Urinary Stone Location with Ureteral Stents in Place: Always on the Move, and not Where you Would Expect

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Purpose: To assess migration of urinary stones with ureteral stents in place.

Materials and Methods: We performed a retrospective analysis of stone characteristics and locations in patients treated with secondary retrograde intrarenal surgery for symptomatic urinary stones at our institution. We analyzed 393 patients with a median age of 53 years and a median stone size of 7 mm. Stone location was assessed at ureteral stent insertion and four weeks later prior to stent removal and retrograde intrarenal surgery (RIRS).

Results: Migration of urinary stones was seen in 33.1% of the patients with an indwelling ureteral stent. Stones with caudal migration were smaller for any given initial position. 7.1% of the stones were located at one of the three sites of narrowing at initial presentation, this percentage increased to 18.8% at the time of stone extraction. Stone composition did not affect stone migration.

Conclusion: Radiographic imaging prior to retrograde intrarenal surgery is recommended due to the migration of urinary stones with indwelling ureteral stents. The most appropriate surgical approach can be devised depending on stone localization.

Keywords: nephrolithiasis; retrograde intrarenal surgery; stone composition; stone migration; ureteral stents; ureterolithiasis; urolithiasis;

INTRODUCTION

Spontaneous expulsion of urinary stones requires passage of the three anatomic sites of narrowing: the ureteropelvic junction (UPJ), the crossing of iliac vessels and the ureterovesical junction (UVJ)[1]. Ureteral stents can be inserted to offer symptomatic relief and prepare the ureter for secondary interventions. Whilst it is well established that small stones can pass with a ureteral stent in place[2,3], there is still very little scientific understanding of the migration process of urinary stones with indwelling ureteral stents. The specific objective of this study was to assess the migration of urinary stones with indwelling ureteral stents, and assess the role of stone size, location and composition.

METHODS

We performed a retrospective analysis of stone characteristics and positions in patients treated with secondary retrograde intrarenal surgery (RIRS) for symptomatic urinary stones between January 2015 and 2019 at our institution. Stone location was assessed at the time of ureteral stent insertion and three to four weeks later before the planned stent removal and RIRS. Inclusion criteria were the availability of a computed tomography prior to ureteral stent insertion and an abdominal x-ray prior to stent removal. The latter is routinely performed at our institution in order to identify stone location and aid RIRS planning, as well as identifying patients in which spontaneous stone passage has occurred. Patients with radiolucent stones in the abdominal x-ray were excluded from the analysis. Patients requiring initial ureteral stenting due to persistent pain, associated urinary tract infections, as well as progressive kidney failure were all included. Ureteral stent insertion was performed at the discretion of the surgeon (Percuflex, Boston Scientific, USA; Charr. 6; Stent length 26 or 30 cm). For each of the two time points, stone position was classified as one of six positions on the pathway from the kidney to the bladder (**Figure 1**), and the proportion of stones found at each position was determined. For the analysis of stone migration, the positions were pooled to distinguish three main parts (kidney: only stones in the kidney, proximal: ureteropelvic junction and proximal ureter and vessel intersection, distal: distal ureter and ureterovesical junction) (**Figure 1**). The proportion of stones staying in place (no migration), and of stones with cranial or caudal migration was determined. Wilcoxon's signed-rank test, based on the positions ranked from kidney to distal, was used to test whether one sense of migration predominated. In addition, the proportion of stones found at a site of anatomic narrowing (ureteropelvic junction, vessel intersection or ureterovesical junction) was determined for the two time points and compared between time points with McNemar's test. To assess whether stone migration was related to stone size, we needed to consider that opportunities for stone migration depended on initial position, which could itself depend on stone size. We therefore compared mean stone size between the three types of migration after adjusting for initial stone position with a two-way analy-

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Table 1. Categorized stone composition based on the presence or absence of certain minerals with the frequency of each category (total n = 376).

With calcium oxalate monohydrate / Whewelit (no dihydrate)	206 (54.8%)
With calcium oxalate dihydrate / Weddellit (no monohydrate)	40 (10.7%)
With calcium oxalate monohydrate and dihydrate	99 (26.3%)
With uric acid, no calcium oxalate	14 (3.7%)
With carbonate apatite / Dahllit, no calcium oxalate	12 (3.2%)
No calcium oxalate, no uric acid, no carbonate apatite	5 (1.3%)

sis of variance. Stone composition was analyzed for the presence or absence of certain minerals using infrared spectroscopy and classified into six types, according to the predominant stone composition (**Table 1**). The associations of these six composition types with stone position and with stone migration were assessed using Chi-squared tests with continuity correction. The study was conducted according to the declaration of Helsinki and Good Clinical Practice and was approved by the local Ethics Committee (EKOS 2019-00923).

RESULTS

A total of 393 patients were included (284 males, 109 females), the median age was 53.0 years (range 17-89) and the median stone size (largest diameter on axial images) was 7 mm (range 2–30). At initial presentation, 39.7% of stones were located in the kidney, 30.5% in the proximal ureter, 22.6% in the distal ureter (Figure 1), while 7.1% of the stones were located at one of the three sites of narrowing.

In regard to stone migration, prior to RIRS (pooled position in three main parts), 14.3% of the stones were located in the kidney, 58.0% in the proximal part (ureteropelvic junction, proximal ureter and vessel intersection) and 27.7% in the distal part (distal ureter and ureterovesical junction) (**Table 2**). When considering individual transitions between the three main parts, 66.9% of the stones stayed in place, 29% moved caudally (mostly from the kidney) and 4.1% moved cranially (**Table 2**), with a significant predominance of caudal migration (Wilcoxon signed-rank test, $p < 0.001$). The proportion of stones located at a site of anatomic narrowing increased significantly from 7.1% (28/393) at initial presentation to 18.8% (74/393) at the time of stone extraction (McNemar's test, $X^2 = 27.4$, $p < .001$). The mean size of stones was significantly ($p < .001$) related to their initial position and to the type of migration: The largest stones were initially seen in the kidney, and for any given initial position, stones with caudal migration were smallest (**Figure 2**). Patient age had no effect on stone migration. In a two-way analysis of variance analogous to that carried out for stone size, patient age was not significantly related to initial stone position ($p = .46$) nor to the presence and direction of stone migration ($p = .39$). Patient sex was also unrelated to initial stone position ($p = .30$) and to the presence and direction of stone migration ($p = .86$) in a logistic regression model.

Stone composition classified into six types (**Table 1**) was not associated with the stone's tendency towards migration (Chi-squared test, X2 = 0.9, $p = .97$) or probability of being found at a site of anatomic narrowing prior to RIRS (X2 = 2.42, $p = .79$). However, stone composition appeared to be associated with different locations of stones prior to RIRS (X2 = 20.1, $p = .03$): Calculi containing carbonate apatite without calcium oxalate were more commonly seen in the kidney than calculi containing calcium oxalate or uric acid. Stones

Table 2. Frequency of stone positions at the time of ureteral stent insertion (initial) and prior to RIRS (final), and frequency of stone migration between these two time points. In order to assess migration, stone position was pooled in three main parts, ranked from 1 to 3: Kidney (1), proximal (2, combining ureteropelvic junction, proximal ureter and vessel intersection) and distal (3, combining distal ureter and ureterovesical junction). The number of stones with each combination of initial and final positions is given, as well as the total number and percentage of stones at each position per time point. Cell colors indicate the combinations of initial and final positions corresponding to caudal, cranial and no migration, respectively. The number and percentage of stones with each migration type is given at the bottom of the table.
The lower part of the Table gives the number of stones found either at a site of anatomic narrowing or at another position; again for each combination of initial and final positions and in total per time point.

Initial position		**Position prior to RIRS**		**Total n (%)**
	kidney (1)	**proximal (2)**	**distal (3)**	
kidney (1)	50	87	19	156 (39.7%)
proximal (2)	4	131	8	143 (36.4%)
distal (3)	2	10	82	94 (23.9%)
total n (%)	56 (14.3%)	228 (58.0%)	109 (27.7%)	
	narrowing	other	total n (%)	
narrowing	14	14	28 (7.1%)	
Other	60	305	365 (92.9%)	
total n (%)	74 (18.8%)	319 (81.2%)		
Types of migration				
n (%)				
Caudal	114 (29.0%)			
None	263 (66.9%)			
Cranial	16 (4.1%)			

Abbreviations: RIRS, Retrograde intrarenal surgery.

	Initial presentation	Presentation prior to RIRS	
Kidney	39.7%	14.3%	kidney
Ureteropelvic junction	5.6%	12.0%	proximal
Proximal ureter	30.5%	44.7%	
Vessel intersection	0.3%	1.3%	
Distal ureter	22.6%	22.1%	distal
Ureterovesical junction	1.3%	5.6%	

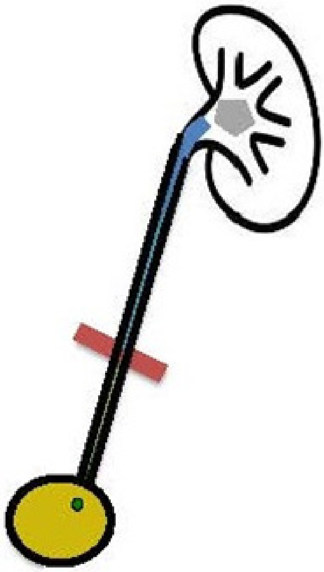

Figure 1. Six classified and possible ureteral stone positions on the pathway from the kidney to the. The percentage on the left denotes the frequency at initial presentation, the frequency on the right the frequency prior to RIRS. The positional pooling performed for the analysis of stone migration is given on the right: kidney (only stones in the kidney), proximal (ureteropelvic junction and proximal ureter and vessel intersection) and distal (distal ureter and ureterovesical junction).

containing calcium oxalate monohydrate alone or in combination with calcium oxalate dihydrate were more often seen in a distal position (30.2%) than stones without this mineral (15.5%).

DISCUSSION

In line with previous studies describing the spontaneous passage of stones with an indwelling ureteral stent[2,3], a caudal migration of urinary stones was seen in 29% of the patients with indwelling ureteral stents. Contrary to popular belief, symptomatic urinary stones were rarely seen at a site of anatomic narrowing, as this was the case in only 7.1% of the patients at initial presentation. This increased to 18.8% with an indwelling ureteral stent in place. Compared to previous studies, more ureteral stones were seen in the proximal ureter and less at the distal ureter or UVJ, while the mean stone size in our study was also slightly larger[4,5]. Both of these findings may in-part be due to the fact that patients with

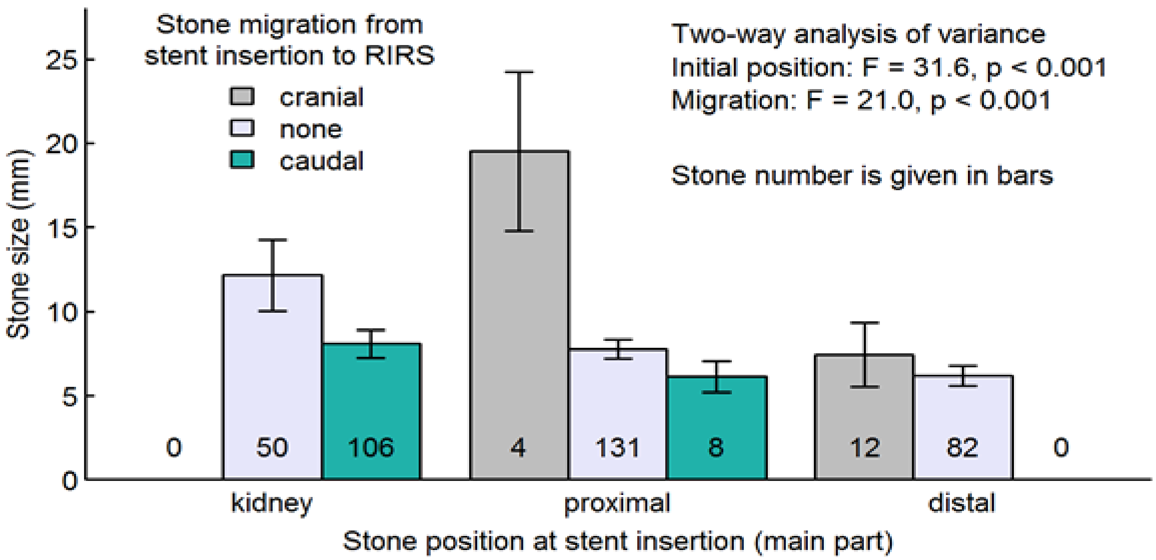

Figure 2. Stone size in relation to initial position and direction of migration from stent insertion to time of retrograde intrarenal surgery.

a spontaneous passage of stones were not included in this analysis, as all data were collected from patients who underwent RIRS.

A recent analysis by Stojkova Gafner et al. assessed the migration of urinary stones with an indwelling ureteral stent in place and within 24 hours after stent removal for patients with symptomatic ureterolithiasis [6]. In their retrospective analysis of 216 patients, they demonstrated that 34% of the patients had spontaneous stone expulsion with a stent in place. In a multivariate analysis, they showed that spontaneous stone expulsion was significantly associated with smaller stone size and distal stone location. In line with these findings, we were able to demonstrate an increased rate of stone migration associated with smaller stone size. The study by Stojkova Gafner et al. was limited to the spontaneous expulsion rate of ureterolithiasis, and the overall stone size was significantly smaller than in our study (median stone size 5 mm vs. 7 mm). Furthermore, we were able to demonstrate that kidney stones also tend to migrate with a urinary stent in place. Considering the findings of both studies, it appears that the overall rate of urinary stone migration with a urinary stent is higher than previously assumed[7].

Stone composition was available for 376 patients. Interestingly, the stone composition appeared to influence the location of the calculi prior to RIRS, with carbonate apatite containing stones often found in the kidney, and calculi composed of calcium oxalate monohydrate often seen in more distal positions. A possible explanation for this finding may be the smooth surface of calcium oxalate monohydrate calculi[8], which may help facilitate caudal migration with an indwelling ureteral stent. In clinical practice, the knowledge of stone composition is of great use when planning stone treatment, e.g. deciding which stones may be treated by urinary alkalinisation, and which stones may be amendable to extracorporal shock wave lithotripsy[9]. While the stone composition did not appear to affect the rate of stone migration in our study, it is worth noting the differing stone location with a ureteral stent in place in dependency of stone composition. This may aid decision-making in cases where population-specific studies regarding stone composition are available, as stone composition can vary regionally and across climates zones[10].

Our study has limitations that need to be addressed. The position of stones was assessed by two different methods, namely with a computed tomography at initial presentation and with less sensitive abdominal x-ray imaging prior to stent removal. We used a more granular classification of stone location (e.g. omitting middle third of ureter), in order to minimize potential discrepancies between the different imaging modalities. Nonetheless, the determination of definitive stone location is challenging with plain films, in particular the distinction between distal ureter and UVJ does not always appear to be clear[1]. However, in clinical practice it is not common to perform several CT - scans on a regular base due to the radiation exposure. Furthermore, possible positional changes of the urinary stones through the insertion of the ureteric stents were not factored in this analysis (push-back). This is a potential limitation, though cranial migration was only noted in 4.1% of cases. As the population studied was exclusively patients treated with secondary RIRS, patients with spontaneous stone expulsion were omitted from the analysis, which leads to an underestimation of the rate of caudal migration. A further potential limitation lies in the retrospective analysis which may have potentially introduced an unknown bias.

Our study further supports the notion of urinary stone migration with a ureteral stent in place. In line with other studies, we were able to demonstrate that smaller stones are more likely to migrate caudally. Furthermore, we showed that urinary stones are more than twice as likely to be found at a site of anatomic narrowing, when a ureteral stent is in place. These findings further support the use of radiographic imaging prior to retrograde intrarenal surgery. Depending on the stone localization, the most appropriate surgical approach can be devised.

CONFLICT OF INTEREST

None of the contributing authors have any conflict of interest, including specific financial interest or relationships and affiliations relevant to the subject matter or materials discussed in the manuscript.

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