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ARTICLE

Bilateral same session flexible ureterorenoscopy for endoscopic management of bilateral renal calculi is noninferior to unilateral flexible ureterorenoscopy for management of multiple unilateral renal calculi: outcomes of a prospective comparative study

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ABSTRACT

Purpose: The aim of the study was to prospectively evaluate safety and efficacy of bilateral same session ureterorenoscopy (BSS-FURS) for management of bilateral renal calculi.

Methods: A prospective comparative study was designed to compare the results of BSS-FURS with unilateral flexible ureterorenoscopy (U-FURS) for management of renal calculi between June 2003 and May 2016. A sample size of 55 patients in each arm was calculated considering a 20% increase in the incidence of complications with BSS-FURS over 15% complication rate in U-FURS (alpha = 0.05; Beta = 0.90). Patient demographics, stone burden, total operative time, postoperative creatinine level, duration of hospital stay, perioperative complications and stone free rate (SFR) were compared in both the groups. The literature pertaining to BSS-FURS was reviewed.

Results: Although the study group patients had higher overall stone burden (18.60 ± 7.70 mm vs. 13.32 ± 6.43 mm) and significantly longer operative time (48.30 ± 16.71 min vs. 32.95 ± 13.05 min; $p < 0.05$) as compared to the control group, the length of hospital stay, SFR (67.85% vs. 78.5%; $p = 0.436$) and perioperative complications were comparable in both the groups. Most patients who developed postoperative fever from both groups had struvite stones.

Conclusion: BSS-FURS is a safe and efficient procedure for the management of bilateral renal calculi in the hands of an experienced endourologist. It has comparable SFR and morbidity compared to U-FURS. Caution should be exercised in patients with struvite stones, as they are more likely to develop postoperative fever.

Abbreviations: BSS: bilateral same session; FURS: flexible ureterorenoscopy; MCCS: modified Clavien complication system; SFR: stone free rate; U-FURS: unilateral flexible ureterorenoscopy

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Bilateral renal calculi; flexible ureterorenoscopy; complications; retrograde intrarenal surgery; Holmium laser lithotripsy

Introduction

The rising prevalence and incidence of renal stones globally is continuously increasing the overall cost burden to the health care system [1]. Around 15% of the patients with renal calculi will have bilateral and multiple stones [2]. Flexible ureterorenoscopy (FURS) is a currently preferred treatment option for renal stones ≤ 2 cm [3]. It is also the technique of choice in patients with coagulopathy, obesity, renal anomalies and solitary kidney [4]. Bilateral same session(BSS) FURS has a potential of treating patients with bilateral renal stones in the same sitting thereby avoiding unnecessary hospital visit and saving undue health care expenses. Inspite of these perceived advantages, the clinical research office of The Endourological Society study on multiple urolithiasis involving 11,885 patients from 32 countries revealed that only 273 patients had BSS ureteroscopy. Surprisingly, none of the patients in this large prospective study underwent BSS ureteroscopy for bilateral renal stones [5]. These real-world data clearly show that many patients with bilateral renal stones are usually not offered BSS-FURS.

In 1994, Camilleri et al. were the first to report a case series of 15 BSS ureteroscopy in 13 patients over 4 years [6]. From their experience, authors recommended a staged approach in patients needing therapeutic ureteroscopy for bilateral upper tract pathologies due to concerns for higher postoperative fever, hematuria and ureteral injury in the bilateral arm. However, over past two decades miniaturizing of flexible ureteroscopes, improved vision, ergonomics and use of holmium laser for lithotripsy has led to better results [3,7–10]. Most of the studies published in this space have included ureteral stones [8–14]. Of the five studies published on the outcome of BSS-FURS for the treatment of bilateral renal calculi, only two compared the outcome with unilateral ureteroscopy and all except one are retrospective in nature [15–19]. The systematic reviews published recently highlighted the lack of high-quality evidence on BSS-FURS in the management of urolithiasis [20–23].

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We aim to prospectively compare the outcome of BSS-FURS for management of bilateral renal calculi with unilateral flexible ureteroscopy for management of multiple unilateral renal calculi (U-FURS). To the best of our knowledge, this study is the largest prospective study evaluating the safety and efficacy of BSS-FURS as compared with U-FURS.

Materials and methods

All patients who opted to undergo BSS-FURS for management of bilateral renal calculi by a single surgeon (SHN) at R.G. Stone Urological and Laparoscopy Hospital, S. L. Raheja (Fortis associate) Hospital and Criticare Superspeciality hospital, Mumbai, India from June 2003 to May 2016 were prospectively enrolled in the study. Patients with stone size $>$ 20 mm, associated ureteric stones, those with residual renal calculi after prior shock wave lithotripsy or percutaneous renal surgery and those undergoing simultaneous procedure for associated ureteropelvic junction obstruction or calyceal diverticulum were excluded from the study. Patient with suspected struvite stones and history of recurrent UTI were not offered BSS-FURS. Since patients from both groups had different stone characteristics (unilateral vs. bilateral renal calculi), we could not randomize these patients in our study. To reduce selection bias, patient who underwent U-FURS for the treatment of multiple unilateral renal calculi at our institution after every patient enrolled in study group was invited to serve as our controls. Such pseudo-randomization has been described in the past to reduce bias in studies comparing two surgical techniques [24]. Patients with bilateral nephrolithiasis undergoing planned staged procedure were not included in control group. This study was exempt from our institutional review board approval and was conducted in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. Informed consent was obtained from the patients for the same. Patients with bilateral stones planned for BSS-FURS were counseled that the second kidney will be operated in the same session only if the procedure on the first side was uneventful and was completed in a reasonable time. During study design in 2003, the incidence of complication reported following unilateral ureteroscopy ranged from 11% to 16.8% [25,26]. Hence, we hypothesized that overall incidence of complication after U-FURS with stent placement is 15% and BSS-FURS is noninferior to U-FURS. A 20% increase in the incidence of complications associated with BSS-FURS over U-FURS (15% for U-FURS to 18% for BSS-FURS) might be considered acceptable as a tradeoff for avoiding another procedure. Considering pseudo-randomization in our study, a sample size of 55 individuals per treatment arm was calculated (alpha $=$ 0.05; beta $=$ 0.90).

Preoperative evaluation included patient's demographics, presenting symptoms, history of nephrolithiasis and other medical co-morbidities including use of antiplatelet or anticoagulant medications. Laboratory investigations included estimation of serum creatinine and urine examination with culture. Patients with urinary tract infection were given culture specific antibiotics before surgery. Those with negative urine culture had a single dose preoperative antibiotic prophylaxis with Inj. Ceftriaxone 1 g intravenously $\sim$1 h before surgery. Patients with history of penicillin allergy received single dose of Inj. Levofloxacin 500 mg intravenously. A preoperative intravenous pyelography or computerized tomography scan was done to assess the total stone burden (measured by cumulative maximum diameter of renal stones) and renal collecting system anatomy. All procedures were performed by a single endourology trained and experienced urologist (SHN) under general anesthesia in lithotomy position. Although ureteroscopy is an outpatient surgical procedure done on ambulatory basis in many countries, our patients had their procedure done as inpatient as per hospital policy and as requirement from insurance companies. For patients in the study group, the first side to be treated was the one which was symptomatic or with more obstruction or the side with lower stone burden in that sequence of priority. Ureteric orifices were actively dilated under direct vision using Storz® 6/7.5 Fr semirigid ureteroscope. The introducer of access sheath was used to dilate ureter if resistance was encountered during introduction of semirigid ureteroscope. A 9.5/11 Fr ureteral access sheath (Cook Biomedical, Bloomington, IN, USA) was preferred in all patients and was passed over the working guide wire up to upper ureter. Patients in whom ureteral access sheath could not be introduced had two guide wires placed with the help of double lumen ureteral catheter. Thereafter, the flexible ureteroscope was passed over one guide wire under fluoroscopy guidance. Patients who had significant resistance during insertion of 9.5/11 Fr. ureteral access sheath or 6/7.5 Fr. semi-rigid ureteroscope or 8 Fr flexible ureteroscope over guide wire were considered to have 'narrow caliber ureter'. The ureteroscopy was abandoned in these patients and they were stented to allow passive dilatation of ureter. These patients were subjected to repeat ureteroscopy after 2 weeks and the outcome of the second procedure was included in the analysis.

We used Flex X-2 fiber-optic flexible ureteroscopes (Karl Storz, Tuttlingen, Germany) in all cases. Stones were dusted and/or fragmented using 100 W Holmium laser machine (Versa Pulse Power Suite; Coherent Medical Group, Santa Clara, CA, USA) with 200-μm laser fiber. Active stone fragments were retrieved with nitinol N-circle or N-gage basket (Cook Biomedical). A 6 Fr ureteral stent was placed in all patients postoperatively. The selection of ureteral stent length was based on patients' height and the stents were placed indwelling for 3–4 weeks. The stone fragments were sent for chemical analysis.

All patients had postoperative foley catheter and were observed in hospital overnight. Patients had complete hemogram and creatinine repeated on the first postoperative day. If they remained afebrile and had clear urine, they were discharged after a voiding trial. They were given diclofenac sodium or acetaminophen for postoperative pain management. No patients were prescribed opioids. All patients from both groups had follow up with X-ray KUB and renal ultrasound with DJ Stent *in situ* after 3–4 weeks to confirm stone free rate (SFR). SFR was defined as absence of stone

fragments or stone fragments <4 mm in size on both ultrasound as well as X-ray KUB. Patients who demonstrated elevated serum creatinine on first postoperative day (above normal range) were asked to repeat serum creatinine at 3 weeks postoperatively before they came for follow-up visit to remove their stent, to confirm return of levels to baseline, which would suggest relief of ureteral obstruction/renal damage. Hence, all postoperative creatinine estimations were done while patient had indwelling ureteral stent *in situ*. Patients with residual stone fragments >4 mm were offered the options of active surveillance, repeat ureteroscopy or shock wave lithotripsy.

Patient's preoperative parameters analyzed included demographic data, stone size and multiplicity. Intraoperative parameters analyzed included use of ureteral access sheath, duration of surgery and need to abandon surgery. The operative time was calculated in minutes from the time of cystoscope insertion to double J stent placement. We did not calculate lasing time and fluoroscopy time separately. Postoperative creatinine level, length of catheterization and hospital stay were analyzed. We did not evaluate postoperative pain scores, analgesia usage and ureteral stent related discomfort in the present study. Intraoperative complication recorded include ureteral or renal pelvic trauma, need to abandon procedure, and intraoperative bleeding causing impaired visibility. Postoperative complications collected included persistent hematuria, fever, urinary infection, urine retention, development of perirenal urinoma or hematoma and need for readmission. Perioperative complications, stone composition and SFR were compared in both groups. The recording of intraoperative and postoperative complications was done by co-author (RHS) during the course of patient treatment on a data entry sheet. The data was later entered in SPSS software for statistical analysis.

Statistical analysis

Statistical analysis was done using IBM SPSS Statistics 24 software. Two-tailed independent sample t test with 95% CI was used to compare continuous variables and chi-square test was used to analyze categorical variables among both groups. p value < 0.05 was considered significant. Overall, stone burden was higher in study group as compared to the control group. However, we did not perform any statistical analysis to compensate for differences between two groups.

Results

Of 59 patients who qualified for BSS-FURS, three refused to consent for BSS-FURS due to fear of increased complications. Data from 56 patients in both groups was available for analysis. Patient's demographic data and baseline clinical information are shown in Table 1. Overall, stone burden was higher in study group as compared to the control group and 44.64% patients in the study group had multiple bilateral stones. Although the total operative time was longer in the study group, the time to catheter free trial, length of hospital stay and perioperative complications were not significantly different in both the groups (Table 2). FURS was abandoned on both the sides in two patients from study group due to bilateral tight ureter prohibiting introduction of flexible ureteroscope. One patient had bilateral 4.5 Fr ureteral stent placement and repeat procedure was successfully performed after 2-weeks interval. In this patient, we avoided stent placement after second procedure, as he had significant stent related discomfort. Unfortunately, he came back with significant pain after 3 days of surgery. His CT scan showed hydronephrosis without any residual stones. He underwent stent placement on emergency basis. Another patient had intraoperative bleeding causing poor visibility associated with forniceal rupture and contrast extravasation on the first side. He also had poorly controlled diabetes with glycosylated hemoglobin of 9.2. Hence, we decided to abandon second side procedure and place a stent on the attempted side to facilitate future procedure. This was the only patient in whom we could not perform ureteroscopy on the second renal unit (one renal unit = every individual kidney/renal pelvis) as planned due to challenging procedure on first renal unit. In the control group, the procedure was abandoned in one patient due to flexible ureteroscope malfunction. One renal unit from two patients undergoing BSS-FURS had ureteral mucosal injury and or sub-mucosal passage of guide wire. One renal unit in a patient in the study group had lower ureteral perforation identified during withdrawal of ureteral access sheath.

The postoperative complications were comparable in both the groups. One patient in the control group developed perirenal urinoma that was incidentally detected on postoperative ultrasound and managed conservatively. Complete SFR after the first procedure was 78.5% in the U-FURS arm and 67.85% in the BSS-FURS arm, respectively ($p = 0.436$). Patients in whom the procedure was abandoned due to tight ureter, the outcome from the second procedure was considered while calculating SFR. If we incorporate the patients who had <3 mm residual fragments as stone free also, the SFR increases to 87.5% in the BSS-FURS arm as compared to 91.07% in the U-FURS arm. The details of retreatment are provided in Table 2. The stone compositions were similar and there was no significant rise in the postoperative serum creatinine in both the groups.

Discussion

Although a nonsignificant number of patients in the real world have bilateral nephrolithiasis, neither American Urological Association nor the European Association of Urology provide any recommendation on their management. Review articles on BSS ureteroscopy either are limited to treatment of ureteral stone or have combined ureteroscopic management of renal and ureteral stones [20–23]. All these reviews were based on retrospective studies and the quality of evidence was low. In the present prospective comparative study, although patients undergoing BSS-FURS had larger stone burden, the SFR and complications after BSS-FURS for bilateral renal calculi were comparable with U-FURS done for multiple renal stones. The aim of our study was to

Table 1. Patient demographics.

Variables	Group 1 (BSS-FURS) Mean ± SD	Group 2 (U-FURS) Mean ± SD	*p* value
Number of patients (*n*)	56	56	
Age (Years)	40.86 ± 13.60	42.95 ± 15.54	0.451
Sex (M:F)	40:16	37:19	0.541*
BMI (kg/m^2)	24.25 ± 4.60	26.50 ± 5.36	0.019
Associated medical co-morbidities			0.518*
Diabetes mellitus	12	7	
Hypertension	9	7	
Ischemic heart disease	4	2	
Multiple	5	5	
Others	3	2	
Associated coagulopathy	4	5	
Past history of urolithiasis	18	12	0.200*
Presenting symptoms			0.783*
Pain	39	40	
Fever	9	5	
Dysuria	1	2	
Hematuria	4	5	
Asymptomatic	3	4	
Serum creatinine (mg/dl)	1.19 ± 0.61	1.21 ± 0.68	0.873
Size of stone (mm)	18.60 ± 7.70	13.32 ± 6.43	0.000
Multiple stones	25	56	0.000*

BSS-FURS: bilateral same session-flexible ureterorenoscopy; U-FURS: unilateral-flexible ureterorenoscopy.
*chi-square test @-few patients had multiple complications).

compareresults of BSS ureteroscopy in patients undergoing unilateral ureteroscopy for multiple renal stones. Patients who underwent unilateral ureteroscopy for solitary stone were excluded from our study. The logic was to see whether BSS-FURS could be performed without increasing the risk of intraoperative complications or compromising on SFRs within acceptable time limits. Patients undergoing unilateral ureteroscopy for solitary renal calculi were excluded from control group as they were associated with better SFR when compared with patients with multiple calculi [27]. The only prospective study comparing 23 patients undergoing BSS-FURS with 69 patients of U-FURS for renal stones found no differences in SFR and hospitalization time [19]. This outcome was similar to our study.

Danilovic et al. also cautioned against BSS-FURS due to significantly more overall complications (15.9% vs. 39.9%, $p < 0.001$) and higher emergency room visits (11.6% vs. 34.8%) as compared to U-FURS [19]. Our complication rate for BSS-FURS was comparable with that of U-FURS (10.71% vs. 12.5%, $p = 0.453$). This was much less than our anticipated complication rate of 15% for U-FURS and 18% for BSS-FURS. We attribute the same to surgeon experience and exclusion of complex stone cases with stone burden $>$ 20 mm and those with residual fragments after SWL or percutaneous surgery and those with associated anatomical abnormalities. Most of the complications were Clavien Grade I and the single patient in the BSS-FURS group who had grade IIIb complication needed a double J ureteral stent since it was not placed during his repeat ureteroscopy. Similarly, most of the Clavien grade III (anuria) complications reported in retrospective studies are due to nonplacement of ureteral stents [9,10]. We preferred placing double J stent in all patients as we attempted placement of access sheath in most renal units (87.5% in BSS-FURS and 92.85% in U-FURS). We strongly recommend placement of ureteral stent at least in one renal unit in BSS-FURS surgeries. Although we did not offer BSS-FURS to patients with suspected struvite stones, stone analysis revealed that seven patients in BSS-FURS and two in U-FURS had struvite stones. We also noted that three out of four patients from BSS-FURS group and one out of two patients from U-FURS group who developed postoperative fever were harboring struvite stones. Based on our experience, we recommend caution with regards to offering BSS-FURS to patients with struvite stones.

The reported incidence of transient elevation in serum creatinine after ureteroscopy range from 1.4% to 1.6% [15–18]. We did not notice any significant increase in postoperative creatinine with BSS-FURS as noted by Danilovic et al. These authors noted a significant increase in serum creatinine on postoperative day 3 in the bilateral group as compared with unilateral group; however, their values plateaued at 3 months follow up [19]. Only one patient in our BSS-FURS group noted rise in creatinine from 1.2 mg/dl to 1.8 mg/dl on first postoperative day. The level however returned to 1.1 mg/dl in a month.

The SFR reported in the literature for BSS-FURS exclusively done for renal calculi range from 70% to 92% (Table 3). These differences can be attributed to the variation in imaging studies and the definition used to determine stone free status. In the present study, although patient had either an intravenous pyelography or computerized tomography scan to assess preoperative total stone burden, the postoperative SFR was evaluated by X-ray KUB and renal ultrasound after 3–4 weeks in all patients from both groups. As most of our patients were self-pay and CT scan was more expensive than X-ray KUB and renal ultrasound, we did not perform postoperative CT scan in our study for evaluation of stone free status. Although CT is considered as gold standard for identification of residual fragments, it might also detect clinically insignificant fragments and renal papillary calcification [28].

BSS-FURS is promising in terms of patient care and health care expenditure. It decreases multiple hospitalization, workday loss, stress from multiple surgeries and anesthesia, radiation exposure, preoperative and postoperative lab work and follow up imaging to almost half [8–19]. It also reduces the

Table 2. Perioperative outcomes and complications.

Intraoperative and postoperative outcome			
Variables	Group 1 (BSS-FURS) Mean ± SD	Group 2 (U-FURS) Mean ± SD	*p* value
Duration of surgery (min)	48.30 ± 16.71	32.95 ± 13.05	0.000
Access sheath used (*N*)	49	52	0.341
Duration of postop. catheterization (h)	21.11 ± 8.66	20.07 ± 9.85	0.556
Duration of hospital stay (h)	24.88 ± 9.51	24.04 ± 10.66	0.661
Postoperative creatinine (mg/dl)	1.21 ± 0.42	1.22 ± 0.40	0.911
Complications			
None	49 (87.5%)	50 (89.29%)	
Patients with one or more complications @	7 (12.5%)	6 (10.71%)	0.453
Intraoperative complications			0.623*
Number of patients	3	3	
Abandon procedure	3	1	
Bilateral renal unit	2	NA	
Unilateral renal unit	1	1	
Stage procedure (poor visibility)	1	1	
Ureteral mucosal injury (renal unit)	2	1	
Ureteral perforation (renal unit)	1	2	
Fornix rupture	1	0	
Renal pelvic perforation	0	1	
Postoperative complications (Modified Clavien Complication system)			0.298*
Number of patients	5	4	
Grade I			
Hematuria	3	2	
Grade II			
Fever/UTI	4	2	
Perirenal urinoma	0	1	
Grade IIIa			
Urine retention (re-catheterization)	1	0	
Grade IIIb			
Ureteral stent placement	1	0	
Unplanned hospitalization	2	0	
Stone composition			0.347*
Calcium oxalate	40	45	
Triple phosphate	7	2	
Uric acid	6	5	
Mixed	3	4	
Stone free status after single ureteroscopy			0.436*
Stone free-#	38 (67.85%)	44 (78.5%)	
Residual fragments <3 mm			
Unilateral	5	7	
Bilateral	6	NA	
Residual fragments ≥4 mm			
Unilateral	5	5	
Bilateral	2	NA	
Retreatment for residual fragments > 4 mm			
Observation	2	1	
Ureteroscopy	4	3	
Shock wave lithotripsy	1	1	

BSS-FURS: bilateral same session-flexible ureterorenoscopy; U-FURS: unilateral-flexible ureterorenoscopy.
#SFR indicative for both renal units; *p* value with independent sample T test; *chi-square test @-few patients had multiple complications.

need for disposables thereby potentially decreasing the environmental impact of the carbon footprint [29]. However, less number of urologists are opting for a same session procedure [6]. Possible reasons include concerns about patient safety and inconsistent reimbursements, which may not represent the true complexity of the procedures. In the USA, the urologist is reimbursed 50% for the second side if he performs BSS ureteroscopy.

The strength of the present study is that it is the largest prospective single surgeon study comparing BSS-FURS with U-FURS thereby eliminating the biases associated with retrospective studies, studies involving multiple surgeons and in studies with smaller sample size. Limitations include lack of cost analysis, postoperative pain score and analgesia use in both arms as well as a single surgeon experience. Another limitation was the use of X-ray KUB and ultrasound to detect SFR as compared to the gold standard CT scan. We also did not calculate total number of stones in both groups. Most ureteroscopies in western countries are performed as an ambulatory surgery. Since all patients in our study were admitted overnight, the results of our study may not be applicable to patients undergoing ureteroscopy on ambulatory basis. Despite these limitations, the present study should provide additional evidence pursuing urological community to consider BSS ureteroscopy in selected patients for management of bilateral renal calculi in the hands of an experienced endourologist.

Conclusion

BSS-FURS is a safe and efficient procedure for the management of bilateral renal calculi in the hands of experienced endourologist. The procedure has a comparable SFR and morbidity as U-FURS.

Table 3. Results of BSS ureterorenoscopy for bilateral renal calculi in published literature.

Author (year of publication) Country	Study design/No of Surgeons	No. of patients (*n*)	Stone size/ imaging used	Operative time (min ± SD)	Primary SFR (%) per patient Definition of SFR	Postoperative DJ stent placement (%) Change in postoperative serum Cr	Clavien Dindo Grade classification (%)
Studies based exclusively on management of bilateral renal calculi							
Huang et al. (2012) China [15]	RS 1	25	24 ± 5 mm CT	81.2 ± 25	70[@] RF < 1 mm on US	B: 100 NS	I: 8 II: 8
Atis et al. (2013) Turkey [16]	RS Multiple	42	24.09 ± 6.37 mm XR	51.08 ± 15.22	92.8 RF < 4 mm on US/IVU	B:71.4 U:28.16 NS	I/II: 4.7
Peng et al. (2015) China [17]	RCS Multiple	B: 59 U: 59	B: 1.3 cm^3 (0.7–2.3) U: 0.8 cm^3 (0.5–1.8) CT	B: 100 (66–126) U: 65 (50–80)	B: 84.7 U: 91.5 No RF on XR	B:100 U: 100 NS	B:I: 5.1 II: 6.8 U:I: 3.4 II: 5.1
Bansal et al. (2016) India [18]	RS NA	74	11.7 ± 2.4 mm XR	51.08 ± 15.22	86.84 RF < 4 mm on XR/US	B:87.83 NS	I/II: 10.8
Danilovic et al. (2021) Brazil [19]	PCS NA	B: 23 U: 69	B: 16.21 ± 8.40 mm U: 14.05 ± 6.30 mm CT	B:88.65 ± 33.19 U: 61.24 ± 26.62	B: 76.1 U: 73.9 No RF on CT	NA S at 1 month NS at 3 months	B: I: 30.4 II: 4.4 IIIb: 4.4 U:I: 10.1 II: 5.8
Studies based on management of both renal and ureteral calculi							
Hollenbeck et al. (2003)* USA [8]	RCS NA	B: 23 U: 54 SB: 22	B: 16.1 ± 11.7 mm U: 16.4 ± 7.1 mm0 SB: 7.0 ± 4.2 mm XR	B: 90 ± 46 U: 74 ± 35 S: 68 ± 34	B: 73 U: 73 SB: 79 No RF on XR	B: 75 U: 63 SB: 59 NA	B: I:8.3 II: 12.5 IIIa: 4.1 IIIb: 4.1 V: 4.1 U: I: 7.4 IIIa: 3.7 SB:II: 13.6 IIIb: 4.5
Watson et al. (2011)** USA [9]	RS 7	71	R: 13.9 mm L: 14.3 mm CT/XR	98 (only for 36 patients)	29 RF ≤ 2 mm on CT	B: 61 U: 2.5 NS	I: 4.7 II: 2.3 IIIa: 2.3 V: 1.2
Alkan et al. (2014) Turkey [10]	RS 3	42	30 ± 15.4 mm CT	89.1 ± 35.7	90 RF < 4 mm on CT	B:75 U:82 NA	I:6.8 II:15.9 IIIb:22.72
Drake et al. (2015) UK [11]	RS 1	21	21 (4–63) mm CT	70 (35–129)	RF < 2 mm on XR/US	80 NA	I/II: 14.28
Ingimarsson et al. (2017) USA [12]	RCS 1	B113 U:134	B: 6.9 ± 4.4 mm U: 7.5 ± 4.7 mm CT	NA	B: 89.8 U: 74 No RF on XR/US	B: 100% U: NA NA	B: I:9.4 II: 3.4 IIIb: 3.4 U: I:9.8 II: 3.8 IIIb: 2.2
Yang et al. (2017) China [13]	RS 2	44	26.1 ± 6.1 mm XR/CT/US	94.8 ± 29.0	86.4 RF < 4 mm on XR	NA NS at 1 month	I:22.72 II:9.09
Ozveren et al. (2017) Turkey [14]	RS	64	29.87 ± 14.96 XR/CT/US	112.5 ± 38.21	82.8 RF ≤ 2 mm on XR/US	B: 64.1 U: 21.9 NA	I: 9.4 II: 7.8 III: 9.4

B: bilateral same session flexible ureterorenoscopy; NA: not available; NS: not significant; PCS: prospective comparative study; RCS: retrospective comparative study; RS: retrospective case series; S: significant; SB: staged bilateral flexible ureterorenoscopy; SFR: stone free rate; U: unilateral flexible ureterorenoscopy; XR: X ray; US KUB: ultrasound KUB.
*No of renal units treated; **Flexible ureterorenoscopy for other indications (urothelial cancer, ureteral stricture, hydronephrosis) were also included to calculate the results. The total number of patients were 84 and the total units treated was 95; @ SFR per renal unit).

Ethical approval

Ethics committee approval was not necessary for this study.

Consent to participate

Every patient consented to participate in study.

Consent for publication

Every patient consented to participate in study.

Author contributions

Indraneel Banerjee: writing original draft.

Abhishek Bhat: review of literature, editing manuscript, submission and revisions.

Nicholas A Smith: manuscript editing and review of literature.

Jonathan Katz: manuscript preparation and review.

Rashmi H. Shah: resources and data curation.

Shah Hemendra Navinchandra: conceptualization, methodology, visualization, resources, statistical analysis, writing review and editing.

Disclosure statement

The authors declare no competing financial interests for this study.

Hemendra Shah received $1000 from Lumenis for mentoring urologist for HoLEP in 2019. All other authors have nothing to disclose.

Data availability statement

The raw data was lost in a laptop crash in Jan 2020. However, the tables made from same were available.

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