

The impact of the pelvicalyceal anatomy characteristics on the prediction of flexible ureteroscopy outcomes

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Abstract

Background: The anatomical architecture is a prominent factor in the outcomes of flexible ureteroscopy (FURS). **Aims and Objectives:** The aim to regard the success of procedures based on Pelvicalyceal body that called Sampaio classification system.

Materials and Methods: A total of 125 FURS procedures were reviewed between December 2012 and December 2016 in our department. Seven patients were excluded from the study due to the horseshoe kidney in two cases and recurrent cystine stone configuration in five patients. The patient's renal collecting system anatomy characteristics are regarded, and they are classified into four main groups based on the mid-renal-zone anatomy assessed according to Sampaio Classification.

Results: Total stone-free rate (SFR) during the postoperative 1st-month evaluation was noncontrast computerized tomography 75 (63.6%). The evaluation of the SFR in all subgroup of cases based on Sampaio classification noticed easily, SFR was significantly lower in subgroup A2 (30.4%) ($P = 0.00$), significantly higher in subgroup B2 ($P = 0.008$). The comparative analysis of the operative duration defined that it was the shortest (75.3 ± 18.1 min) in Type B1 subgroup cases, and the longest (84.7 ± 25.7 min) in the Type A2 subgroup cases. Even though this duration was found to be relatively higher in Type A2 subgroup cases than the others, this difference was not statistically significant ($P = 0.271$). Fluoroscopy time was noted to be the shortest (11.9 ± 13.4 s) in B1 subgroup and the longest in A2 subgroup with a statistically significant different (median: 21.3 ± 30.4) ($P = 0.04$). While 6 (5.1%) cases had Clavien 2 and 3 (2.5%) cases, demonstrated Clavien 3a complications.

Conclusion: The calyceal structure of the kidney affects the SFR; therefore, a detailed classification of pelvicalyceal could improve the outcomes, decrease the rate of auxiliary procedures and prevent the complications.

Keywords: Flexible ureteroscopy, kidney stones, pelvicalyceal anatomy, Sampaio classification, stone-free

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INTRODUCTION

The management of the urinary stones constitutes approximately 30% of all treatments in urology practice.^[1]

Among the available minimal invasive stone management alternatives; the European Association of Urology (EAU) Guidelines recommend flexible ureteroscopy (FURS) as a preferable and safe therapeutic alternative for stones

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sizing <20 mm with acceptable stone-free rates (SFRs).^[2] Success rates tend to decrease with repeated treatment sessions for large renal stones particularly for the ones located in the lower calyceal position.^[3] However, regarding the optimal management of the renal stones no established and commonly accepted consensus has been reported so far in all guidelines and well-performed relevant studies.^[4,5]

Currently, FURS is rapidly evolving and promising treatment modality due to the relatively safer nature of the procedure with high success rates when compared with shock wave lithotripsy (SWL). The entire collecting system particularly the lower pole portion of the involved kidney could easily be reached with this technique in an attempt to pulverize the stone(s) and remove the relatively large fragments with delicate accessory equipment.^[6] However, despite a successful procedure small fragments left for spontaneous passage could reside in the kidney and cause further problems (mainly pain and obstruction affecting the patients' quality of life) both for the patients as well as the surgeons. These patients may require additional procedures (re-FURS or SWL) to render them stone-free.^[7,8] On the other hand, it has been well stated that success rates of FURS management in renal stones could be influenced by the patient (anatomical characteristics of the kidney collecting system) as well as the stone (location, number, and the size) related factors.^[9,10] Among these factors, the anatomical characteristics of the pelvicalyceal system are paramount importance due to the close relationship between the drainage capabilities of each dependent calyx, its shape as well as the location in the kidney. In other words, endourologists may get an idea about the likelihood of stone-free status by evaluating these factors in detail before the procedure.

In this present study, we aimed to assess the predictive value of Sampaio renal anatomical classification on the success of FURS treatment in terms of SFRs and to identify the ideal patients for FURS modality in the management of renal stones.

MATERIALS AND METHODS

Patients and characteristics

A total of 125 FURS procedures for kidney stones have been performed between December 2012 and December 2016 in our department. Seven patients were excluded from the study protocol due to the horseshoe kidney in two cases and recurrent cystine stone formation in the remaining cases. Preoperatively, in addition to a detailed patient history including demographic features and related factors have been well assessed and recorded.

Patients are divided into four main groups with respect to the mid-renal-zone anatomy assessed according to Sampaio Classification. This classification has been reported based on the detailed anatomical characteristics of the renal collecting system anatomy for endourological interventions in 1988. The classification was made in the light of the calyceal structure characteristics, particularly the existence of the middle calyceal body. Based on this classification, Group A consisted of two subgroups, namely A1 and A2 drainage characteristics of the middle portion of the kidney. Group B again had two subgroups as; B1 consisted of the cases in whom the middle part of the kidney was drained through major calyces independent of the other calyces and B2 consisted of the cases in whom the middle section of the kidney was drained by minor calyces through the renal pelvis.^[11] Stone volume was calculated using the general formula (total stone volume [TSV]: stone width \times Stone length \times stone depth $\times \pi \times 0.167$) on noncontrast computerized tomography (CT) evaluation.^[2] The success rate of the procedure in terms of SFR was assessed by CT during 1-month evaluation postoperatively. The SFR was defined as the absence of any stone fragment or the presence of clinically insignificant residual pieces sizing <4 mm.

Operative method

All procedures were performed under general anesthesia with three different flexible scopes (Karl Storz, Flex X2, Tuttlingen, Germany) by experienced senior surgeons. Following the placement of 0.035-inch polytetrafluoroethylene-coated guidewire (Boston Scientific, Marlborough, Massachusetts, USA), up into the renal collecting system through ureteric, the Ureteral Access sheath (9.5/11.5 Fr, Cook Medical, Bloomington, Indiana, USA) was inserted over the guidewire under C-arm fluoroscopy guidance. Following the completion of stone disintegration, a 4.8/6 Fr Double J (DJ) stent (Coloplast, Humlebæk, Denmark) was placed in all cases for 2–3 weeks' period. The stone fragmentation has been performed by using holmium: yttrium aluminum garnet (Ho: Yag) laser (273 μm fibers, Quanto system 30W Litho, Samarate [VA], Italy).

Statistical methods

SPSS 21 (SPSS, Inc., Chicago, IL, USA) Software was utilized for data analysis.

RESULTS

Overall, 118 cases were included in this study and 75 (62.5%) of them were male and mean TSV was $338.3 \pm 227 \text{ mm}^3$. Access sheath was used in all but

2 cases with a tight ureteral orifice which did not allow sheath placement. A DJ stent has been placed in all cases and both the stent removal as well as necessary auxiliary procedures for the residual fragments were done 3 weeks after the FURS application [Table 1].

As noticed easily, SFR was significantly lower in subgroup A2 (30.4%) ($P = 0.00$) and significantly higher in subgroup B2 ($P = 0.008$) [Table 2]. Although the hospitalization time was the longest in subgroup A1 cases (36.2 ± 31.2 h) and shortest in Sampaio Type A2 subgroup cases (26.4 ± 15.6 h), the overall analysis showed no statistically significant difference between the subgroups evaluated with respect to this parameter ($P = 0.702$). On the other hand, comparative evaluation of the operative duration in all subgroup cases demonstrated that it was the shortest (75.3 ± 18.1 min) in Type B1 subgroup cases, type and the longest (84.7 ± 25.7 min) in the Type A2 subgroup cases. Although this duration was found to be relatively higher in Type A2 subgroup cases than the others, this difference was not statistically significant ($P = 0.271$). Finally, as an important parameter, fluoroscopy time was noted to be the shortest (11.9 ± 13.4 s) in B1 subgroup and the longest in A2 subgroup with a statistically significant difference than other types (median: 21.3 ± 30.4) ($P = 0.046$) [Table 2].

Clavien–Dindo classification system^[12] was used to determine the type of complications and while 6 (5.1%) cases had Clavien 2 (long-term hospitalization and antibiotic

therapy for the treatment of infectious complications) complications and 3 (2.5%) cases demonstrated Clavien 3a (percutaneous nephrostomy tube insertion because of the ureteral injury and loss of the urinary tract intact) complications. Majority of the complications were noted in subgroup A1 cases. There was however, no significant difference between the subgroups on this aspect mainly due to insufficient case volume and limited data for a reliable comparison ($P = 0.253$) [Table 2]. SFR graph did clearly show a close relationship between SFR values in the groups and the number of patients evaluated [Figure 1].

Ethical approval

All procedures performed in studies involving human participants were in accordance with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Additional informed consent was obtained from all individual participants for whom identifying information is included in this article.

DISCUSSION

Currently, as a result of marked technological advancements, the use of small caliber devices with higher image resolution all parts of the renal collecting system could easily be accessed. With this great opportunity again following the localization of the stone(s) in the kidney use of the thin laser fiber, extractors and baskets fine fragmentation (pulverization) and extraction the stone

Table 1. Demographic features of the patients and stone characteristics

Groups	Number	Percentage	Mean±SD	Minimum	Maximum
Patient	118				
Age (years)			43.2±14	14	77
Gender					
Female	43	35,8			
Male	75	62,5			
BMI*			27.8±6	18,7	48,9
Hypertension	24	20			
Diabetes	17	14,2			
Hyperlipidemia	13	10,8			
Previous Open Stone Surgery	29	24,2		1	4
Previous Endo Stone Surgery	71	59,2		1	14
Stone Side (R/L)*	83/81	50.6/49.4			
Preop Double J	39	32,5			
Total Stone volume (mm ³)			338,38±227	15	1682
Stone Density (HU)*			1099.3±363,9	310	1762
Stone Location					
Upper pole	8	6,7			
Middle calyxc	14	11,7			
Lower Pole	42	35			
Pelvis	31	25,8			
Upper and Middle	1	0,8			
Middle and Lower	10	8,3			
Upper and Lower	1	0,8			
Pelvis and Other Calyceal Bodies	7	5,8			
Whole	3	2,5			
Proximal Ureter	1	0,8			

*Body Mass Index, Right/Left and Hounsfield Unit

Table 2: Outcomes based on the Sampaio Classification

	Type A1	Type A2	Type B1	Type B2	Overall	P
Stone-Free Rate (n/%)	32 (65.3%)	7 (30.4%)	21 (70%)	15 (93.8%)	75 (63.6%)	0.00chi
Hospitalization Time (Hour)	36.2±31.2	26.4±15.6	33.6±21.3	30±18.6		0.702
Operative Time (Min)	75.6±24.6	84.7±25.7	75.3±18.1	75.6±22.7		0.271
Fluoroscopy Time (Sec)	12.5±14.7	21.3±30.4	11.9±13.4	9.9±17.3		0.046
Stone Density (HU)	1074.1±380.5	1133.5±389.7	1049±348.4	1000±316.2		0.563
Perioperative Complication						0.253
Clavien 2	5 (10.2%)		1 (3.3%)		6 (5.1%)	
Clavien 3a	2 (4.1%)			1 (6.3%)	3 (2.5%)	

Chi-fe: Chi-Square- fisher exact test

fragments could be performed in a practical and safe manner.^[13] Although FURS has a specific role in the management of renal stones by replacing SWL and percutaneous nephrolithotomy (PNL) to a certain extent, this modality has some limitations being debated at every scientific platform. Related with this issue stone-related factors (TSV, number of stones, stone location, and stone density) could significantly affect the outcome of the procedure by decreasing the SFR, increasing the operative time, fluoroscopy time and that of postoperative hospitalization period.^[14]

Regarding the possible effects of the parameters as mentioned above on the success rates of FURS, in their original study Ilgi *et al.* mentioned that TSV is the most crucial factor for the management of kidney stones with this modality and their findings showed significantly lower SFR values for calculi with a TSV value of $>330 \text{ mm}^3$.^[15] Although the stone density is a critical issue for the success of SWL; but with the intracorporeal use of Ho-YAG laser, this parameter is no more a major concern for FURS procedure where all types of stones could easily be disintegrated with highly developed laser technology.^[16] However, accumulated experience so far has clearly demonstrated that stone location and anatomical characteristics of the pelvicalyceal system may form specific problems for stone surgery with FURS.^[17] Related with this critical issue, Marroig *et al.* evaluated the influence of the lower pole anatomy and mid-renal-zone classification on the successful access to these calyces during the FURS. They experienced relative difficulty in accessing to the calyces of the lower pole in cases with type A2 Sampaio classification when compared to others.^[18-20] By announcing a complicated classification system Takazawa *et al.* classified the kidneys based on just CT urography findings in patients under follow-up for hematuria or ureteral tumor. They demonstrated only the anatomical data obtained but provided no data regarding the clinical and surgical outcomes. In our study, based on Sampaio classification, we focused on the possible influence of the anatomical characteristics of the collecting system on the surgical outcomes of flexible ureteroscopic

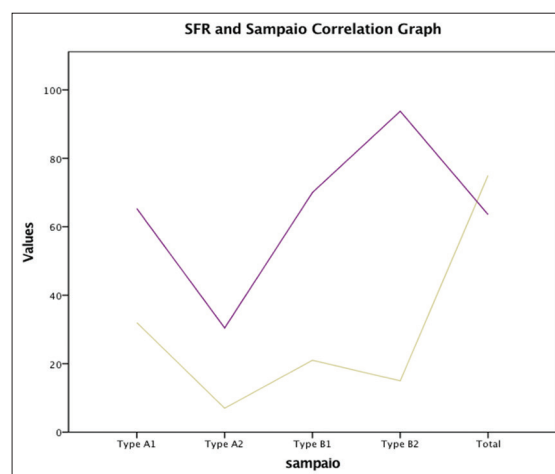


Figure 1: Stone-free rate graphs show the stone-free rate and patients volume

renal stone disintegration. As the main advantage of our current study, we were able to provide parameters that will be predictive for the final outcome of this procedure in advance.^[21] These observations indicate the importance of the anatomical characteristics of the renal collecting system, which may closely affect the outcomes of stone treatment with this approach. Unfavorable anatomical characteristics of the lower pole with narrow infundibulopelvic angle along with high stone density and obesity could be major concerns for this treatment alternative.^[22] PNL, is very successful for the removal of relatively larger ($>20 \text{ mm}$) renal calculi^[23] with higher SFR in a single session; however, it is the most invasive method and severe complication such as bleeding, perforation as well as infections are the major drawbacks of this approach.^[3,5]

In the light of all the parameters discussed above, it is clear that detailed radiological imaging of pelvicalyceal structure is highly critical for the surgeon to have an idea about the possible renal anatomy related consequences of the procedure applied mainly for the FURS application. EAU guidelines recommend contrast-enhanced imaging to identify the entire renal collecting system before and stone removal procedure.^[2] Enhanced images such as CT

urography and intravenous pyelography (IVP) will enable the endourologist to realize the characteristics of both the renal collecting system and the stone related parameters.^[24] In their original study, Rachid Filho *et al.* noted that IVU could be as reliable as three-dimensional-helical computed tomography in the investigation of the lower pole anatomy without the remarkable difference in the measurement of anatomical parameters between two imaging modalities.^[25]

It is well-known that currently no standardized protocol. Regarding this critical issue, different studies aimed to predict the SFRs and perioperative parameters in advance during stone management procedures. Okhunov *et al.* presented S. T. O. N. E nephrolithometry method and they found that standardized metrics from preoperative CT could help to make a great surgery plan, predict the outcomes and also make an effective patient counseling in PNL cases.^[26] Another researcher mentioned that the S. T. O. N. E score could be utilized for the prediction of final results of ureteroscopy.^[27] However, evaluation of all data reported in the literature on this aspect reveals no well-described study on the predictive modeling for the FURS outcomes. For the first time in literature, we aimed to use Sampaio classification in an attempt to predict the success rates after FURS and identify the appropriate cases for a successful outcome with lower complication rates.

The evaluation of our findings on this aspect clearly showed that while the SFR's were significantly higher in broad pelvis group such as B1 and B2 (or more higher), these values were found to be lower in crossing calyceal structure, called Type A. Additionally, we were able to show that safe, effective, and practical fragmentation of renal stone(s) could be anticipated in Sampaio Type B kidney group compared to the type A ones. Our results are also compatible with the literature based data focusing on the possible impact of calyceal structure on the outcomes of the stone removal procedures.

In the light of our current findings and published data in the literature as well, we may say that a detailed evaluation and grouping of the involved renal collecting system structure according to Sampaio classification may enable endourologists to get an idea about the special anatomical characteristics of the renal collecting system to predict the likelihood of stone passage and stone-free status after FURS. By this way, we believe that appropriate cases could be identified for this modality to achieve a high SFR associated with minimal or no complications. This approach will again on one side shorten the procedure time and on the other side will enable the endourologist to avoid unnecessary procedures, which in turn may necessitate

additional procedures under anesthesia and increased radiation exposure risk, which will undoubtedly affect the life quality in such cases.

Our study has some certain limitations. First of all, the retrospective design of our trial is a major concern. In addition, the number of cases in each Sampaio subgroup is relatively small making the statistical evaluation somehow tricky. However, taking the highly limited data reported in the literature so far on this aspect as well as the ongoing debate about the optimal scoring system to make these critical predictions prior to FURS. We believe that our preliminary findings indicate well the superiority of this approach to create a reliable prediction on the SFR and the outcomes prior to the procedure. Our study is also the first one to propose a predictive model regarding the impact of the renal anatomy on the probability of stone clearance as well as the final success rates after FURS. However, we believe that further multicenter, prospective studies with a higher volume of cases are certainly needed to support our findings and establish a reliable, standard model to predict the outcomes of commonly performed FURS procedure.

CONCLUSION

The calyceal architecture of the kidney is a critical parameter for both the operative course of endourological stone management method and also final outcomes of such approaches. A detailed evaluation and classification of pelvicalyceal system anatomy preferably by Sampaio method before retrograde intrarenal surgery procedure can provide an orientation of the renal collecting system, enable to predict the outcomes of the operation and perform the procedure in a safe manner with limited or no complications.

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Conflicts of interest

There are no conflicts of interest.

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