Original Article

Predictive factors of stone-free status in renal stone treatment with flexible ureterorenoscopy

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Keywords:
Flexible ureterorenoscopy, stone-free status, renal stone

Abstract

Objective: Flexible ureterorenoscopy (fURS) is one of the standard treatments for renal calculi up to 20 mm. This study aims to identify factors associated with stone-free status.

Materials and Methods: We included patients undergoing fURS for treatment of small to medium-size renal stone (no single stone larger than 20 mm) from April 2017 to September 2019 at King Chulalongkorn Memorial Hospital. All patients had a preoperative CT scan and postoperative imaging for comparison. We collected patient characteristics (sex, age, previous ipsilateral urinary tract surgery, preoperative ureteral stent placement), stone factors (total stone burden, stone number, stone density) and renal factors (anatomical abnormalities, stone location in a lower pole, number of caliceal involvement) and correlated the data against postoperative stone-free status (defined as residual fragment ≤ 2 mm).

Results: The overall stone-free rate was 53.3%. From the univariate analysis, previous surgery, total stone burden, stone number, stone location in the lower pole, and the number of caliceal involvement were associated with stone-free status. However, only the total stone burden remained statistically significant in the multivariate analysis (p-value < 0.05). The stone-free rates were 75.9%, 57.1%, and 11.1% in the total stone burden ≤ 10 mm, 11-20 mm, > 20 mm, respectively.

Conclusion: Following treatment of renal stones ≤ 20 mm with fURS, the stone-free rate was 53.3% and was significantly associated with the preoperative total stone burden.

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Introduction

Flexible fiber-optic ureterorenoscopy was first introduced in the 1960s for diagnostic purposes but the technique was unable to apply any therapeutic procedure due to a lack of a deflecting system and working channel[1-3]. Later, the development of the deflecting system, working channel, and holmium: YAG laser made it possible to treat renal stones[1,2,4]. However, poor durability of the fiber optics was a major limitation from a wide adoption of this procedure. Subsequent development of flexible digital ureterorenoscopy in the 2010s had a significant impact on renal stone treatment. The digital system improved the stone visualization, scope durability and offered improved ergonomics[1,2].

According to the European Association of Urology (EAU) guidelines on urolithiasis, flexible ureterorenoscopy (fURS) is one of the standard treatments for renal stone up to 20 mm. Depending on stone size and location, fURS is suitable for a non-lower pole < 20 mm, lower pole stone < 10 mm, and lower pole stone 10-20 mm, which is unfavorable for SWL[5]. However, the treatment selection is more complicated in real-life practice. Many patients, especially in Thailand, have a complex stone burden beyond the guideline algorithm. In addition, fURS is invasive and potentially leads to perioperative complications such as urinary tract infection, ureteral injury and ureteral stricture[5,6].

This study primarily aims to identify predictive factors associated with stone-free status for treatment of renal stone up to 20 mm. The secondary purpose is to determine the correlation between the stone-free rate and the predictive factors.

Materials and Methods

Patients

This study was a retrospective cross-sectional study of adult patients undergoing fURS for stone treatment at King Chulalongkorn Memorial Hospital from April 2017 to September 2019. All patients had small to medium-size kidney stones with no single stone larger than 20 mm based on a preoperative CT scan. Exclusion criteria were patients at the extremity of age (< 18 or > 80 years old), presence of any single stone larger than 20 mm, failure to approach into the renal pelvis, and incomplete perioperative imaging. We collected patient characteristics (sex, age, previous ipsilateral urinary tract surgery, preoperative ureteral stent placement), stone factors (total stone burden, stone number, stone density), renal factors (anatomical abnormalities, number of caliceal involvement) and lower pole factors (infundibulum width, infundibulum length, infundibulopelvic angle) if stone was presenting in the lower pole. Stone size was defined as the longest axis of each stone (millimeters), stone density was defined as a mean of three times the measurement of stone density (Hounsfield Unit). For patients with multiple stones, the total stone burden was a sum of all stone sizes, and stone density was a mean density of all stones.

Operation techniques

All procedures were performed under general anesthesia in a lithotomy position by a single surgeon. Fluoroscopic guidance was utilized for instrumental navigation, and a 12/14 French ureteral access sheath (Bi-Flex EVO, Rocamed, Monaco) was applied in all cases. We only used flexible digital ureterorenoscope (URF-V, Olympus Medical System, Tokyo, Japan). Lithotripsy was performed with a 30-watt holmium: YAG laser machine (Sphinx Holmium Laser, LISA Laser Products GmbH, Katlenburg-Lindau, Germany), either with a fragmenting or dusting technique. Active stone retrieval was done with a 1.3 French tip-less nitinol basket (Optiflex, Boston Scientific Marlborough, MA, USA). At the end of the procedure, the ureteral access sheath was removed under vision, and a double-J stent was placed based on surgeon decision.

Follow up

All patients did not receive any medical chemolysis and underwent postoperative imaging (plain KUB, renal ultrasonography, or non-contrast CT scan) two months after the procedures. Stone-free status was defined as no fragment left or residual stone fragment ≤ 2 mm.

Data analysis

Patients were classified into two groups; the stone-free group and the non-stone-free group. Patient characteristics were compared between the two groups. Qualitative data are presented as number (%). Quantitative data are shown as mean (standard deviation) or median (interquartile range). Statistical significance between the two groups was determined. Categorical variables were analyzed using a chi-square test, and continuous variables were analyzed with a two-sample independent t-test and Wilcoxon rank-sum test. Statistical significance was considered at p-value < 0.05. Binary logistic regression was applied for univariate analysis. Factors with a p-value < 0.1 from the univariate analysis were subsequently included in the multivariate analysis. Binomial distribution was applied to calculate the stone-free rate and 95% confidence interval from significant factors. Statistical analysis was carried out using STATA version 15.1 (StataCorp, College Station, TX, United States).

Table 1. Patient's characteristics.

Characteristic	Total (N=75)	Stone free (N=40)	Non-stone free (N=35)	P-value
Patient's baseline				
Sex ----- no. (%)				0.23
Male	31 (41.3)	14 (35)	17 (48.6)	
Female	44 (58.7)	26 (65)	18 (51.4)	
Age ----- mean years (SD)	52.8 (13.5)	51.4 (13.7)	54.5 (13.4)	0.31
Previous urinary tract surgery ----- no. (%)				0.006
Yes	28 (37.3)	9 (22.5)	19 (54.3)	
Endoscopic ureteric procedure	19 (25.3)	9 (22.5)	10 (28.6)	
PCNL	4 (5.3)	0 (0)	4 (11.4)	
Open renal procedure	3 (4)	0 (0)	3 (8.6)	
Endoscopic ureteric procedure and PCNL	1 (1.3)	0 (0)	1 (2.9)	
Open ureteric procedure and PCNL	1 (1.3)	0 (0)	1 (2.9)	
No	47 (62.7)	31 (77.5)	16 (45.7)	
Preoperative ureteral stent placement				0.1
Yes	23 (30.7)	9 (22.5)	14 (40)	
No	52 (69.3)	31 (77.5)	21 (60)	
Stone factor				
Total stone size ----- median mm. (IQR)	12 (8-20)	10 (6-14.5)	19 (12-28)	< 0.001
Stone number ----- median no. (IQR)	2 (1-3)	1 (1-2)	2 (2-3)	< 0.001
Stone density ----- median HU (IQR)	705 (482-954)	668 (447-996)	820 (584-949)	0.28
Anatomical factor				
Anatomical abnormality ----- no. (%)				0.01
Yes	6 (68)	0 (0)	6 (17.1)	
UPJO	1 (1.3)	0 (0)	1 (2.9)	
Bifid renal pelvis	3 (4)	0 (0)	3 (8.6)	
Kidney malrotation	2 (2.7)	0 (0)	2 (5.7)	
No	69 (92)	40 (100)	29 (82.9)	
Stone location in lower pole ----- no. (%)				0.005
Yes	50 (66.7)	21 (52.5)	29 (82.9)	
Lower pole and non-lower pole	23 (30.7)	7 (17.5)	16 (45.7)	
Only lower pole*	27 (36)	14 (35)	13 (37.1)	
No	25 (33.3)	19 (47.5)	6 (17.1)	
Number of caliceal involvement ----- median no. (IQR)	1 (1-2)	1 (1-2)	2 (1-3)	0.001
***Only lower pole stone**	**Total (N = 27)**	**Stone free (N = 14)**	**Non-stone free (N=13)**	**P-value**
Infundibulum width ----- mean mm. (SD)	5.2 (2.7)	5 (2.8)	5.5 (2.6)	0.66
Infundibulum length ----- mean mm. (SD)	25.7 (4.3)	25.4 (3.7)	26.1 (5)	0.7
Infundibulopelvic angle ----- median degrees (IQR)	33 (21.2-55.1)	33.7 (21.3-55.1)	32.9 (16.7-51.2)	0.72

Results

A total of 133 flexible ureterorenoscopy procedures was reviewed during the study period. Nineteen procedures were excluded due to them being in the non-target population. Thirty-nine procedures were excluded due to incomplete clinical or imaging data. Finally, a total of 75 procedures were analyzed and classified into a stone-free group (n = 40, 53.3%) and a non-stone-free group (n = 35, 46.7%) (Figure 1). Females (n = 44) slightly predominated males (n = 31), and the mean age at operation was 52.8 years. The majority of clinical characteristics of both groups were similar, exceptions being previous ipsilateral urinary tract surgery, total stone burden, stone number, anatomical abnormality, presence of stone in the lower pole, and a number of caliceal involvement (Table 1).

Univariate analysis revealed five clinical factors were significantly associated with stone-free status including the absence of previous ipsilateral urinary tract surgery (OR = 4.09, p-value = 0.006), a total stone burden less than 20 mm (OR = 25.14, p-value < 0.001 for stone burden ≤ 10 mm and OR = 10.67, p-value = 0.005 for stone burden 11-20 mm), the presence of a single stone (OR = 6, p-value = 0.001), the absence of stone in the lower pole (OR = 4.37, p-value = 0.007), and the presence of stone in a single calyx (OR = 3.98, p-value < 0.001) (Table 2).

Subsequently, these five factors were included in the multivariate analysis. The only factor sig-

Table 2. Odds ratio of factors in the univariate and multivariate analysis.

Parameter	Total (N=75)	Stone free (N=40)	Non-stone free (N=35)	Univariate analysis			Multivariate analysis		
				Odds ratio	95% CI	P-value	Odds ratio	95% CI	P-value
Previous urinary tract surgery									
No	47	31	16	4.09	1.51-11.08	0.006	correlate with stone number		
Yes	28	9	19		reference				
Preoperative ureteral stent placement									
Yes	23	9	14	0.44	0.16-1.18	0.11		-	
No	52	31	21		reference				
Total stone size									
≤ 10 mm	29	22	7	25.14	4.60-137.4	< 0.001	11.14	1.67-74.1	0.01
11-20 mm	28	16	12	10.67	2.05-55.52	0.005	6.72	1.20-37.76	0.03
> 20 mm	18	2	16		reference			reference	
Stone number									
1	31	24	7	6.00	2.11-17.01	0.001	2.25	0.66-7.60	0.19
≥ 2	44	16	28		reference			reference	
Stone density									
< 500 HU	19	12	7	0.69	0.15-3.04	0.62		-	
500-999 HU	42	18	24	0.30	0.08-1.11	0.07			
≥ 1000 HU	14	10	4		reference				
Anatomical abnormality									
No	69	40	29		n/a				
Yes	6	0	6		reference				
Stone location in lower pole									
No	25	19	6	4.37	1.49-12.82	0.007	2.04	0.61-6.86	0.25
Yes	50	21	29		reference			reference	
Number of caliceal involvement									
1	39	27	12	3.98	1.52-10.41	0.005	correlate with stone number		
≥ 2	36	13	23		reference				

Table 3. Significant factors related to stone-free percentage rates.

Parameter	n/N	Stone free rate (%)	95% CI	P-value
Total stone size				< 0.001
≤ 10 mm	22/29	75.9	56.5-89.7	
11-20 mm	16/28	57.1	37.2-75.5	
> 20 mm	2/18	11.1	1.4-34.7	

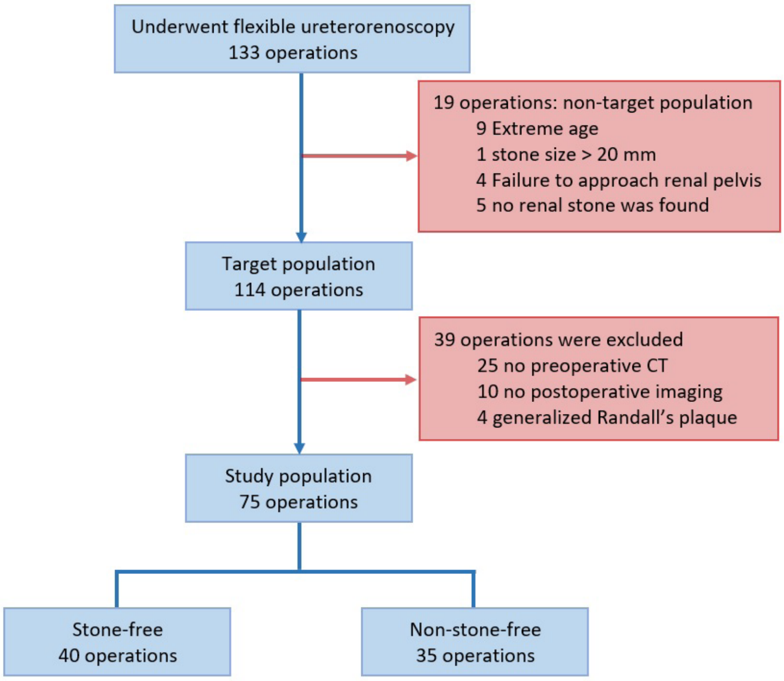

Figure 1. Flow chart

nificantly correlated to stone-free status was the total stone burden less than 20 mm (OR = 11.14, p-value = 0.01 for stone burden ≤ 10 mm and OR = 6.72, p-value 0.03 for stone burden 11-20 mm) (Table 2). The stone-free rates were 75.9%, 57.1%, and 11.1% for the total stone burden ≤ 10 mm, 11-20 mm, and > 20 mm, respectively (Table 3).

Stone-free status was not affected by the learning curve of the physicians. We divided 75 procedures into three groups chronologically: the first case to the twenty-fifth case, the twenty-sixth case to the fiftieth case, and the fifty-first case to the seventy-fifth case. The stone-free rates were 60%, 60% and 40%, respectively.

Discussion

Previous studies have determined several factors to be associated with stone-free status. Some studies have proposed a scoring system predictive for stone-free status. The Resorlu-Unsal Stone Score (RUSS) includes four clinical conditions (stone size > 20 mm, lower pole stone location with infundibulopelvic angle < 45°, stone involvement in more than one calyx, and abnormal renal anatomy)[7]. The modified S-ReSC score included the number of caliceal involvement from 9 sites[8]. The R.I.R.S scoring system consisted of stone density, stone in the lower pole with infundibulopelvic angle < 30°, infundibulum length, and stone burden[9]. One study by Tonyali et al. proposed that the lower pole stone location and the use of a ureteral access sheath were significant factors[10].

We included almost all of these potential factors in our analysis, which finally revealed that the total stone burden of less than 20 mm was the only factor significantly correlated to stone-free status. This finding is consistent with others and is stated in the current guidelines issued by the EAU and AUA/Endourological Society. These guidelines mention that the stone-free rate of fURS declines with increased stone burden, and a staged procedure might be required in cases of stone burden more than 20 mm[5,11].

The main limitation to our study was the relatively small number of included patients. One-third of total patients undergoing fURS during the study period were excluded due to incomplete data. Further limitations were that the study results were derived from a single institution, which makes generalization of the findings difficult and also a variety of imaging modalities was used to assess stone-free status, and an interpretation bias may be unavoidable.

Conclusion

Stone-free rate of fURS for treatment of renal stone < 20 mm was 53.3%. The only predictive factor for stone-free status was the total stone burden, which revealed a stone-free rate of 75.9%, 57.1%, and 11.1% for the total stone burden ≤ 10 mm, 11-20 mm, and > 20 mm, respectively.

Conflict of Interest

The authors declare no conflict of interest.

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