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ORIGINAL PAPER

Dynamic renal scans as a modality for follow-up of flexible ureteroscopy

Murad Asali [1, 2], Osman Hallak [1]

[1] Urology Department, Barzilai Medical Center, Ben Gurion University of the Negev, Beer Sheva, Israel;
[2] Assuta Medical Center, Ramat Hyal, Ben Gurion University of the Negev, Beer Sheva, Israel.

Summary *Objective: To determine whether dynamic renal scans – DTPA or MAG3 – routinely performed after flexible ureteroscopies (f-URS) could detect the development of an obstruction and thus promote prompt early intervention for kidney preservation.*
Patients and methods: In this retrospective study, with all the data recorded prospectively between April 2010 and October 2023, 250 renal units in 242 patients with upper urinary tract stones (UUTS) who underwent ureterorenoscopy by one surgeon in the same medical center were evaluated. Stone-free rate (SFR) was defined as no residual fragments at all using an intraoperative "triple test". The following characteristics were examined: gender, BMI, age, Hounsfield unit, stone diameter, laterality, renal/ureteral stones, stone-free rate, and auxiliary procedures per renal unit. The Clavien-Dindo classification was used to report complications. Renal units with residual stones were scheduled for a 2nd f-URS. Post- flexible ureteroscopy ureteral obstruction and renal function were detected using renal scan DTPA or MAG-3. The primary outcome was renal/ ureteral obstruction.
Results: The mean patient age was 53 years. The mean stone size was 12.3 mm. Stones in renal pelvis, upper, middle and lower calyces were treated in 9.2% (23), 27.6% (69), and 30.8% (77) of cases, respectively; 44% (110) ureteral stones were also treated. The single- and second-session SFRs were 94.8% and 99.7%, respectively. A third auxiliary procedure was needed in one renal unit (0.4%). The mean number of procedures per renal unit was 1.06 (264/250). Ureteral double-J stents were inserted in 53.6% (134) of the cases. In 37 (14.8%) cases, a stent was placed before surgery. Post-operative complications were minor, with readmission and pain control needed in only two patients (0.8%). No avulsion or perforation of the ureters was observed. In six patients with t1/2 between 10-20 minutes, a second renal scan revealed spontaneous improvement and no obstruction in five patients. One patient with large stones and a history of prior ureteroscopy developed a ureteral stricture (0.4%) and needed treatment with laser endoureterotomy.
Conclusions: Post-flexible ureteroscopy obstruction due to ureteral stricture is very rare. A routine renal scan post-operatively may be used in potentially high-risk patients.

KEY WORDS: *Renal scan; DTPA; MAG3; RIRS; Retrograde intrarenal surgery; Ureteral stricture.*

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INTRODUCTION

As known, nephrolithiasis is a common disease in Asia with a rate of 1%-5% (1). With the development of small flexible ureteroscopes and the improvement of laser lithotripsy, flexible ureteroscopy has become the standard of care for treating urolithiasis less than 2 cm (2, 3). In the early 1970s, *Takagi et al.* (4) and *Takayasu et al.* (5) first reported the clinical application of a fiberoptic pyeloureteroscope. With technological advancements in endourology, including new lasers, and advanced flexible ureteroscopes, the treatment indications for *retrograde intrarenal surgery* (RIRS) have expanded to include not only large stones but also upper urinary tract urothelial carcinoma, ureteral stricture, and a diagnostic tool for hematuria. In 1991, *Grasso et al.* presented an advanced flexible ureteroscope with a 7.5-Fr tip and an up 120º/down 170º deflection system. In 1998, they published a clinical study of 492 patients treated with a flexible ureteroscope with a larger 3.6-Fr working channel (7). Later, in 2001, a f-URS with a two-way deflection system (270º/270º) and stronger durability was introduced to the market, improving access to the pelvicalyceal system (8). Surgeons must consider the risk of various complications due to ureteroscopy including thermal injury, ureteral injury caused by the ureteral access sheath, and strictures (6).

Ureteral stricture is a late complication that may cause severe damage to a patient's health. The incidence rate of postoperative ureteral stricture varies from 0.23 to 2.97% (9-13). Subsequent treatment of the stricture should be tailored according to the stricture length and severity of hydronephrosis. Strictures longer than 1 cm with severe hydronephrosis should be treated with reconstructive surgery and not by endourological interventions (6, 14).

This study presents the results of diagnosis of possible complications associated with f-URS for treating *upper urinary tract stones* (UUTS) in particular renal/ ureteral obstruction, using dynamic renal scans using either *diethylenetriaminepentaacetic acid* (DTPA) or *mercapto acetyl tri glycine* (MAG-3), in order to answer the question if there is a need of routine renal scan after f-URS.

DTPA = diethylenetriaminepentaacetic acid.

MAG3 = mercapto acetyl tri glycine.

PATIENTS AND METHODS

One surgeon performed ureterorenoscopy on 917 renal units in patients with UUTS in the same medical center between April 2010 and October 2022.

A 7.5 Fr flexible ureteroscope was utilized with Holmium: YAG (yttrium aluminum garnet) laser for lithotripsy in all patients. The laser fibers used were 200 µ, 230 µ, and 272 µ, with an energy of 0.3-1 joule and a frequency of 8-80 Hz. The calculi fragments were taken out with a basket. The *ureteral access sheath* (UAS) was always placed below the ureteral stone and moved up to the middle or proximal ureter for renal stone treatment.

A total of 267 patients who underwent a post-operative dynamic renal scan using either DTPA or MAG3 were included in the study.

Out of them, 13 needed a second session, one needed a third session.

The patients were included in the study after meeting our inclusion criteria, as follows:

1. Upper urinary tract stones.
2. Use of the same 7.5Fr flexible ureteroscope (flexible uretero-renoscope Flex- X2s [Karl Storz & Co. KG, Tuttlingen, Germany]).
3. Use of a Holmium: YAG laser with consistent energy, frequency, and fibers (200 µ, 230 µ, and 272 µ) usage.
4. Use of Sphinx JR 30-watt [LISA Laser Products GmbH, Germany], Mega Plus 15 Watt [Richard Wolf GmbH, Knittlingen, Germay], or Luminis 120-watt [Luminis, Yokneam, Israel] laser generator.
5. Use of a UAS (Flexor ureteral access sheath 12/14F, 28, 35, 45 cm; FUS- Cook Medical, Bloomington, IN, USA).
6. All data recorded.
7. Adults aged 18 years and older.
8. A dynamic renal scan, either DTPA or MAG3 was done postoperatively.

The exclusion criteria were as follows:

1. Using other flexible ureteroscopes.
2. Missed data.
4. No other access sheath type use.
5. Using a rigid ureteroscope.
6. Single kidney.

At the end of the operation, a triple test was done for all calyces, using 1) a plain abdominal radiograph of the kidneys, ureters, and bladder, 2) using the scope and the C-arm while injecting contrast intraoperatively as a retrograde pyelography and 3) screening every calyx using the endoscope and following the anatomy on the C-arm screen as described in *Asali et al.* article (15).

In all the patients, the following characteristics were evaluated: gender, BMI, age, stone radiopacity (Hounsfield unit), stone diameter, stone laterality (Table 1), stone location (renal/ureteral), stone-free rate (Table 2), auxiliary procedures per renal unit (Table 3), double-J stent insertion, and perioperative complications (Table 4). Stone-free status was defined as complete stone removal. This study was retrospective, and all the data (demographics data, stone characteristics, operative and postoperative data) were recorded prospectively.

Postoperative follow-up was scheduled one month later with a dynamic renal scan DTPA/ MAG3, urine culture, and renal function. The results were divided into obstructed (t1/2 more than 20 minutes), equivocal (t1/2 10-20 minutes), and non-obstructed (t1/2 less than 10 minutes). The primary endpoint was a renal/ureteric obstruction demonstrated by a renal scan with a t1/2 of more than 20 minutes.

Patients with residual stones were scheduled for a 2nd f-URS/RIRS (retrograde intrarenal surgery), and patients with obstruction were scheduled for re-intervention.

The Clavien-Dindo classification was used to report complications (16).

All procedures performed in this study were performed after receiving informed consent from all the patients.

Results

The mean patient age was 53 years. The mean maximum stone diameter was 12.3 mm (Table 1). Stones were in the renal pelvis, upper, middle, and lower calyces stones in 9.2% (23), 27.6% (69), and 30.8% (77) of cases, respectively (Table 2); 44% (110) were ureteral stones.

The mean stone diameter of stones of the renal pelvis, upper and middle calyces, lower pole, upper ureter, middle ureter, and lower ureter was 11.3 mm, 8.2 mm, 7.9 mm, 8.8 mm, 7.8 mm, and 8.2 mm, respectively. The characteristics of renal and ureteral stone are shown in Table 2. The single- and second-session SFRs were 94.8% and 99.7%, respectively. A third auxiliary procedure was needed in one renal unit (0.4%) (Table 3).

Table 1.
Patient demographic and stone characteristics.

Patients	242
Gender M/F	162/80
BMI	28.5
Renal Units (Kidney +/- Ureter)	250
Age (years)	53
Hounsfield unit (mean)	809
Mean Maximum Stone Diameter (mm)	12.3
Lateralization R/L	110/140

Table 2.
Renal and ureteral stone location and diameter.

	No	%	Mean Stone Diameter (mm)
Renal Pelvis	23	9.2	11.4
Upper and Middle Calyx	69	27.6	8.2
Lower Pole	77	30.8	7.9
Upper Ureter	34	13.6	8.8
Middle Ureter	27	10.8	7.8
Lower Ureter	54	21.6	8.2

Table 3.
Stone-free rate/auxiliary f-URS.

	No	SFR (%)	Cumulative Stone Free %
Renal Units	250	**	**
1st Session	250	237 (94.8%)	94.8%
2nd Session	13	12 (92.3%)	99.7%
Third Auxiliary	1	1 (100%)	100%
Laser Frequency (HZ) &	31.2	**	**
Energy (Joule) &	0.54	**	**

SF = Stone Free; f-URS = Flexible Ureteroscopy; HZ = Hertz. 1st session = &.

Table 4.
Complications.

	No	%
Patients	242	96.8
Renal units	250	100
Renal colic needs IM/IV* treatment	2	0.8
Haematuria	2	0.8
Prolonged Flank Pain (~2 weeks)	5	2
Insertion of stent due to pain	0	0
Fever	0	0
Urinary tract infection	0	0
Ureteral Stricture	1	0.4
Ureteral Avulsion	0	0
Ureteral Perforation	0	0
Clavien- Dindo classification I	9	3.6
Clavien- Dindo classification III	1	0.4

IM = Intramuscular; IV = Intravenous.

The mean number of procedures per renal unit was 1.06 (264/250).
Ureteral double-J stents were inserted in 53.6% (134) of the cases. In 37 (14.8%) cases, a stent was placed before the surgery.
Post-operative complications were minor, with readmission for pain control needed in only two patients (0.8%) while two patients (0.8%) had intermittent haematuria secondary to the stent. No avulsion or perforation of the ureters was observed (Table 4). Grade I complications according to Clavien-Dindo classification were observed in nine cases (3.6%) (9/250). No grades II, IV, or V were observed.
The mean hospital stay was one day.
At postoperative renal scan 244 renal units demonstrated t1/2 less than 10 minutes and six patients a t1/2 between 10-20 minutes; a second renal scan revealed improvement and no obstruction in five patients. One patient developed ureteral stricture (0.4%) and needed treatment with laser endoureterotomy (Table 4).

Discussion

Advances in flexible ureteroscope designs, accessory instrumentations, and new laser generators have allowed endoscopic treatment for more challenging cases. Using the UAS makes it easier to enter and exit the ureter, renal pelvis, and calyces during the operation and even more when handling large stones.
RIRS is a safe and valuable modality of treatment for renal stones. It is a well-established procedure under constant evolution with advances in technique and technology. It has gained worldwide popularity due to its minimal invasiveness and satisfactory outcomes (17). Flexible URS has become the standard of care for treating urolithiasis less than 2 cm (2, 3). There is no doubt that f-URS surgery has become very common in the treatment of UUTS even though the SFR is higher after *percutaneous nephrolithotomy* (PCNL). Furthermore, f-URS is also an option for renal stones larger than 2.5 cm with low morbidity (18). Despite this, ureteral strictures are still observed after f-URS as a result of injury from impacted stones, ureteral perforations, or unclear intraoperative vision (19, 20). *Darwish et al.* concluded that post-URS ureteral stricture incidence is low and that impacted stones are the most common cause of URS complications and stricture formation (21). *Traxer et al.* reported a higher risk of severe ureteral injury secondary to UAS use (22). However, *Özsoy et al.*'s experimental animal model demonstrated that after two weeks, only minimal inflammatory changes were evident in the ureter suggesting negligible long-term impacts secondary to UAS use (23). According to *Manger et al.*, ureteral strictures typically appear during the first four weeks of follow-up postoperatively (24). Renal loss can result from ureteral strictures, therefore, we need to be aware of this risk throughout our postoperative follow-up. Even if our standard approach involves the use of UAS and small-diameter flexible ureteroscopes, our concern is how to diagnose an obstruction secondary to strictures as early and as feasibly as possible.
In this study, a dynamic renal scan was routinely performed post-operatively.
Early diagnosis and treatment of ureteral stricture is the cornerstone of its management. So, could routine postoperative imaging help in the early diagnosis of ureteral stricture and prevent renal loss? Patients with high-risk indicators for the development of stenosis, such as impacted stones, should undergo postoperative imaging, according to *May et al.* (25). *Jung et al.* compared two groups of patients who underwent mini-PCNL or RIRS and were monitored by ^{99m}Tc-DTPA preoperatively and postoperatively. No differences in renal function between the groups were noticed (26). *Piao et al.* reported their results using ^{99m}Tc-DTPA to check the relative renal function after minimal invasive renal surgery, although their purpose was not to diagnose ureteral stricture (27). In this study, a UAS was standardly used, and a routine scan was done postoperatively; 244 renal units demonstrated no obstruction, while in six patients t1/2 was between 10-20 minutes. In these patients, a second renal scan was done, and improvement was achieved. However, one symptomatic patient underwent a retrograde pyelography (1/250) which diagnosed a ureteric stricture and was subsequently treated endoscopically with laser endoureterotomy and placement of a temporary stent.
We showed that renal or ureteral obstruction post-f-URS is very rare (2.4% of the renal units), when renal retention was suggested by a dynamic renal scan with t1/2 between 10-20 minutes, but only one out of six patients needing treatment.
The advantages of our study include: outcomes may be more easily compared because all surgeries were carried out by the same surgeon using the same equipment, personnel, ureteroscope, holmium laser energy and UAS from the same company. The disadvantages include: its retrospective design, absence of a control group, and the untested duration of the surgery, which may be a risk factor for stricture formation.
To our knowledge, there are no studies that investigated the use of a routine dynamic renal scan post-f-URS to diagnose ureteral strictures and suggest an early evaluation and treatment.

We showed that f-URS was successful in 94.8% (237/250) of cases in the first session, and cumulative SFR in a two-stage procedure was 99.7% (249/250). A third auxiliary procedure was done successfully in one patient.
In this study, favourable results were achieved, even if it included 30.8% (77/250) of lower pole stones. The mean number of procedures per renal unit was 1.06.
According to the Clavien-Dindo classification, no major complications were observed.

Conclusions

Obstruction due to ureteral stricture post-flexible ureteroscopy is very rare, a dynamic renal scan post-operatively may be used in high-risk patients.

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Correspondence
Murad Asali, MD (Corresponding Author)
dr.muradasali@gmail.com
Department of Urology, Barzilai Medical Center,
Ben Gurion University of the Negev, Beer Sheva, Sokolov 26/99, 8430905

Osman Hallak, MD
Urology Department, Barzilai Medical Center, Ben Gurion University
of the Negev, Beer Sheva, Israel

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