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RESEARCH

Comparison of dusting and fragmentation methods in the flexible ureteroscopic treatment of kidney lower calyx stones

Ümit Yildirim[1] · Mehmet Ezer[1] · Mehmet Uslu[1] · Rasim Güzel[2] · Kemal Sarica[3]

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Abstract

To compare the long-term stone-free status of patients who underwent fragmentation of stones followed by active basketing versus stone dusting and spontaneous passage following flexible ureteroscopic treatment for lower calyceal stones. The dusting or fragmentation methods were randomly assigned to patients who were scheduled to undergo RIRS for only renal lower calyceal stones between February 2019 and May 2022, prospectively. Stone-free rates were determined after 3 months by non-contrast computed tomography and patient demography; preoperative and postoperative follow-up data of both groups were evaluated comparatively. While the fragmentation method was applied in 32 patients, the dusting method was applied in the remaining 31 cases. The two groups did not differ significantly regarding the demographic data and laboratory findings. Mean stone size was similar in both groups of cases. Operation time was significantly longer for fragmentation (93.23 ± 27.20 vs 78.43 ± 30.08, $p = 0.045$) and evaluation of the success rates after 3 months did show that patients in the dusting group had a higher rate of stone-free status when compared with the other group of cases (65.6 vs 87.1%, $p = 0.043$). Lastly, post-operative fever rates were not significantly different between the two groups (12.5 vs 9.7%, $p = 0.518$). Our findings showed that dusting the lower calyceal stones during fURS would reveal higher stone-free rates during long-term follow-up periods, and the mean operation time will be shorter in these patients.

Keywords Lower calyx · Flexible ureteroscopy · Dusting · Fragmentation

Introduction

The optimal management of lower calyceal kidney stones is one of the most contentious issues in contemporary urologic practice, with no established guidelines [1]. Although the majority of the cases have a silent, uneventful clinical course, disintegration and/or removal might be necessary in cases demonstrating an increase in stone size, associated de novo pain, infection, and obstruction [2]. Due to the anatomical characteristics of the lower pole, spontaneous passage of the stones and fragments is significantly lower [3].

Regarding the management of symptomatic lower pole stone(s), due to its non-invasive nature, extracorporeal shock wave lithotripsy (ESWL) has been commonly offered by the guidelines as the first choice for small and moderate-sized stones. However, the disadvantages of this approach are the need for multiple sessions and relatively lower success rates, with stone-free rates ranging from 24 to 84%. [4, 5]. As another valuable option, percutaneous nephrolithotomy (PCNL) provides significantly higher stone-free rates in a single session, and success rates are less affected by stone size. However, PCNL is more invasive than the other options, and severe complications such as bleeding and infectious problems could be noted in a certain percentage of the cases [6]. Last but not least, with the introduction of the holmium-YAG laser and evident developments in fiber-optic technology, retrograde intrarenal surgery (RIRS) has become another valuable option with its less invasive nature and comparable outcomes [7]. In the European Urology

Work was conducted in Kafkas University School of Medicine, Training and Research Hospital.

✉ Ümit Yildirim
dr.umityildirim87@gmail.com

1 Medical School, Department of Urology, Kafkas University, Şehitler mah, 36100 Merkez/Kars, Turkey

2 Department of Urology, Medistate Kavacık Hospital, Istanbul, Turkey

3 Medical School, Department of Urology, Biruni University, Istanbul, Turkey

Association (EAU) Urolithiasis Guidelines, ESWL and RIRS are recommended for the first-line treatment of kidney stones smaller than 2 cm, while PCNL is in the first place for stones > 2 cm [4].

Based on the use of different energy and frequency combinations, it is possible either to fragment or dust the stones located in any part of the collecting system. High frequency and low energy (0,2–0,5 J; 15–40 Hz) cause the stone to break into point-sized pieces called 'dusting.' In the majority of instances, dust that forms under these conditions is left in place to discharge on its own without any additional measures being taken. In contrast, the use of high energy and low frequency (1–1,2 J; 6–10 Hz) will disintegrate the stone into larger fragments, a process known as 'fragmentation,' and the larger fragments are removed using baskets or graspers during the procedure to rid the patient of the stone [8]. Although both methods are being applied in clinical practice based on the experience of the endourologist, data regarding the long-term success rates in terms of "stone-free status" is limited in the literature.

In this present study, we aimed to compare the efficacy and complications of two different stone disintegration methods (dusting and fragmentation) on the long-term stone-free rates for lower calyceal stones.

Patients and methods

Patients who were scheduled to undergo RIRS for only renal lower calyceal stones between February 2019 and May 2022 were randomly allocated to either the dusting or fragmentation method in consecutive order. Patients treated with RIRS for lower pole stones < 2 cm were included in the study; however, patients with a ureteral stent placed prior to the intervention, renal functional deterioration, ureteral stenosis, solitary kidney, ectopic kidney, and other anatomical anomalies were excluded, as were patients with ureteral trauma during surgery. There were 63 cases included in the study that met all inclusion and exclusion criteria. Data were collected prospectively and analyzed retrospectively. Our study was approved by our institute's ethics committee, and all ethical rules outlined in the Declaration of Helsinki were followed. All patients provided a written, informed consent form.

KUB and non-contrast computerized tomography (NCCT) was performed in all cases to evaluate the stone and renal anatomy-related factors, particularly the characteristics of lower calyx during the pre-treatment radiological evaluation procedures, and urinary sonography, as well as excretory pyelography, were performed in cases when necessary. Stone size was assessed as the longest diameter identified in the KUB for opaque stones and the NCCT for lucent stones.

In addition to biochemical tests focusing mainly on renal functional status, urinalysis along with urine culture sensitivity tests were performed in all cases. Patients with negative urine culture tests were included, and the ones with documented urinary tract infections were treated with an appropriate antibiotic prior to the procedure. All patients were given prophylactic antibiotics during the procedure (single dose of 2nd generation cephalosporin). Based on the opacity characteristics of the stones, USG, KUB, and NCCT were performed to determine stone-free status 3 months after treatment. The absence of any residual fragments or the presence of small stone fragments (< 3 mm) was considered a successful outcome.

Two skilled endourologists with more than 10 years of experience doing retrograde intrarenal surgery and training from the same authority carried out every procedure. All procedures were performed in the lithotomy position under general anesthesia. A 0.038 Fr guide wire was inserted into the renal pelvis with a 9.5 Fr semi-rigid ureteroscope under fluoroscopic guidance. The pelvicalyceal system was evaluated by retrograde pyelography. A ureteral access sheath (UAS) (9.5/11.5 Fr, Cook Medical, Bloomington, IN) was placed under fluoroscopy. The collecting system was entered with a 7.5 Fr fiberoptic flexible ureteroscope (Storz FLEX-X2). Fragmentation of stones was performed with a holmium laser using a 273 μ fiber (Litho 30 W Holmium laser, Quanta System, Samarate, Italy). All stones in the lower pole were treated in situ, and none of the stones was displaced into another position. In cases undergoing the dusting method, stones were disintegrated into dust size, and no fragment was not extracted. However, in patients undergoing the fragmentation method, stone particles larger than 3 mm were extracted by using a nitinol basket (ZeroTip™; Cook Urological Inc.).

Based on the holmium-YAG laser settings and type of disintegration performed during the procedure, the patients were divided into two groups: Patients in whom the stones were fragmented (Group F) and those in whom the stones were dusted (Group D). During the lithotripsy of the patients in Group D, the laser was set at 0.5 J—20 Hz, however, for Group F, this setting was employed at 1.2 J—8 Hz, and the settings were not modified intraoperatively. The two groups were compared in terms of preoperative and postoperative data.

Statistical analysis:

SPSS 22.0 was utilized for the statistical analysis (SPSS Inc., Chicago, IL, USA). Means and standard deviations were displayed for the continuous variables. Non-normally distributed data were represented as median-IQR. Both the T-test and the Mann–Whitney U-test were used to make comparisons between these variables. The numerical or percentage representations of the categorical variables were used. These variables were compared using the Chi-square test and the Fisher's exact test.

Results

A total of 63 patients with lower pole stones were included in our study program. There were 32 patients in Group F and 31 patients in Group D. Mean age (44.59 ± 12.28 vs 50.29 ± 15.98, $p = 0.117$), and gender distribution was similar between the two groups. Regarding the preoperative patient characteristics, the incidence of diabetes mellitus (9.4 vs 22.6%, $p = 0.138$), anticoagulant use (9.4% vs 22.6%, $p = 0.138$) along with mean Charlson Comorbidity Indexes [median-IQR, 1(0–2) vs 1(0–2), $p = 0.355$] and ASA scores were similar between the two groups without any significant difference. Likewise, both groups did not show any statistically significant difference with respect to the stone-related factors, namely size (12.47 ± 5.60 vs 11.03 ± 3.82, $p = 0.240$), number, lateralization, and opacity of kidney stones. Additionally, presence of hydronephrosis (25.0% vs 29.0%, $p = 0.469$), mean infundibulopelvic angle (45.47 ± 13.08 vs 48.26 ± 15.24, $p = 0.438$), mean parenchymal thickness (28.47 ± 10.93 vs 26.00 ± 12.03, $p = 0.401$) values did not differ significantly between the two groups. However, our findings demonstrated that operational duration was significantly longer in Group F when compared to Group D (93,23 ± 27,20 vs 78,43 ± 30,08, $p = 0,045$). There was no significant difference between the two groups regarding pre- and postoperative hemoglobin and creatinine levels. Demographic and laboratory findings of the two groups are given in Table 1.

Evaluation of the postoperative period parameters showed that in addition to the hospitalization time (2,38 ± 1,21 vs 2,16 ± 0,73, $p = 0,402$), the presence of treatment requiring

Table 1 Clinical characterization and laboratory findings of patients.

Groups	Group F (*n* = 32)		Group D (*n* = 31)		*p*
Gender					
Male	21	65.6%	23	74.2%	0.321
Female	11	34.4%	8	25.8%	
Age	44.59	± 12.28	50.29	± 15.98	0.117
ASA					
ASA 1	11	34.4%	8	25.8%	0.462
ASA 2	17	53.1%	21	67.7%	
ASA 3	4	12.5%	2	6.5%	
ASA 4	0	0.0%	0	0.0%	
Diabetes	3	9.4%	7	22.6%	0.138
Charlson Index [median- (IQR)]	1	(0.0–2.0)	1	(0.0–2.0)	0.355
Stone Lateralization					
Right	17	53.1%	12	38.7%	0.186
Left	15	46.9%	19	61.3%	
Stone Size	12,03	± 4.69	11.03	± 3.82	0.358
Opacity					
Opac	18	56.3%	16	51.6%	0.454
Non-opac	14	43.8%	15	48.4%	
Number of Stones					
Single	15	46.9%	16	51.6%	0.451
Multiple	17	53.1%	15	48.4%	
Operative Time (min)	93.23	± 27.20	78.43	± 30.08	0.045
Hydronephrosis	8	25.0%	9	29.0%	0.469
Infundibulopelvic angle (º)	45.47	± 13.08	48.26	± 15.24	0.438
Parenchyma Thickness	28.47	± 10.93	26.00	± 12.03	0.401
Preop. Hg (g/dL)	14.33	± 2.12	14.18	± 1.91	0.773
Preop Cr (mg/dL)	0.99	± 0.36	1.03	± 0.60	0.792
Anticoagulant Use	3	9.4%	7	22.6%	0.138
Alpha-blocker Use	1	3.1%	3	9.7%	0.294

ASA American Society of Anesthesiologists, *Hg* hemoglobin, *Cr* creatinine, *Postop* postoperative, *Preop* preoperative fever (12,5 vs 9,7%, $p = 0{,}518$), and admission to the emergency department (15,6 vs 9,7%, $p = 0{,}372$) did not differ significantly between the two groups. Lastly, but more importantly, a comparative evaluation of success rates in terms of stone-free status between the two groups at the postoperative 3-month evaluation period clearly demonstrated that higher stone-free rates were found in Group D cases (65.6 vs 87.1%, $p = 0.043$). Patients undergoing the dusting method for lower pole stones were found to have stone-free status in the majority of the cases when compared to the stones fragmented and left for spontaneous passage during the procedure. Postoperative data of the two groups are given in Table 2.

Discussion

Obtaining the highest stone-free rate (SFR) with the least invasive treatment (if possible, in a single session) has become the most essential objective for all stone removal procedures. In addition to the available infrastructure and the surgeon's level of experience, stone (size, location, hardness, and number) and patient (collecting system anatomy) related factors play a role in achieving the desired success rates [9]. Associated with the anatomical location and configuration of the kidney's lower calyces, the likelihood of spontaneous passage is lower for stones located in this position, and which surgical technique will produce more successful outcomes has been a matter of particular interest [3].

There are studies that compare spontaneous passage rates after dusting or fragmentation/basket retrieval techniques used in the disintegration of kidney stones during RIRS [8]. We aimed to make this comparison following the removal of lower calyx stones. In a prospective multicenter study, fragmentation and dusting methods were compared in terms of SFR, and the fragmentation method was found to be more advantageous than the dusting of the stones (58.2 vs 74.3%, $p = 0.04$). In contrast, SFR was defined in this study as the absence of a single fragment in the collecting system during postoperative evaluation. In addition, data were provided for kidney stones in all kidney parts for which calyx-related subgroup analysis was not performed. In contrast to this study, our findings demonstrated that Group F had a lower mean SFR compared to Group D. As in our study, when residual fragments < 3 mm in size were included in the success criteria, the SFR after using the fragmentation technique was higher (89% vs 86.8%) in another study [10]. The study's results also accounted for stones in all calyceal positions. Contrary to the findings of this study, we observed a higher SFR in Group D (65,6 vs 87,1%, $p = 0{,}043$). Regarding the removal of residual fragments with auxiliary instruments such as the nitinol basket; the use of these instruments could seriously restrict the tip flexion and deflection movements of the flexible scopes, which in turn makes it difficult to direct the ureteroscope to the lower calyx [11]. In our study, this disadvantage induced by the use of baskets/graspers can be interpreted as the possible reason for the lower SFR noted in Group F. Recently, laser devices allowing almost unlimited power and frequency combinations have been introduced into clinical use. In these high-power devices (100–120 W), when settings called pop-dusting are used (0.5 J-80 Hz), an SFR as high as 93% was achieved after RIRS (mean operative time: 56,6 min ± 19,4) [12].

On the other hand, in studies comparing the results of dusting and fragmentation techniques for stones in all calyces, the application of the fragmentation method revealed a longer operation time [8, 13]. Although only lower calyceal stones were included in our study, the mean operational duration was longer in cases undergoing the fragmentation method, consistent with the data reported in this study (93,23 ± 27,20 vs 78,43 ± 30,08, $p = 0{,}045$). As mentioned above, the need for a basket catheter in the removal of stone fragments after disintegration did cause the prolongation of operation time and also an increase in the cost of the procedure [14]. As demonstrated in many studies, placement of an access sheath in the ureter prior to the RIRS reduces the pressure in the collecting system and also reduces the risk of potential damage to the ureter during repeated entries to the involved ureter. Additionally, UAS placed in the ureter will also improve the quality of visualization with continuous irrigation under lower pressure levels [15]. In our present study also, we preferred to use UAS in all patients no severe complications such as ureteral avulsion or rupture were noted in any case. While the fragmentation technique requires repetitive passages into the ureter to remove all large fragments after disintegration, a single passage will be sufficient in the majority of the cases during the application of the dusting method. For this reason, studies indicate that the dusting method is applicable in cases where the UAS cannot be advanced into the ureter [13]. There was no significant difference between the two groups in terms of hospital stay, postoperative fever, and admission to the

Table 2 Postoperative follow-up data

	Group F ($n = 32$)		Group D ($n = 31$)		p
Postop. hg	14.08	1 ± 0.92	14.15	± 1.86	0.892
Postop. cr	0.91	± 0.26	0.98	± 0.34	0.395
3rd month SFR	21	65.6%	27	87.1%	0.043
Hospitalization (days)	2.38	± 1.21	2.16	± 0.73	0.402
Postop. Fever	4	12.5%	3	9.7%	0.518
Emergency service admission	5	15.6%	3	9.7%	0.372

Hg hemoglobin, *Cr* creatinine, *Postop* postoperative, *Preop* preoperative, *SFR* stone-free rate emergency department after discharge in our study. Based on the fact that residual fragments > 4 mm have a higher risk of re-growth, the aim of laser lithotripsy should be to disintegrate stones to a greater extent with great care and reduce the fragment size as much as possible [16].

Our present investigation has some limitations. First, the small number of included patients could be considered a limitation. In addition, although our study was prospectively designed, it was not double-blind and lacked a control group. Taking into account the limited information that has been published to date, we believe that our findings may be informative enough in this regard.

Conclusions

Endourologists face a unique challenge when it comes to the management of lower pole stones during fURS and the technique used for stone disintegration (dusting and fragmentation). Our findings indicated that when treating medium-sized calculi (10–20 mm) with fURS, higher stone-free rates and a shorter operative time could be achieved with the in situ dusting technique for lower calyceal stones. In the case of fragmentation, it does not appear that the long-term stone-free rates are greater in favor of this method. This is in addition to the extended operative time and risk of ureteral injury from repeated accesses (by keeping the UAS in situ for a longer period of time).

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Data availability The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Declarations

Conflicts of interest Authors have no conflicts of interest. The authors have nothing to disclose.

Ethical approval IRB approved our study (80576354–050-99/113). All ethical rules in the Declaration of Helsinki were complied with.

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