3.61 ± 1.22 mm and 5.98 ± 1.31 mm vs 3.47 ± 1.11 mm, respectively; $p<0.001$). Mean attenuation values were also markedly higher in stones than in phleboliths (1058.3 ± 236.7 HU vs 389.4 ± 170.2 HU; $p<0.001$). Geometric configuration was identified in 44% of ureteral stones and was absent in phleboliths, demonstrating excellent specificity for stone diagnosis. Central lucency, bifid peak on profile analysis, and comet-tail sign were observed exclusively in phleboliths, whereas the soft tissue rim sign was noted only in ureteral stones. ***Conclusion:*** Thin-slice non-contrast CT provides reliable imaging features for differentiating distal ureteral stones from pelvic phleboliths. Evaluation of morphologic characteristics, attenuation values, and secondary CT signs improves diagnostic confidence and may assist in accurate clinical decision-making in patients presenting with acute flank pain.

Keywords: Distal ureteral stone; Pelvic phlebolith; Thin-slice CT; Non-contrast CT; Urolithiasis; Soft tissue rim sign.

INTRODUCTION

Urolithiasis is one of the most common urological disorders worldwide and contributes significantly to emergency department visits due to acute flank pain. Distal ureteric calculi are particularly challenging to diagnose because their clinical presentation may overlap with several other pelvic pathologies. Non-contrast computed tomography (NCCT) has become the imaging modality of choice in the evaluation of suspected ureteric stones because of its high sensitivity and specificity, rapid acquisition time, and ability to detect alternative causes of abdominal pain [1, 2].

Despite the excellent diagnostic performance of NCCT, differentiation between distal ureteric stones and pelvic phleboliths remains a common radiological dilemma. Phleboliths are calcified venous thrombi frequently seen within the pelvic veins and are often located along the expected course of the distal ureter, thereby mimicking ureteric calculi on imaging. This overlap can lead to diagnostic uncertainty, inappropriate management decisions, and unnecessary interventions [3].

Several CT findings have been described in the literature to aid in distinguishing ureteric stones from phleboliths. These include assessment of shape, size, attenuation values, central lucency, comet-tail sign, soft tissue rim sign, and profile analysis. Geometric configuration and the presence of a soft tissue rim sign are considered suggestive of ureteric calculi, whereas central lucency, bifid peak on profile analysis, and a comet-tail sign are more commonly associated with phleboliths [4, 5].

Thin-slice CT imaging has further improved lesion characterization by providing enhanced spatial resolution and reducing partial volume averaging artifacts. Previous studies have demonstrated that thin-section unenhanced CT can improve diagnostic confidence in differentiating distal ureteric stones from pelvic phleboliths. [4, 8] However, the relative diagnostic utility of these imaging criteria may vary across populations and imaging protocols.

The present study evaluated the utility of thin-slice non-contrast CT findings in differentiating distal ureteral stones from pelvic phleboliths. Particular emphasis was placed on lesion morphology, attenuation characteristics, profile analysis, central lucency, soft tissue rim sign, and comet-tail sign in order to identify the most reliable imaging indicators for accurate radiologic diagnosis.

MATERIALS AND METHODS

Study Design and Population

This prospective observational analytical study was conducted at Sree Mookambika Institute of Medical Sciences between August 2025 and January 2026 to evaluate the usefulness of thin-slice non-contrast computed tomography (CT) criteria in differentiating distal ureteral stones from pelvic phleboliths. All eligible consecutive patients undergoing thin-slice non-contrast CT during the study period were prospectively evaluated. Institutional Ethics Committee approval was obtained before commencement of the study, and informed consent was obtained from all participants.

The sample size was calculated using the prevalence of soft tissue rim sign (67%) reported in a previous similar study by Akdamar et al. Using a 95% confidence interval and 10% allowable error, the minimum required sample size was estimated to be 85 calcific lesions. During the study period, 114 eligible calcific lesions fulfilling the inclusion criteria were available and were therefore included in the final analysis, comprising 36 distal ureteral stones and 78 pelvic phleboliths.

Patients with confirmed distal ureteral calculi on non-contrast CT and patients with pelvic calcifications identified as phleboliths were included in the study. Only calcific lesions located along the expected anatomical course of the distal ureter were evaluated. Patients with inadequate CT image quality, indeterminate calcific lesions, calcifications outside the distal ureteric region, or previously treated ureteral calculi were excluded from the analysis.

CT Imaging Protocol

Thin-slice non-contrast CT examinations were performed for all subjects, with imaging focused on calcific lesions along the expected distal ureteric course. Thin-section imaging was used to improve lesion characterization and reduce partial volume averaging artifacts. Imaging analysis included evaluation of lesion size, attenuation characteristics, morphologic appearance, central lucency, profile analysis findings, soft tissue rim sign, and comet-tail sign.

Imaging Analysis

For each calcific lesion, vertical and transverse dimensions were measured in millimeters, and mean attenuation values were recorded in Hounsfield units (HU). Lesions were morphologically categorized as round, oval, or geometric in configuration. Geometric morphology was considered suggestive of distal ureteral calculi based on previously described CT characteristics.

Central lucency was assessed visually on thin-slice CT images. Profile analysis was performed to evaluate attenuation distribution patterns within each calcification and to identify either a single-peak or bifid-peak appearance. The presence of central lucency and a bifid peak pattern favored the diagnosis of pelvic phlebolith.

Periureteral soft tissue attenuation surrounding a calcification was recorded as a soft tissue rim sign and considered suggestive of a ureteral calculus. An eccentric tapering soft tissue extension adjacent to a calcification was categorized as a comet-tail sign and favored the diagnosis of phlebolith.

Statistical Analysis

Statistical analysis was performed using Statistical Package for the Social Sciences (SPSS) software version 27.0. Continuous variables were expressed as mean ± standard deviation. The Mann–Whitney U test was used to compare continuous variables, including lesion size and attenuation values, between ureteral stones and phleboliths. Categorical variables were analyzed using the Chi-square test.

Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated for individual imaging criteria. A p-value less than 0.05 was considered statistically significant.

RESULTS

The mean vertical size, mean transverse size, and mean attenuation values were significantly greater in distal ureteral stones compared to pelvic phleboliths (Table 1). The mean vertical diameter of ureteral stones was 6.45 ± 1.42 mm, whereas pelvic phleboliths measured 3.61 ± 1.22 mm. Similarly, the mean transverse diameter was higher in stones (5.98 ± 1.31 mm) than in phleboliths (3.47 ± 1.11 mm). Ureteral stones also demonstrated markedly higher mean attenuation values (1058.3 ± 236.7 HU) compared to phleboliths (389.4 ± 170.2 HU). These differences were statistically highly significant ($p < 0.001$) on the Mann–Whitney U test analysis, suggesting that lesion size and attenuation characteristics are useful parameters in distinguishing distal ureteral stones from pelvic phleboliths on thin-slice non-contrast CT imaging.

Table 1. Mean size and density values of distal ureter stones and pelvic phleboliths.

	Stone n:36	**Phlebolith n:78**	**P***
Mean vertical size (mm)	6.45 (±1.42)	3.61 (±1.22)	<0.001
Mean transverse size (mm)	5.98 (±1.31)	3.47 (±1.11)	<0.001
Mean density HU	1058.3 (±236.7)	389.4 (±170.2)	<0.001

Shape assessment demonstrated distinct morphological differences between distal ureteral stones and pelvic phleboliths (Table 2). Geometric configuration was observed exclusively in distal ureteral stones, being present in 16 (44%) lesions, while none of the phleboliths demonstrated geometric morphology. This finding showed 100% specificity and positive predictive value (PPV) for ureteral stones, suggesting that geometric shape is a highly reliable indicator of urinary calculi.

Round morphology was identified in 11 (31%) stones and 30 (38%) phleboliths, whereas oval morphology was observed in 9 (25%) stones and 48 (62%) phleboliths. Oval shape demonstrated relatively higher sensitivity (62%) and PPV (84%) for phleboliths compared to round morphology. However, both round and oval configurations showed only moderate specificity and lower negative predictive values, limiting their reliability as independent diagnostic indicators.

Table 2. Results of shape assessment of distal urinary stones and phleboliths

Shape	**Stone n:36**	**Phleboliths n:78**	**Sensitivity***	**Specificity***	**PPV***	**NPV***
Round	11 (31%)	30 (38%)	38	69	73	33
Oval	9 (25%)	48 (62%)	62	75	84	47
Geometric	16 (44%)	0 (0%)	44	100	100	82

Table Legend: Sensitivity, specificity, PPV, and NPV of round and oval shape features were for phleboliths. The same values of geometric shape were for urinary stones.

Evaluation of CT criteria demonstrated several characteristic findings that were useful in differentiating pelvic phleboliths from distal ureteral stones (Table 3). Central lucency, bifid peak on profile analysis, and comet-tail sign were observed exclusively in phleboliths and were absent in all ureteral stones. Central lucency and bifid peak were identified in 20 (26%) phleboliths each, while the comet-tail sign was present in 14 (18%) lesions. All three findings demonstrated 100% specificity and positive predictive value (PPV) for phleboliths, indicating that their presence strongly favours the diagnosis of pelvic phlebolith rather than ureteral calculus. However, their relatively low sensitivity suggests that these signs are not universally present in all phleboliths.

Profile analysis demonstrated a single peak pattern was observed in all ureteral stones [36 (100%)] and in 58 (74%) phleboliths. This finding showed very high sensitivity (100%) and negative predictive value (100%) for urinary stones, although its specificity remained low (26%). Soft tissue rim sign was identified in 24 (67%) ureteral stones and was not observed in any phleboliths, yielding 100% specificity and PPV for stone diagnosis. Chi-square test analysis demonstrated statistically significant differences between ureteral stones and phleboliths for all evaluated CT criteria.

Table 3. Criteria used to differentiate phleboliths from distal urinary stones

	Stone n:36	**Phleboliths n:78**	**Sensitivity***	**Specificity***	**PPV***	**NPV***
Central lucency	0 (0%)	20 (26%)	26	100	100	38
Profile analysis bifid peak	0 (0%)	20 (26%)	26	100	100	38
Profile analysis single peak	36 (100%)	58 (74%)	100	26	38	100
Soft tissue rim sign	24 (67%)	0 (0%)	67	100	100	87
Comet tail sign	0 (0%)	14 (18%)	18	100	100	35

Table Legend: PPV: Positive predictive value, NPV: Negative predictive value. Sensitivity, specificity, PPV, and NPV of central lucency, bifid peak on profile analysis, and comet-tail sign were for phleboliths. The same values of a single peak on profile analysis and soft tissue rim sign were for urinary stone.

DISCUSSION

Accurate differentiation between distal ureteral stones and pelvic phleboliths is essential in patients presenting with acute flank pain, particularly when calcifications are located along the distal ureteric course. Thin-slice CT significantly improves the characterization of calcific lesions and enhances diagnostic accuracy.

In the present study, ureteral stones demonstrated significantly larger dimensions and higher attenuation values compared to phleboliths. The mean attenuation value of stones was 1058.3 HU, whereas phleboliths showed a substantially lower mean density of 389.4 HU. These findings are consistent with the study by Akdamar et al., who reported significantly higher density values in stones compared to phleboliths [10]. Bell et al. also observed significant attenuation differences between calculi and phleboliths, supporting the diagnostic utility of density measurements [4].

Geometric configuration emerged as a highly specific indicator of ureteral calculi in the present study. None of the phleboliths demonstrated geometric morphology, while 44% of stones exhibited this feature. Similar observations were reported by Bell et al., where geometric shape strongly favored urinary calculi. The high specificity and PPV suggest that identification of geometric configuration on CT should strongly raise suspicion for ureteral stones [4].

Central lucency and bifid peak on profile analysis were observed exclusively in phleboliths in the present study. These findings demonstrated 100% specificity and PPV for phlebolith diagnosis. Arac et al. similarly reported that central lucency is a useful distinguishing feature on thin-slice CT [8]. However, Traubici et al. noted that central lucency may not always be consistently visualized on routine CT studies [7]. The use of thin-slice CT in the present study likely contributed to improved visualization of these subtle findings.

The soft tissue rim sign was present in 67% of ureteral stones and absent in all phleboliths. Heneghan et al. described the soft tissue rim sign as a valuable indicator of ureteral calculi on unenhanced CT. Bell et al. also reported high specificity of the rim sign for stones, although occasional phleboliths may demonstrate similar appearances [4]. The absence of rim sign in phleboliths in the present study may be attributable to the improved spatial resolution achieved with thin-slice imaging.

Comet-tail sign was identified only in phleboliths in this study, supporting previous observations by Boridy et al., who described the comet-tail sign as highly specific for pelvic phleboliths [9]. Although sensitivity was relatively low, its presence effectively excluded ureteral calculi.

Overall, the findings of the present study reinforce the importance of combining multiple CT criteria rather than relying on a single imaging feature. Thin-slice CT allows better visualization of morphological and attenuation characteristics, thereby improving differentiation between distal ureteral stones and pelvic phleboliths.

The present study has certain limitations. The sample size was relatively limited, and the single-center observational design may reduce the generalizability of the findings. Interobserver variability among radiologists was not assessed. In addition, stone composition analysis was not performed, and some imaging criteria, such as comet-tail sign and central lucency, demonstrated relatively low sensitivity despite high specificity.

CONCLUSION

Thin-slice non-contrast CT proved to be highly effective in differentiating distal ureteral stones from pelvic phleboliths in the present study. Findings such as geometric morphology, higher attenuation values, and the presence of a soft tissue rim sign strongly favored ureteral calculi, whereas central lucency, bifid peak on profile analysis, and comet-tail sign were more suggestive of pelvic phleboliths. The combined evaluation of these morphologic, attenuation-based, and secondary CT features significantly improves diagnostic confidence and helps achieve more accurate radiologic interpretation, thereby supporting appropriate clinical management and reducing unnecessary interventions in patients presenting with suspected distal ureteric obstruction.

Conflict Of Interest: The authors declare no conflict of interest.
Funding: No external funding was received for this study.

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