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Is there any predictive value of the ratio of the upper to the lower diameter of the ureter for ureteral stone impaction?

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Abstract

Background: We aimed to determine if the ratio of the upper to the lower diameter of the ureter could have any predictive value for ureteral stone impaction.

Materials and methods: Patients who had a solitary unilateral ureteric stone, determined by noncontrast computerized tomography, were assessed if they had undergone ureteroscopic lithotripsy. A total of 111 patients, 84 males (76%), and 27 females (24%), were recruited to the study. Demographic data of the patients and preoperative radiological parameters based on noncontrast computerized tomography were recorded. The impaction status was also assessed during the operation.

Results: Of the 111 patients, ureteral stones in 63 (57%) patients were determined to be impacted, and ureteral stones in 48 (43%) were nonimpacted. Impacted stones were more common in older patients, female patients, and patients with an American Society of Anesthesiologists score of 2.

Conclusions: Significant relationships were found between the impaction status and transverse stone length, longest stone length, upper diameter of the ureter, ratio (upper diameter of the ureter/lower diameter of the ureter), and anteroposterior diameter of the pelvis. These parameters were higher in patients with impacted stones.

Keywords: Diameter; Impaction; Ratio; Ureteral stone

1. Introduction

Ureteral stones are a common disorder encountered in daily urological practice, with many different treatment options, such as extracorporeal shock wave lithotripsy, retrograde or antegrade ureterolithotripsy, and open or laparoscopic ureterolithotomy.[1] Selection of the optimal treatment modality is generally based on location and stone burden of ureteral stones.[2] However, impaction is another important factor that affect the success rate of treatment; thus, it should be considered before all types of intervention. Moreover, higher complication rates have been reported in patients with impacted stones.[3] In addition, prediction of ureteral stone impaction is important for providing information about the probable result of the operation for patients and for selecting the appropriate treatment modality. Selection of the appropriate treatment strategy is crucial in order to diminish the frequency of hospitalization and to prevent higher health care expenditures.[4]

The aim of this study was to investigate the predictive factors of stone impaction. There are limited data about the predictive criteria of impaction in the literature. Patients with impacted stones are more likely to have a higher degree of hydronephrosis, and larger stones are more often impacted.[3] Impacted stones cause complete obstruction and prevent urine passage. However, urine can be passed beyond nonimpacted stones. Therefore, dilatation should be more prominent in ureters in patients with impacted stones. According to the stone location in the ureter, the ureteral diameter at the upper part of the ureter should be wider than that of the lower part of the ureter. Thus, the ratio of the upper to the lower diameter of the ureter could have predictive value for impaction. To the best of our knowledge, there has been no study assessing this relationship in the literature. Therefore, we calculated the anteroposterior diameter of the pelvis, the ratio of the upper and lower diameter of the ureter, the transverse stone length, the longest stone length, and the Hounsfield units of stone on preoperative noncontrast computerized tomography (NCCT) in patients with ureter stones. Demographic data of patients were also recorded. After the operation, these parameters were compared according to the impaction status.

2. Materials and methods

After obtaining local ethics committee approval, patients who had solitary unilateral ureteric stones determined by NCCT

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were assessed if they had undergone the ureteroscopic lithotripsy operation. A total of 111 patients in which 84 were males (76%) and 27 were females (24%) with eligible criteria, were recruited to the study. We excluded patients with a solitary kidney, multiple unilateral ureteric stones, bilateral ureteric stones, and stones in the ipsilateral kidney. We also excluded patients who had a known ureteral stricture or previous surgical history for ureteral stricture. Patient age, sex, body mass index (BMI), creatinine level, American Society of Anesthesiologists (ASA) score, stone side, stone location, anteroposterior diameter of the pelvis, upper and lower diameter of the ureter and its ratio, transverse stone length and longest stone length, Hounsfield units of the stone, operative time, duration of symptoms, impaction status, stone migration, and complications were recorded.

The ureter was divided into 3 anatomic regions according to stone location. Stones above the sacroiliac joint were determined to be in the proximal ureter, those anterior to the sacroiliac joint as in the middle ureter, and those below as in the distal ureter.

The anteroposterior diameter of the pelvis was calculated as the longest length of the renal pelvis diameter on NCCT. We determined the same location to assess the upper and lower ureteral diameters for standardization. Thus, we determined the diameter of the proximal ureter at the level of the lowest border of the kidney as the upper ureteral diameter (Fig. 1). We measured the location 3 cm distal to the stone in the ureter as the lower ureteral diameter (Figs. 2 and 3).

The impaction status of the ureteral stone was determined during the operation according to whether a guide wire could pass beyond the stone. If a guide wire could be passed beyond the stone, it was determined to be nonimpacted. If the wire could not pass, the stone was determined to be impacted.

All ureteroscopic lithotripsy procedures were performed by 2 surgeons in 2 centers (center 1 by D.A., center 2 by A.B.) using an 8/9.8 Fr semirigid ureteroscope (Richard Wolf, Knittlinger, Germany) and an 8.6/9.8 Fr semirigid ureteroscope (Olympus, Tokyo, Japan) under general anesthesia. A pneumatic lithotripter or Holmium laser lithotripsy system was used for stone disintegration.

Figure 2. Lower diameter of the ureter (arrow head).

2.1. Statistical analysis

All analyses were performed using the IBM SPSS Statistics Version 20.0 statistical software package. Categorical variables were expressed as numbers and percentages, whereas continuous variables were summarized as means and standard deviations and as medians and minimum-maximum values where appropriate. The Chi-square test was used to compare categorical variables between the 2 groups. The normality of distribution for continuous variables was confirmed with the Shapiro–Wilk test. For comparison of continuous variables between the 2 groups, the Student's *t* test or the Mann–Whitney *U* test was used depending on whether the statistical hypotheses were fulfilled. The statistical level of significance for all tests was considered to be 0.05.

Figure 1. Upper diameter of the ureter (small arrow) and the lowest border of the kidney (big arrow).

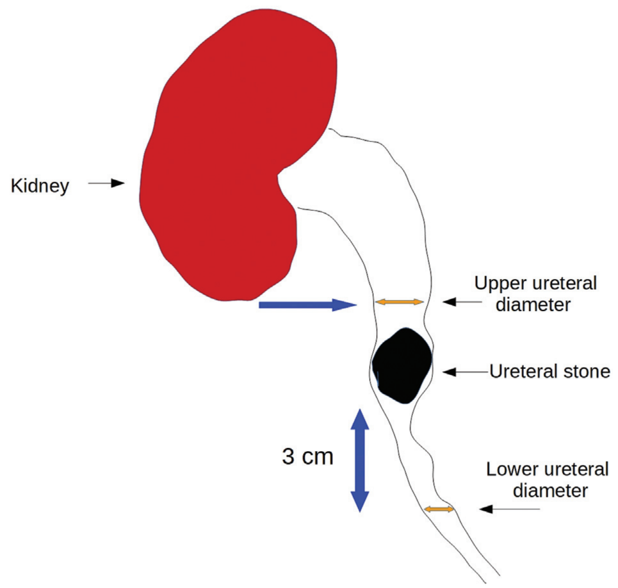

Figure 3. Demonstration of the method of ureter diameter measurement.

Table 1

Demographic and operative data of patients.

Parameters	Results
Age, years	43.1 ± 13.4
Gender, *n*	
Male	84 (76%)
Female	27 (24%)
Side, *n*	
Left	47 (42%)
Right	64 (58%)
ASA, *n*	
1	90 (81%)
2	21 (19%)
BMI, kg/m^2	26.9 ± 4.1
Creatinine, mg/dL	0.97 ± 0.29
Location, *n*	
Proximal ureter	32 (29%)
Middle ureter	45 (41%)
Distal ureter	34 (31%)
Surgical technique, *n*	
Laser	51 (47%)
Pneumatic	58 (53%)
Stone migration, *n*	
No	103 (93%)
Yes	8 (7%)
Impaction, *n*	
No	48 (43%)
Yes	63 (57%)

ASA = American Society of Anesthesiologists; BMI = body mass index.

3. Results

Of the 111 patients, 84 (76%) were male and 27 (24%) were female, and the mean age was 43.1 ± 13.4 years. Forty-seven (42%) patients had left ureteral stones, and 64 (58%) patients had right ureteral stones. The mean body mass index was 26.9 ± 4.1 kg/m^2, and the mean creatinine level was 0.97 ± 0.29 mg/dL. ASA 1 was determined in 90 (81%) patients, and ASA 2 in 21 (19%) patients. Thirty-two (29%) ureteral stones were located in the proximal ureter, 45 (41%) in the middle ureter, and 34 (31%) in the distal ureter. Sixty-three (57%) ureteral stones were determined to be impacted, and 48 (43%) were nonimpacted. For stone disintegration, a Holmium laser system was used on 51 (47%) patients, and a pneumatic lithotripter on 58 (53%) patients. Stone migration was seen in 8 (7%) patients. Perioperative major complications such as ureteral perforation and avulsion were not seen (Table 1).

There were significant relationships between age, gender, and the ASA score according to impaction status. Impacted stones were more prominently seen in older patients, female patients, and patients with ASA 2. In addition, the duration of the operation was significantly longer in patients with impacted stones. The symptom duration was determined in patients with impacted stone as 37.3 ± 59.7 days and patients with non-impacted stone as 46 ± 65.1 days. There was no significant relationship between symptom duration and impaction status (Table 2).

Significant relationships were found between the impaction status and transverse stone length, longest stone length, upper diameter of the ureter, the ratio (upper/lower diameter of the ureter), and anteroposterior diameter of the pelvis. According to the results, these parameters were higher in patients with impacted stones (Table 3). We also separately compared these

Table 2

The results of the parameters according to impaction status.

	Impaction		
Parameters	No	Yes	*p*
Age, years	40.1 ± 12.8	45.4 ± 13.5	0.037*
Gender, *n*			0.011*
Male	42 (88%)	42 (67%)	
Female	6 (12%)	21 (33%)	
Side, *n*			0.094
Left	16 (33%)	31 (49%)	
Right	32 (67%)	32 (51%)	
ASA, *n*			0.003*
1	45 (94%)	45 (71%)	
2	3 (6%)	18 (29%)	
BMI, kg/m^2	26.8 ± 3.63	27.1 ± 4.44	0.708
Symptom duration, days			0.074
Mean ± SD	46 ± 65.1	37.3 ± 59.7	
Median (range)	30 (3–365)	15 (3–365)	
Location, *n*			0.882
Proximal ureter	15 (31%)	17 (27%)	
Middle ureter	19 (40%)	26 (41%)	
Distal ureter	14 (29%)	20 (32%)	
Duration of operation, minutes			0.004*
Mean ± SD	31 ± 12.9	38.3 ± 12.7	
Median (range)	30 (15–65)	37 (15–80)	
Stone migration, *n*			0.074
No	42 (88%)	61 (97%)	
Yes	6 (12%)	2 (3%)	
Creatinine, mg/dL			0.267
Mean ± SD	0.93 ± 0.22	1 ± 0.34	
Median (range)	0.9 (0.6–1.83)	0.94 (0.48–2.3)	

ASA = American Society of Anesthesiologists; BMI = body mass index.
* Statistically significant *p* value ($p < 0.05$).

Table 3

The results of the radiologic parameters according to impaction status.

	Impaction		
Parameters	No	Yes	*p*
Transverse stone length, mm			0.007*
Mean ± SD	7.18 ± 2.22	8.42 ± 2.48	
Median (range)	7.05 (2.5–13.1)	7.8 (4.8–17)	
Longest stone length, mm			<0.001*
Mean ± SD	9.81 ± 3.65	13.14 ± 3.63	
Median (range)	9.72 (3.6–21)	12.7 (5.5–22)	
Upper ureter diameter, mm			0.001*
Mean ± SD	9.85 ± 5.29	11.55 ± 3.4	
Median (range)	8.94 (3–29.7)	11.5 (6.1–20.5)	
Lower ureter diameter, mm			0.871
Mean ± SD	4.22 ± 1.61	4.18 ± 1.16	
Median (range)	4.05 (1.87–12.6)	4.17 (1.71–7)	
Upper/lower ureter ratio			0.003*
Mean ± SD	2.46 ± 1.34	2.93 ± 1.05	
Median (range)	2.16 (1–7.98)	2.66 (1.62–6.57)	
Anteroposterior diameter of the pelvis, mm			<0.001*
Mean ± SD	19.57 ± 6.75	27.26 ± 7.51	
Median (range)	20.1 (6.5–37)	27.5 (9.7–43.1)	
Hounsfield units score			0.198
Mean ± SD	673.5 ± 245	732.3 ± 230.3	
Median (range)	655.1 (271.7–1,449.1)	745.2 (337.1–1,316.9)	

* Statistically significant *p* value ($p < 0.05$).

parameters according to impaction status in proximal, middle and distal locations of the ureter. Significant relationships were seen between the impaction status and longest stone length and anteroposterior diameter of the pelvis for all locations of the ureter. The ratio and upper diameter of the ureter were significantly related to impaction status only in the distal ureter (Table 4).

4. Discussion

Ureterorenoscopy is a widely accepted treatment procedure for all locations of ureteral stones. Although ureteroscopy is a safe and highly effective treatment modality, some parameters, such as stone location, stone size, experience of the surgeon, and stone impaction, are correlated with unfavorable results and complications, such as longer operation time, ureteral perforation, avulsion, and ureteral stricture.[5,6] Why does the stone impaction status affect the intraoperative and postoperative complication rates?

Ureteroscopic management of impacted ureteral stones requires longer operation times than of non-impacted stones. The increased number of manipulations and the longer time spent with a ureteroscope in the ureter can increase the complication rates. Impacted ureteral stones can also cause ureteral perforation and avulsion. Impacted ureteral stones generally cause a tortuous ureter and excessive angulations of the ureter. In addition, inflammatory ureteral polyps related to impaction can cover the stones.[7] During the operation, the guide wire can be submucosally advanced or into the intramural area between the stone and the edematous ureteral wall or inflammatory ureteral polyps. Following the guide wire with a ureteroscope can cause ureteral perforation or avulsion.[6,7] Another increased risk is ureteral stricture, which is a rare complication of ureteroscopic management, the incidence rate of which is reported as <1%–4%.[8] However, this ratio reaches 15%–24% in impacted ureteral stones.[9] Small stone fragments embedded in the ureteral wall can cause ureteral stricture. In addition, ureteral tissue ischemia can occur because impacted stones can cause ureteral stricture. Ureteral stricture can cause detrimental results and can necessitate auxiliary procedures, such as endoscopic management or nephrectomy.[8]

Therefore, stone impaction is an important parameter, and there have been few studies addressing the preoperative predictive factors of stone impaction in the literature.[3,10–12] There are, however, some definitions of stone impaction in the literature.[10,13,14] The common definition of impaction is the inability to pass a guide wire or catheter beyond the stone on the initial attempt. In the present study, we preferred this definition for impaction status. The other definition is that the stone remained in the same location for at least 2 months. Actually, it is difficult to precisely determine the duration of stones in the ureter. Uncertainty of the initial day of impaction could cause suspicious results. Because of this reason, we avoided use of this criterion. Another definition of impaction is failure to visualize the distal site of the ureter according to stone location on intravenous urography or CT urography. In daily practice, we do not routinely use intravenous urography or CT urography to diagnose patients with ureteral stones. We mostly prefer NCCT, so we did not select this criterion. An intraoperative endoscopic view of the ureter at the stone location was also used as a criterion of impaction. An intraoperative endoscopic view of the ureter may be subjective and may vary from surgeon to surgeon, so we did not prefer this one either.

Table 4

The results of the radiologic parameters according to impaction status based on stone location proximal, middle and distal ureter.

	Impaction		
Proximal ureter	**Absent**	**Present**	***p***
Transverse stone length, mm			0.053
Mean ± SD	7.52 ± 2.61	9.36 ± 2.5	
Median (range)	7.3 (3.79–13.1)	9.42 (5.82–17)	
Longest stone length, mm			0.011
Mean ± SD	10.8 ± 3.61	13.4 ± 2.91	
Median (range)	10 (6–21)	13.9 (8–21)	
Upper diameter, mm			0.134
Mean ± SD	10.24 ± 3.24	11.96 ± 3.06	
Median (range)	9.5 (6.5–17)	12.42 (7–16.8)	
Lower diameter, mm			0.901
Mean ± SD	4.09 ± 1.07	4.04 ± 1.24	
Median (range)	4 (1.87–5.95)	4 (2.1–7)	
Upper/lower ratio			0.141
Mean ± SD	2.63 ± 0.93	3.15 ± 0.99	
Median (range)	2.62 (1.3–4.73)	2.94 (1.62–4.81)	
Anteroposterior diameter of the pelvis, mm			0.022
Mean ± SD	20.87 ± 4.62	25.63 ± 6.11	
Median (range)	20.5 (13.7–30.32)	27.4 (12.9–32.1)	
Hounsfield units score			0.367
Mean ± SD	695.8 ± 292.0	776.7 ± 204.2	
Median (range)	654 (271.7–1,449.1)	820.3 (366.1–1,169)	
Middle ureter			
Transverse stone length, mm			0.340
Mean ± SD	7.45 ± 1.97	8.12 ± 2.27	
Median (range)	7.1 (3.76–11)	7.32 (5.2–15.7)	
Longest stone length, mm			0.018
Mean ± SD	9.85 ± 4.19	12.85 ± 3.92	
Median (range)	9.93 (3.6–19.8)	12 (5.5–22)	
Upper diameter, mm			0.058
Mean ± SD	9.9 ± 5.99	11.45 ± 3.62	
Median (range)	8.1 (3.48–29.7)	11.1 (6.12–20.5)	
Lower diameter, mm			0.408
Mean ± SD	4.3 ± 2.32	4.28 ± 1.21	
Median (range)	3.9 (2.36–12.6)	4.34 (2.5–6.78)	
Upper/lower ratio			0.144
Mean ± SD	2.48 ± 1.32	2.84 ± 1.18	
Median (range)	2.17 (1–5.85)	2.44 (1.65–6.57)	
Anteroposterior diameter of the pelvis, mm			0.003
Mean ± SD	20.67 ± 7.3	28.67 ± 9.29	
Median (range)	20.6 (6.5–37)	28.5 (9.7–43.1)	
Hounsfield units score			0.151
Mean ± SD	605.8 ± 210.9	708.3 ± 246.6	
Median (range)	568 (293–927)	680.0 (345.1–1,316.9)	
Distal ureter			
Transverse stone length, mm			0.192
Mean ± SD	6.45 ± 2.06	8.02 ± 2.65	
Median (range)	6.55 (2.5–9.31)	7.59 (4.8–14.7)	
Longest stone length, mm			0.001
Mean ± SD	8.69 ± 2.73	13.32 ± 3.93	
Median (range)	7.56 (5.7–15)	13.6 (6.1–21.9)	
Upper diameter, mm			0.047
Mean ± SD	9.36 ± 6.3	11.35 ± 3.51	
Median (range)	8.45 (3–28.9)	12.05 (6.1–18.7)	
Lower diameter, mm			0.800
Mean ± SD	4.24 ± 0.83	4.15 ± 1.07	
Median (range)	4.29 (2.3–5.5)	4.19 (1.71–6.81)	
Upper/lower ratio			0.011
Mean ± SD	2.26 ± 1.74	2.84 ± 0.96	
Median (range)	1.81 (1.02–7.98)	2.62 (1.7–4.92)	
Anteroposterior diameter of the pelvis, mm			<0.001
Mean ± SD	16.7 ± 7.38	26.81 ± 5.83	
Median (range)	15.05 (7.63–33)	27.1 (13.3–38.8)	
Hounsfield units score			0.847
Mean ± SD	741.6 ± 226.5	725.8 ± 235.1	
Median (range)	677.5 (434–1,167)	689 (337.1–1,306)	

In the present study, we especially focused on predicting the impaction status using demographic and preoperative radiologic parameters. We noticed that impacted stones are more prominently seen in older patients. The upper limit of the normal ureteral diameter is 3 mm on CT.[15] The ureter has dilatation capabilities during cases of obstruction. Pediatric patients are more prone to spontaneously pass ureteral stones, as children have more elastic and expansible ureters than adults.[16] This elasticity decreases with increased age. Therefore, increased age could be a risk factor for stone impaction.

In the present study, we found that patients with higher ASA scores were more often associated with impacted stones. A similar relationship was shown in a previous study.[3] This relationship might be related to ureteral tissue ischemia. Patients with higher ASA scores have comorbid diseases, and vascular and circulatory pathologies are more often seen in these patients. Impairments of vascular and circulatory conditions can include decreases in blood flow and the oxygenation of ureteral tissue. Ureteral tissue at the stone location has been exposed to higher pressure, and thus, the impairment of the vascular supply is more prominently seen in that area. Finally, ureteral edema and fibrosis can depend on inflammatory reactions, and clinical impaction of the stone is seen.[17]

We found a relationship between female gender and stone impaction. A previous study showed a similar relationship; however, this relationship should be further evaluated.[3] There is no information about this relationship in the literature, and we do not suggest this as a causal relationship.

The presence of hydronephrosis has been determined to be a preoperative indicator for impaction.[10,11] Hwang et al.[17] showed that patients with ureteral lesions, such as polyps or strictures related with impacted ureteral stones have more severe hydronephrosis. Importantly, hydronephrosis usually highlights a severe ureteral obstruction, and it has also been shown that the stone-free rate after surgery for ureteral calculi was significantly decreased with increased hydronephrosis.[18] Furthermore, it has been shown that the degree of hydronephrosis is an important predictive parameter for the final results of medical expulsive therapy.[19] As mentioned above, many previously performed studies have indicated that hydronephrosis is an important predictive parameter for impaction. In accordance with the literature, the anteroposterior diameter of the renal pelvis was found to be an important predictive parameter in the present study. Increased anteroposterior diameter of the renal pelvis indicates a high-risk of impaction.

Stone length has been reported as an important predictor factor for stone-free rate in the treatment of ureteral stones.[20] Stone width, with a mean of 8 mm, was predicted to have unfavorable results.[5] A study revealed that the spontaneous passage of ureteral stones was significantly seen for stones 6.1 mm or less in size. However, spontaneous passage has not been generally seen with stones 8.3 mm or larger in size.[21] The rate of spontaneous passage was reported to be >98% for ureteral stones <5 mm, whereas it was almost 39% for stones >7 mm in diameter.[2] Stone impaction can be seen if the stone stayed in the same location for a certain period of time. Thus, larger stones are more likely to adhere of the ureteral wall than smaller stones, which is based on the fact that larger stones are more prone to be impacted. In the present study, we calculated 2 parameters for stone size, transverse and longest diameters, as we think that the geometric shape of a ureteral stone is another important factor in the spontaneous passage period. Long, thin stones can more easily migrate in the ureter than long, thick stones.[2] According to the present study results, increased transverse stone length and longest stone length are strongly correlated with impaction.

We especially assessed the effect of the ratio (upper/lower diameter of the ureter) on impaction. A previous study showed that the diameter of the proximal ureter was found to be associated with stone impaction.[11] According to our knowledge, this ratio has not been previously studied to assess its impaction status. The results of the present study highlighted that an increased ratio and the upper diameter of the ureter are closely related to stone impaction.

We also separately compared these parameters according to impaction status in proximal, middle, and distal locations of the ureter. The ratio and upper diameter of the ureter were significantly related to impaction status only in the distal ureter. This result may be related to performing subgroup analyses with a low number of patients.

Similar to the present study, some current studies have tried to determine the preoperative indicators for ureteral stone impaction. Yoshida et al.[10] revealed that younger age, presence of hydronephrosis, stones in the middle ureter, increased stone burden, and ureteral wall thickness (UWT) were independent predictors of impacted stones. Legemate et al.[3] found that the female gender, ASA score > 1, prior stone treatment, positive preoperative urine culture, and larger stones were predictive variables for stone impaction. Elibol et al.[11] indicated that increased UWT, age, transverse diameter of the stone, ureteral diameter just proximal to the stone, duration of renal colic attack, and renal pelvic diameter were related to impaction. Sarica et al.[12] suggested that increases in the C-reactive protein, erythrocyte sedimentation rate, degree of hydronephrosis, and UWT were closely related to stone impaction.

We measured the diameter of the proximal ureter at the level of the lowest border of the kidney as the upper ureteral diameter and a location 3 cm distal to the stone in the ureter as the lower ureteral diameter. We measured in this manner so that we could apply the same method to all patients for standardization. We determined 3 cm distal to the stone in the ureter. This location should be an unaffected area, because UWT and mucosal edema may reach a few centimeters to the distal site of the ureter. We think that 3 cm length is possible as a safe distance. Some patients were excluded from the study because we could not assess patients whose stones were located between the uretero-pelvic junction and the proximal ureter at the level of the lowest border of the kidney or closer than 3 cm to the bladder. These locations remained out of the study area of the ureter. These conditions were limitations of the present study.

5. Conclusion

The ratio of the upper to the lower diameter of the ureter, transverse stone length, longest stone length, and anteroposterior diameter of the pelvis are closely associated with impaction. Further studies with larger numbers of cases are needed to determine the predictive parameters for impaction.

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None.

Statement of ethics

This study was approved by Ministry of Health, Kaçkar State Hospital Local Ethics Committee, with an approval number

99049742/450. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

Conflict of interest statement

No conflict of interest has been declared by the author.

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Author contributions

Deniz Abat: Concept, design, data collection and/or processing, analysis and/or interpretation, literature search, writing manuscript, critical review;
Ali Börekoglu: Concept, design, supervision, materials, data collection and/or processing, literature search, writing manuscript, critical review;
Adem Altunkol: Concept, design, supervision, materials, analysis and/or interpretation, literature search, writing manuscript, criticla review;
Ilgaz Çagatay Köse: Resources, materials, analysis and/or interpretation;
Mehmet Salih Boga: Supervision, resources, data collection and/or processing, analysis and/or interpretation; critical review.

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