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Unenhanced Helical CT of Ureterolithiasis: Value of the Tissue Rim Sign

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OBJECTIVE. The tissue rim sign—a rim or halo of soft-tissue attenuation seen around the circumference of an intraureteral calculus on unenhanced axial CT—has been described as useful in differentiating ureteral calculi from extraurinary abdominal or pelvic calcifications. The purpose of this study was to determine the prevalence of the tissue rim sign in patients with ureterolithiasis and extraurinary calcifications and to determine the relationship between the tissue rim sign, the size of a calculus, and the degree of urinary obstruction.

MATERIALS AND METHODS. Unenhanced helical CT studies followed by excretory urography were obtained in 59 patients with suspected acute ureterolithiasis. Each calcification along the expected course of the ureter seen on axial CT scans was categorized as a ureteral calculus or as an extraurinary calcification. Each categorization was based on CT, urographic, and clinical findings and the presence or absence of a tissue rim sign. When the outer wall of the ureter could not be seen because there was no clear fat plane at the level of the calcification on CT, the sign was categorized as “indeterminate.” The size of the calculus was measured on CT, and the degree of urinary obstruction was estimated on the basis of the urograms.

RESULTS. Thirty-two patients each had a single ureteral calculus. Of these patients, CT revealed a positive tissue rim sign in 16 patients (50%), was negative in five patients (16%), and was indeterminate in 11 patients (34%). In addition, we saw 57 extraurinary calcifications in 18 patients (11 patients with ureteral calculi and seven patients without ureteral calculi). None of the 57 extraurinary calcifications was associated with a positive tissue rim sign. The tissue rim sign was negative in 39 (68%) of the 57 extraurinary calcifications and indeterminate in the remaining 18 (32%). Ureteral calculi with a negative tissue rim sign were larger than ureteral calculi with a positive tissue rim sign ($p < .01$). A high degree of obstruction was present in four of five patients with ureteral calculi for which CT showed a negative tissue rim sign. Conversely, six of 16 patients in whom CT revealed a positive tissue rim sign also had a high degree of obstruction. Therefore, no clear relationship was found between the degree of obstruction and the presence of a positive tissue rim sign.

CONCLUSION. A positive tissue rim sign is specific for the diagnosis of ureterolithiasis. However, a negative tissue rim sign does not preclude such a diagnosis. The presence or absence of this tissue rim sign correlates with the size of a calculus but not with the degree of urinary obstruction. When CT reveals an indeterminate tissue rim sign, careful inspection for other CT findings, such as ipsilateral ureteral dilatation, perinephric edema, dilatation of the intrarenal collecting system, and renal swelling, is necessary.

The value of unenhanced abdominal CT for examining patients with acute flank pain was demonstrated by Smith et al. [1]. Unenhanced abdominal CT has been reported to be more sensitive in revealing calculi than excretory urography is [1, 2]. The advantages of unenhanced abdominal CT over urography include speed, no requirement of IV contrast media, and the ability to reveal abnormalities outside the urinary tract that clinically mimic renal colic [1–3]. Unenhanced abdominal CT has

limitations, however, including difficulty in differentiating ureteral calculi from extraurinary calcifications and a limited ability to show the degree of urinary obstruction.

The tissue rim sign, a circumferential rim or halo of soft-tissue attenuation surrounding a calculus on unenhanced axial CT, has been reported to be useful in differentiating ureteral calculi from extraurinary calcifications [1]. However, the prevalence of this sign has not been reported. The purpose of our study was to define the prevalence of the tissue rim

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sign and to compare its specificity with that of excretory urography in cases of ureteral calculi. We also attempted to define the relationship of a positive tissue rim sign to the size of a calculus and to the degree of the urinary obstruction.

Materials and Methods

Unenhanced helical CT examinations were obtained on a HiSpeed Advantage CT scanner (General Electric Medical Systems, Milwaukee, WI) for 68 consecutive patients who presented to the emergency department at our institution with suspected acute ureterolithiasis. The CT parameters included 5-mm collimation, a pitch of 1.6, and two to three breath-holds [3]. Axial images were generated at an 8-mm interscan spacing and then reconstructed at a 3-mm interscan spacing. All images were displayed and reproduced on hard copy at a soft-tissue window setting with a window width of 450 H and a window level of 50 H.

After CT, excretory urography was performed when requested by the referring physician unless a patient had a contraindication to iodinated contrast media. Scout and enhanced radiographs were obtained at 5, 10, and 15 min, along with tomographic films of the kidneys at 30 sec and at 7 min after IV administration of approximately 100 ml of iohexol (Omnipaque 300; Nycomed, Princeton, NJ). Excretory urography was completed with a postvoiding film of the bladder when obstruction was absent; when obstruction was present, additional delayed films were obtained until the cause and the level of obstruction were seen.

Fifty-nine patients underwent both unenhanced CT and excretory urography and constitute the basis for this study.

All CT examinations were reviewed by four radiologists to record all calcific densities along the expected course of the ureters. Each calcific density was categorized as a ureteral calculus or as an extraureteral calcification on the basis of CT, excretory urography, and clinical findings.

On CT, criteria for ureterolithiasis included the presence of a stone within the ureter or unilateral dilatation of the ureter to a specific point of the calculus below which the ureter was of a normal caliber [1]. On CT, secondary signs of urinary obstruction suggestive of ureteral obstruction included stranding of perinephric fat, dilatation of the intrarenal collecting system, and a unilateral increase in renal cortical thickness.

On excretory urography, criteria for ureterolithiasis included the presence of a stone within the ureter or unilateral dilatation of the opacified ureter to a specific level of calculus with or without a normal caliber of ureteral lumen inferior to that point.

A positive tissue rim sign was defined as a 1- to 2-mm rim of soft-tissue attenuation (20–40 H) surrounding the intraureteral calculus [1] (Fig. 1). The presence or absence of this tissue rim sign could be determined only when we saw a clear fat plane

around a stone or calcification. When the outer wall of the ureter could not be seen because of the lack of such a fat plane at the level of the stone or calcification, the sign was categorized as indeterminate.

To define the relationship of a positive tissue rim sign to the size of the calculus and the degree of urinary obstruction, the size of the stone was defined as the maximum transverse diameter of the calculus measured on axial CT images at the level of a calculus. Degrees of urinary obstruction were defined as absent, low-grade, and high-grade using excretory urography. When we saw no delay in the time of appearance of excreted contrast media into the renal collecting system and ureter on the side having the stone when compared with the opposite side, the urogram was defined as showing absent obstruction. Low-grade obstruction was defined as opacification of the collecting system and ureter to the specific level of a ureteral calculus no later than 15 min after IV injection of the contrast media. High-degree obstruction was defined as delay of excretion more than 15 min after IV contrast media injection.

Ureteral calculi were categorized by location as proximal third, mid third, or distal third of the ureter or as the ureterovesical junction.

We used the Student's two-tailed *t* test to evaluate the relationship of cases with and without a tissue rim sign to the size of the calculus.

Results

We found 32 ureteral calculi in 32 patients and 57 extraureteral calcifications shown by CT in 18 patients (11 patients with stones and seven patients without stones). Twenty patients had neither ureteral calculi nor extraureteral calcification. Patients with ureterolithiasis were 19–63 years old (average age, 33 years old). Ureteral calculi were located in the proximal ureter in four cases, the midureter in two cases, the distal ureter in 19 cases, and the ureterovesical junction in seven cases.

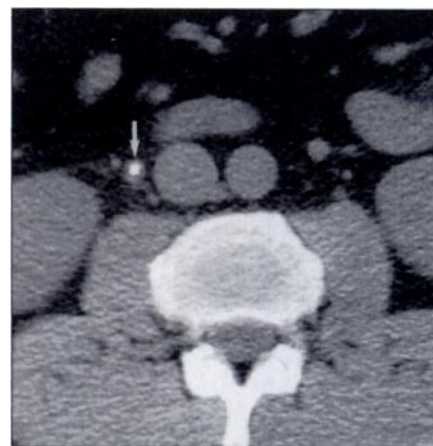
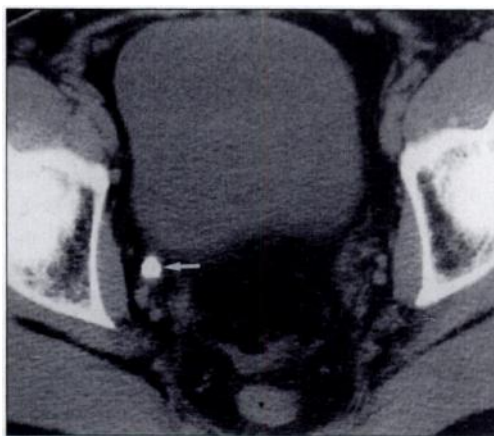


Fig. 1.—Positive tissue rim sign in 45-year-old man with right flank abdominal pain and hematuria. Unenhanced helical CT scan obtained at level of lower pole of right kidney shows rim of soft tissue around right proximal ureteral stone (arrow).

The 18 patients with extraureteral calcifications were 22–63 years old (mean age, 41 years old). The number of the extraureteral calcifications ranged from one to seven per patient (mean, three).

A tissue rim sign was present in 16 (50%) of the 32 patients with ureteral calculi (Fig. 1), whereas a negative tissue rim sign was seen in five (16%) of the 32 patients (Fig. 2). The tissue rim sign was indeterminate in the remaining 11 patients (34%) with proven ureteral calculi (Fig. 3) (these findings are summarized in Table 1); of the 11 patients with indeterminate tissue rim sign, ureteral calculi were located at the ureterovesical junction in seven, in the distal ureter in three, and in the midureter in one.

None of the 57 extraureteral calcifications was associated with a positive tissue rim sign. A negative tissue rim sign was noted in 39 cal-

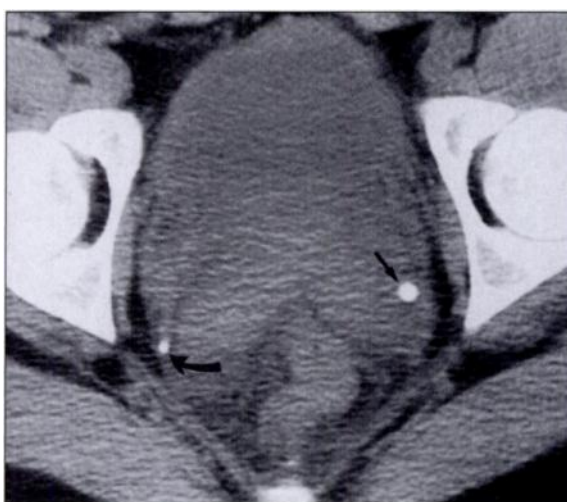
Fig. 2.—Negative tissue rim sign in 43-year-old man with right renal colic. CT scan obtained at level of lower pelvis reveals no rim of soft tissue around calculus (arrow). Right ureter proximal to ureteral calculus is dilated (not shown). Patient later underwent excretory urography (not shown) that revealed high-grade urinary obstruction.

CT of Ureterolithiasis

Fig. 3.—Indeterminate tissue rim sign in 24-year-old man with left renal colic. Unenhanced CT scan obtained at level of lower pelvis shows obscuring of periureteral fat plane around left distal ureteral stone (arrow) that is surrounded by soft-tissue density.



Fig. 4.—Indeterminate tissue rim sign in 38-year-old woman with abdominal pain and hematuria. Unenhanced CT scan obtained through left lower pelvis shows phlebolith (arrow) surrounded by soft tissue. Note another phlebolith (curved arrow) partially surrounded by soft tissue on right. No ureteral calculus was revealed by urography (not shown).



calculi than excretory urography is [1, 4–6]. Direct CT signs of ureteral stones include visualization of a calculus and unilateral dilatation of the ureter to the specific point of the calculus, with its caliber seen as normal below that point [1]. CT has been shown to be more accurate in revealing calculi than excretory urography is [1, 2]. CT attenuation coefficients for urinary calculi range from 200 to 600 H and are substantially higher than for adjacent soft tissue [1, 4–6]. However, extraordinary abdominal and pelvic calcifications are also seen on unenhanced CT scans; calcifications located in the expected course of the ureter on the symptomatic side may be confused with a ureteral calculus. Sommer et al. [3] found multiplanar reformatted images that reveal a ureteral calculus in a manner similar to excretory urography to be useful for this differentiation; however, such reformatted images may take as long as 30 min to be generated from axial images obtained from helical scans.

Differentiating ureteral calculi from extraordinary calcifications when the ipsilateral ureter is not dilated is difficult. Secondary CT signs suggestive of ureteral obstruction include stranding of the perinephric fat (perinephric edema), dilatation of the intrarenal collecting system, and a unilateral increase in renal cortical thickness. When these secondary signs are present, the likelihood that a calcification of interest represents ureterolithiasis rather than an extraordinary calcification is increased. However, the CT finding of perinephric edema is nonspecific; it may be present in cases of acute pyelonephritis, pyonephrosis, and renal vein thrombosis [7].

The tissue rim sign is thought to represent the edematous wall of the ureter [1]. Our study suggests that the tissue rim sign on CT is specific for the diagnosis of ureterolithiasis. Such a sign was present on CT in 50% of cases of ureterolithiasis but in no cases of extraordinary calcifications. The absence of this sign, however, does not preclude the diagnosis of ureterolithiasis because a positive tissue rim sign was absent in 16% of patients with ureterolithiasis. No definite relationship between a positive tissue rim sign and the degree of ureteral obstruction was demonstrated. We also found that large stones lodged in the ureter tend not to produce a positive tissue rim sign (although the number of such cases in this study population was limited). One explanation is that the ureteral wall may be stretched by a large lodged stone and become too thin to be outlined on

Feature	No. (%)			Total
	Positive	Negative	Indeterminate	
Calculi	16 (50)	5 (16)	11 (34)	32
Extraordinary calcifications	0	39 (68)	18 (32)	57

calcifications (68%). The remaining 18 calcifications (32%) were indeterminate (Fig. 4). Fourteen (36%) of the 39 calcifications with negative tissue rim signs were thought to represent iliac arterial calcifications.

The calculi with a positive tissue rim sign ranged from 1 to 6 mm in diameter (mean \pm SD, 3.3 ± 1.7 mm), whereas those with a negative sign measured 4–10 mm in diameter (6.6 ± 2.4 mm) (Student's *t* test, $p < .01$).

Of the five patients with ureteral calculi for which CT showed a negative tissue rim sign, a high grade of obstruction was noted in four

and a low grade of obstruction was noted in one. Conversely, of the 16 patients with ureteral calculi for which CT revealed a positive tissue rim sign, urography showed a high grade of obstruction in six (38%), a low grade of obstruction in seven (44%), and no urinary obstruction in three (19%). Therefore, no clear relationship exists between the degree of obstruction and a positive tissue rim sign.

Discussion

Unenhanced CT has been reported to be a more sensitive technique for showing ureteral

axial CT images that use partial volume averaging. Also, the conspicuity of a rim of soft tissue around a stone might have been underestimated by our imaging technique that used 5-mm collimation and a pitch of 1.6. Increased conspicuity of the tissue rim may be obtained when a thinner sectioning is used; the trade-off in such an approach is longer scanning times.

In one third of our cases in this series, the tissue rim sign was indeterminate because the fat plane around the calcification in question was obscured by surrounding soft-tissue density. In such cases, excretory urography may still be required for differentiation when a ureteral calculus is suspected clinically and no direct or secondary signs of obstruction are seen on unenhanced CT. When the unenhanced CT is equivocal, Talner et al. have suggested repeating the CT after contrast enhancement rather than performing urography (Talner LB et al.,

presented at the American Roentgen Ray Society meeting, May 1996). However, the precise timing of enhanced CT scanning may be difficult to determine because the degree of urinary obstruction affects the timing of ureteral opacification. Contrast-enhanced CT may increase conspicuity of the tissue rim sign, thereby increasing the sensitivity of this tissue rim sign on CT; further studies will be needed to assess this hypothesis.

In conclusion, a positive tissue rim sign is specific for the diagnosis of ureterolithiasis. However, a negative tissue rim sign does not preclude the diagnosis. When the tissue rim sign is indeterminate, careful inspection for other CT findings—including the direct sign of ipsilateral ureteral dilatation to the point of the suspected calcification and the indirect signs of perinephric edema, dilatation of the intrarenal collecting system, and renal swelling—remains necessary.

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