Outcome of Flexible Ureteroscopy and Holmium Laser Lithotripsy in the Management of Renal Stones: A two-year Retrospective Study

Idorenyin Cletus Akpayak[1], Chukwudum Dennis Ikeh[1]

[1]Department of Surgery, Division of Urology, Jos University Teaching Hospital, Jos, Nigeria

Abstract

Background: Over the decades, the management of renal stones has shifted from the undesirably invasive open nephrolithotomy to the more effective and less invasive approaches with lower morbidity. These less invasive options include extracorporeal shock wave lithotripsy, percutaneous lithotripsy, and flexible ureterorenoscopy (fURS). **Aim:** This study seeks to evaluate the outcomes of flexible ureterorenoscopy with holmium: yttrium-aluminum-garnet (holmium:YAG) laser lithotripsy for the treatment of renal stones <2.0 cm in our patients. **Patients and Methods:** Records of 23 patients who underwent flexible ureteroscopy and holmium: YAG laser lithotripsy between October 2020 and September 2022 were reviewed retrospectively. The patients who had the flexible ureteroscopy and laser lithotripsy for renal stones <2.0 cm for various indications were the subjects of this study. All patients had computed tomographic urography preoperatively to locate the stone. Stone-free rate (SFR) was deduced from no stone detected on imaging and resolution of the patient's preoperative complaints related to the renal stones at follow-up. Data on patients' demographics, indication for the surgery, location of the stone, size of the stone, preoperative double J (DJ) placement, postoperative DJ stent placement, intraoperative and postoperative complications, and the SFR were retrieved and subjected to the statistical analysis. **Results:** A total of 23 patients had fURS and laser lithotripsy during the two-year study period. All the patients had solitary stone in the renal unit operated. The mean stone size for all the patients was 1.3 cm (range: 0.5–1.9 cm). Fifteen (65.2%) patients had DJ stent preoperatively. Postoperative DJ stent was placed in all our patients. Four (17.4%) patients had Grade 1 ureteric injury while none had high Grades (2, 3, and 4) ureteral injuries. Two (9.5%) patients had intraoperative bleeding, 1 (4.8%) had transient haematuria postoperatively while 2 (9.5%) patients had urinary tract infection. The SFR was 91.3% in a single surgery. Two patients (8.7%) had residual fragments in the lower calyx. **Conclusion:** Flexible ureteroscopy and laser holmium lithotripsy give a satisfactory SFR, with few complications. It is a safe and effective treatment modality for the treatment of stones <2.0 cm in the renal pelvicalyceal system.

Keywords: Laser, lithotripsy, renal stones, ureteroscopy

Introduction

Over the decades, the management of renal stones has shifted from the undesirably invasive open nephrolithotomy to the more effective and less invasive approaches with lower morbidity.[1] These less invasive options include extracorporeal shock wave lithotripsy (ESWL), percutaneous lithotripsy (PCNL), and Flexible ureteroscopy (fURS).[2]

The enthusiasm that greeted the introduction of ESWL in the treatment evolution of renal stones was tempered with a less than satisfactory stone-free rate (SFR) clearance.[3,4] On the other hand, PCNL achieves a more satisfactory SFR but has a steep learning curve.[5] It also has a higher risk of bleeding and injury to the contiguous renal organs and has now been preserved for large (stone >2 cm) renal stones.[5,6]

These identified limitations of both the ESWL and the PCNL coupled with the continuous improvement and miniaturisation of flexible ureteroscopes have progressively increased the popularity of fURS in the treatment of renal stones.[7,8] It is

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Address for correspondence: Prof. Idorenyin Cletus Akpayak, Department of Surgery, Division of Urology, Jos University Teaching Hospital, Jos, Nigeria.
E-mail: akpayakuro@yahoo.com

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less invasive and has the capacity to access, to a large extent, the entire pelvicalyceal system (PCS).[9]

The concurrent and successful introduction of the holmium: yttrium-aluminum-garnet (holmium:YAG) laser as a flexible and compatible intracorporeal lithotripter device with a high safety margin has heightened this interest.[10,11] Despite the recent introduction of thulium fiber laser, the holmium:YAG laser currently remains the gold-standard energy source for the disintegration of renal stones with a flexible ureteroscope.[12,13]

This study seeks to evaluate the outcomes and complications of flexible ureteroscopy with holmium: laser lithotripsy for the treatment of renal stones <2.0 cm in our patients.

Patients and Methods

Records of 23 patients who underwent flexible ureteroscopy (fURS) and holmium: YAG laser lithotripsy between October 2020 and September 2022 were reviewed retrospectively. The patients who had the flexible ureteroscopy and laser lithotripsy for renal stones <2.0 cm for various indications were the subjects of this study. We also limited the selection to patients who had one stone per renal unit. Patients with concomitant ipsilateral ureteric stones, multiple pelvicalyceal stones, stones in a diverticulum, and those with coexisting pelviureteric junction (PUJ) obstruction were excluded from the study. Furthermore, patients who had staged fURS were also excluded from the review. Stone size was defined as the largest diameter of the stone in a given axis.

All the patients were thoroughly evaluated and had full blood count, urinalysis, and urine microscopy/culture/sensitivity. They also had serum electrolytes/urea/creatinine. They had chest X-ray and electrocardiogram, where indicated, before surgery. All patients had computed tomographic (CT) urography preoperatively to locate the stone, measure its size, and study the PCS.

Data on patients' demographics, indication for the surgery, location of the stone within the PCS, size of stone, preoperative double J (DJ) stent placement, postoperative DJ stent placement, intraoperative ureteric dilatation, intraoperative and postoperative complications, duration of surgery, duration of hospital stay, and the SFR were obtained. The data were entered into and analysed using the SPSS® version 25 (IBM Corporation, Armonk, New York, USA).

Surgical technique

The procedure was performed under general anaesthesia (GA) with endotracheal intubation and muscle relaxation to allow controlled respiratory movements.

The cystoscopy was used to gain retrograde access to the ureter by cannulation of the ureteric orifice with a 5 Fr ureteral catheter. Retrograde pyelography was carried out to display the anatomy of the ureter and the PCS. A size 0.035″ Cobra guidewire was then passed in the PCS and ureteroscopy was performed with a 6/7.5 Fr semirigid ureteroscope (Richard Wolf Medical equipment) to further visualise the ureteric lumen to rule out ureteral pathology before placement of the ureteral access sheath (UAS).

A UAS (Cook Medical, Bloomington, IN, USA) was then passed into the ureter over the guide wire and under fluoroscopic guidance up to just below the PUJ. UAS size 9.5/11.5 Fr or 10/12 Fr was chosen for patients who did not have prior DJ stent and those who had, respectively. The flexible ureteroscope (size 7.5 Fr Karl Storz Flex X2, Tuttlingen, Germany) was then introduced through the UAS to the renal pelvis under gravity normal saline irrigation. Where vision became poor, the PCS was gently flushed with normal saline using size 20 mL hypodermic syringe to improve the vision. Then, a systematic inspection of the PCS was carried out to identify the location of the stone. The stone was then fragmented or dusted at a setting of 0.5–0.8 J; 8–15 Hz or pop-dusted as required with Ho:YAG, Quanta Laser System 200 µm or 272 µm laser fiber. The ensuing stone dust was left *in situ* for spontaneous passage in most cases or where applicable, the stone fragments were retrieved using an NGage basket.

All the pelvicalyceal collecting system was inspected at the end of the procedure. Satisfactory stone disintegration was assessed by the dust appearance of the stone and the disappearance of the stone silhouette on intraoperative fluoroscopic and postoperative ultrasound or CT scan at follow-up.

The ureteral mucosa was endoscopically assessed during the withdrawal of the UAS using the flexible ureteroscope. Ureteric mucosal changes/injuries were endoscopically assessed and graded based on Traxer classification. Grade 0 (no lesion found or only mucosal petechial), Grade 1 (ureteral mucosal erosion without smooth muscle injury [mucosal flap]), Grade 2 (ureteral wall injury, including mucosa and smooth muscle, with adventitial preservation, i.e. periureteral fat not seen), Grade 3 (ureteral wall injury, including the mucosa and smooth muscle, with adventitial perforation, i.e. with periureteral fat seen), Grade 4 (total ureteral avulsion).[14] The patient was said to have postoperative fever if after the fURS the documented temperature rose to 38°C for more than 48 h. DJ stent was inserted in all the patients at the end of the procedure and was removed at three to four weeks after surgery. Furthermore, Foley catheter was passed to rest the bladder after surgery and was removed on the first day after operation before patient was discharged home.

SFR was defined as the absence of renal stone or stone fragment <4 mm on abdominal CT scan or no detectable stone on abdominal ultrasound and the resolution of the patient's preoperative complaints related to the renal stones.

Results

A total of 23 patients had fURS and laser lithotripsy during the two-year study period. Sixteen (69.9%) of the patients were males and 7 (30.4%) were females giving a male-to-female ratio of 2.1:1. The mean age of the patients was 45.83 ± 11 years (range: 30–68 years).

The principal indication for the fURS was recurrent flank pain in 13 (56.5%) patients. In 6 (26.1%), there was flank pain in addition to an episode or recurrent episodes of urosepsis. Four (17.4%) patients had flank pain and renal failure. Of these 4 patients, 1 had borderline renal function and 3 patients had bilateral pelvic stone-precipitating renal failure. They were appropriately treated with antibiotics and the 3 patients additionally had preoperative DJ stenting to correct the renal dysfunction.

All the patients had solitary stone in the renal unit operated. The mean stone size was 1.3 cm (range: 0.5–1.9 cm). The overall SFR was 91.3%. The stone characteristics for all the patients are shown in Table 1.

In 2 (8.7%) patients, during fURS, the stone migrated from the pelvis to the lower calyx and was difficult to relocate and *in situ*, laser lithotripsy was attempted with endoscopic incomplete clearance. These patients were counseled postoperatively for subsequent mini-PCNL to achieve complete stone clearance.

All the patients had the procedure done through a UAS to facilitate the insertion of the ureteroscope. Fifteen (65.2%) patients had DJ stent placed preoperatively and 8 (34.8%) patients did not have preoperative DJ stents. Following the fURS and laser lithotripsy, DJ stent was placed in all our patients.

All the patients had GA. The mean intraoperative time, including lasing time, was 128 min (range: 30–181 min) while the average hospital stay postoperative was first day. The urethral catheters were removed in all patients on postoperative day one before they were discharged home.

All our patients had abdominal ultrasound to objectively assess SFR postoperatively. Furthermore, 10 (43.5%) patients had abdominal CT scan, at various times three months after the fURS and laser lithotripsy.

The perioperative complications observed in the patients were minor complications and are as shown in Table 2 below.

Table 1: Stone characteristic and impact on the pelvicalyceal system

Stone characteristics	*n* (%)
Stone size (cm)	
<1	5 (21.7)
>1	18 (78.3)
Stone location	
Upper calyx	1 (4.3)
Middle calyx	5 (21.7)
Lower calyx	5 (21.7)
Renal pelvis	12 (52.2)
HU	
<1000	11 (47.82)
>1000	12 (52.17)
Laterality	
Right	7 (30.4)
Left	16 (69.6)
Hydronephrosis	
Yes	15 (65.2)
No	8 (34.8)

HU: Hounsfield unit

Table 2: Complications observed in the 23 patients that had flexible ureteroscopy and laser lithotripsy

Perioperative complications	*n* (%)
Intraoperative bleeding	2 (8.7)
Ureteral injury	
Grade 0	19 (82.6)
Grade 1	4 (17.4)
Grades (2, 3, and 4)	0
Postoperative complications	
Postoperative fever	1 (4.3)
Ureteric stricture	0

Discussion

Our study revealed SFR of 91.3%. Many authors have described the SFR from 54% to 96% for renal stone <2.0 cm treated in a single sitting.[15-17] Our SFR is within this range. The wide range of SFR for fURS and laser lithotripsy is due to the fact that different tools are used to determine the SFR and these include endoscopy, ultrasonography, conventional X-ray, and CT scan for reasons including cost and the need to reduce patient radiation exposure.[15] Although many authors assess for SFR at four-week postoperative, there is no agreed time on when to assess for the stone free status at follow-up.[15] In our series, we depended principally on the resolution of patient preoperative symptoms in addition to postoperative CT scan (43.5%) and an abdominal ultrasound to determine SFR in our patients.

However, beyond the shortcomings of the modalities used to assess SFR postoperatively, several parameters also determine SFR. The more important among these factors are presumably the stone size and stone location in the PCS.[18,19] Indeed, renal stone size is the most important determinant of SFR.[20] For instance, stone size >2.0 cm often may require retreatment because it usually results in residual clinically significant residual fragments.[18,21] Different authors are in agreement with this and recommend fURS for stone size <2.0 cm.[21,22] In our study, we carefully selected only patients with stone sizes <2.0 cm in an attempt to avoid retreatment which may be way too expensive for our patients.

The second most important factor affecting SFR is lower calyceal stone location.[16,17] In our study, 2 (8.7%) patients had lower calyceal stones which we carried out holmium laser lithotripsy *in situ* with satisfactory symptomatic improvement and SFR. In 2 (8.7%) patients, stones migrated from the renal pelvis to the lower calyx and it became impossible to relocate the stones to a favorable calyx or to achieve *in situ* lithotripsy. It is common for stone or stone fragments to move to a different location accidentally within the PCS.[23] Treatment of lower calyceal stones with fURS is challenging due to the difficulty in gaining access to the calyx, difficulty in eliminating the stone fragments, and as a result poor SFR.[24,25] Dresner *et al.*[26] in their review of 243 patients found infundibulopelvic angle and stone size as the most important factors affecting SFR during fURS and lithotripsy for the lower calyceal stones.

An important complication of fURS is ureteral injury, ranging from mucosal abrasion to ureteral avulsion.[27] These result principally from UAS placement. UAS is an essential fURS accessory used to facilitate access to the PCS as well as insertion and re-insertion of the scope. It is also thought to protect the flexible ureteroscope from damage and decrease intrarenal pressure.[28] The inner diameter of UAS ranges from 9.5 Fr to 14 Fr, while the outer diameter ranges from 11.5 Fr to 18 Fr. In our series, we used size 9.5/11.5 Fr in all patients who did not have preoperative DJ stenting while we placed 10/12 Fr in patients who had preoperative DJ stent. With smaller UAS (<12/14 Fr), the ureteral injury has been found to be considerably reduced and increase insertion success.[22]

We observed at the end of the procedure that 4 (17.4%) of our patients had Grade 1 injuries. None of our patients had high Grades (2, 3, and 4) ureteral injury based on the Traxer classification system.[14] Furthermore, no case of postoperative ureteral stricture was found in our series probably because of the precautions taken or maybe because of the short follow-up duration.

Postoperative infection is among the most common complications following fURS.[29,30] This is thought to be due to raised intrarenal pressure that presumably occurs during fURS.[29] The raised intrarenal pressure which inevitably occurs during fURS may lead to calyceal rupture and intravasation of bacteria and the development of postoperative fever, bleeding, and perirenal haematoma. This risk is heightened by increasing operative time and preoperative urinary tract infection (UTI).[29,30] Kim *et al*.[31] reported that postoperative fever occurred in 17 (11.3%) of their patients. In that study, they found preoperative pyuria as the only statistically significant risk factor of postoperative fever after fURS. Other authors have reported postoperative fever ranging from 7.6% to 13.4%. These authors have found a wide range of preoperative and postoperative factors other than pyuria to be associated with postoperative fever following fURS.[32-34] We observed postoperative fever in 1 (4.3%) of our patients. This was treated with antibiotics with complete resolution and no need to remove the DJ stent.

Bleeding during fURS or postoperatively is usually due to perforation of PCS by the ureteroscope, the laser fiber, the stone basket, or the guide wire.[35] It may also be caused by the sudden decompression of the hydronephrotic PCS.[35] We encountered intraoperative bleeding in 4.3% of our patients and another 4.3% had postoperative haematuria. However, the haematuria was self-limiting and did not require a blood transfusion.

Preoperatively, DJ stenting was carried out in 65.2% of our patients for various indications and to facilitate the insertion of UAS. We also placed DJ stent in all of our patients postoperatively. Many authors consider placing DJ stents after fURS as a routine to prevent obstruction, renal colics, deterioration of renal function, and other postoperative complications.[14,36,37] For instance, where there is ureteral injury, as happened in 1 (4.3%) of our patients, DJ stenting is found to be reparatory and helps reduce ureteral edema. It also directly reduces pains from residual fragments as well as blood clots.

This study is not without limitations. Its retrospective format, the short duration of the study, and the small sample size are indeed shortcomings of the study. However, our findings even with these shortcomings are similar to those with large sample sizes and long study periods. We feel that our study is relevant and justified to document the outcomes and complications of flexible ureteroscopy for renal stones in our environment. More so as this technique is currently finding in-road into many centers in our sub-region.

Conclusion

Flexible ureteroscopy and laser holmium lithotripsy give a satisfactory SFR (91.3%) for renal stone <2.0 cm. It is associated with minimal complications including low-grade ureteral injury, self-limiting intraoperative bleeding, and UTI which is easily treatable with antibiotics and does not compromise safety of the patient.

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Conflicts of interest
There are no conflicts of interest.

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