Reduced Radiation Fluoroscopy Protocol during Retrograde Intrarenal Surgery for the Treatment of Kidney Stones

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Purpose: To discuss whether fluoroscopic imaging is essential during the ureteroscopic treatment of kidney stones in an effort to diminish radiation exposure.

Materials and Methods: Seventy-six patients with kidney stones were treated with retrograde intrarenal surgery (RIRS). In the operation room, a mobile C-arm fluoroscopy system was ready to use in case fluoroscopic imaging was needed. The manipulations were performed with tactile and visual cues. The perioperative and postoperative parameters were retrospectively evaluated.

Results: The mean age of the patients was 39.9 ± 13.8 years. The mean stone size was 14.1 ± 4.1 mm. The insertion of the access sheath was performed over the guidewire under single shoot fluoroscopic imaging in all patients. Additional fluoroscopic imaging was required to localize the stone ($n = 2$) and to determine the collecting system anatomy ($n = 2$) for 4 (5.2%) patients with previous renal surgery and severe hydronephrosis. Stone-free status was accomplished in 63 (82.9%) patients.

Conclusion: The RIRS with low-dose fluoroscopy protocol for kidney stones can be safely and effectively performed in patients with no special circumstances such as anatomical abnormalities or calyceal diverticular stones.

Keywords: fluoroscopy; kidney calculi; surgery; lithotripsy; adverse effects; treatment outcome; ureteroscopy.

INTRODUCTION

Retrograde intrarenal surgery (RIRS) is an alternative method for the treatment of kidney stones. RIRS has become a safe and optimal treatment modality for renal stones of different sizes.[1] Indications for this technique have recently increased, and many authors have reported increases in the success of this technique, which has a non-invasive method compared to other surgical treatments (percutaneous nephrolithotomy or open surgery) of kidney stones.[2-5]

Imaging methods contribute to the diagnosis and treatment of urolithiasis. Fluoroscopy is used in many urologic procedures, including ureteroscopy (rigid or flexible) and percutaneous nephrolithotomy (PNL).[6] Conventionally, fluoroscopy is used in almost every stage of ureteroscopic procedures and facilitates all stages of the operation. It is well known that radiation exposure by fluoroscopy has potential risks such as genetic mutations and cancers.[7] In recent years, there have been several studies investigating methods to minimize the duration of fluoroscopic imaging during ureteroscopy (flexible or rigid) and presenting fluoro-less ureteroscopy procedures in patients with kidney and ureter stones.[2-4,7] In this study, we investigated the necessity of fluoroscopy in the RIRS technique and aimed to present the outcomes of RIRS technique including fluoroscopy reduced radiation.

MATERIALS AND METHODS

Patients

Between September 2010 and May 2013, 76 patients with kidney stones who underwent RIRS (including reduced radiation fluoroscopy) procedure by two experienced endourologists (MK and AT) in two centers were retrospectively evaluated. Patients with stones in anatomically abnormal kidneys (horseshoe, pelvic, and mal-rotated kidneys, bifid pelvis, ectopic pelvic fusion anomaly, calyceal diverticulum stones) and patients with non-opaque stones that might require additional and detailed fluoroscopic scans during ureteroscopy were excluded from the study. An informed consent form was completed by all patients before the procedure. The patients had a failure of prior procedures as shock wave lithotripsy (SWL) selected for RIRS.

All patients were evaluated by urinalysis, urine culture, complete blood cell count, serum biochemistry, coagulation tests and imaging methods [plain radiography, ultrasonography, computed tomography (CT), and/or intravenous urography] before the procedure. The stone size was determined by the longest axis of the stone.

RIRS Technique

All procedures were performed with the patient under general or spinal anesthesia by two experienced senior endourologists (MK and AT) using 7.5 French (F) flexible ureteroscopes (Karl Storz Endoscopy, Tuttlingen, Germany). The patients were placed in the lithotomy position. The surgical team was protected with lead aprons and thyroid shields. In the operation room, a mobile C-arm fluoroscopy system (Ziehm Solo, Ziehm Imaging, Nürnberg, Germany; Siemens Muenchen, Germany) was ready to use in case fluoroscopic imaging was necessary. A cysto-urethroscopic examination was performed in all patients for any urethral or bladder pathologies. A rigid ureteroscope (8 or 9.5F) was routinely used before flexible ureteroscopy in all patients to detect ureteral stones or dilation of the ureter and to place a hydrophilic guide-wire into the renal pelvis. A 0.035/0.038-inch safety guide-wire (Boston Scientific, Natick, MA, USA) was gently inserted into the renal pelvis with the endoscopic visualization. A ureteral access sheath (12/14F, 35 or 45 cm length, for females or males, respectively; Cook Medical, Bloomington, Indiana, USA) was placed over the guidewire. During the procedure, all manipulations (guidewire, balloon dilatation, etc.) were performed with visual and tactile cues, as previously described in the literature.[2] The ureteral access sheath insertion was terminated if any difficulty arose. Single-shot fluoroscopic images were taken to verify the place of the access sheath. For patients in whom a ureteral access sheath could not be placed, the flexible ureteroscope was pushed forward to the renal pelvis over the guide wire with direct vision. The pelvicalyceal collecting system was displayed and the stone was found using endoscopic vision. The stones were fragmented with a holmium laser (Dornier MedTech GmbH. Argelsrieder Feld 7, D-82234 Wessling, Germany; Quanta System Srl, Milano, Italy) until they were deemed small enough to pass spontaneously. Basket extraction of the residual fragments

Table 1. Characteristics of study participants.

Characteristics	n = 76
Mean age (years)	39.9 ± 13.8
Gender, no. (%)	
Male	50 (65.8)
Female	26 (34.2)
Mean stone size (mm)	14.1 ± 4.1
Stone location, no. (%)	
Upper pole	12 (15.8)
Middle pole	15 (19.7)
Pelvis	24 (31.6)
Lover pole	17 (22.4)
Multi calix	8 (10.5)
Multiple stones, no. (%)	15 (19.7)
Presence of preoperative stent, no. (%)	17 (22.3)
Hydronephrosis, no. (%)	
None	64 (84.3)
Grade 1	7 (9.2)
Grade 2	4 (5.2)
Grade 3	1(1.3)

Table 2. Perioperative outcomes and postoperative complications.

Outcomes	n = 76
Mean operation time (min)	58.5 ± 16.1
Mean hospitalization stay (hour)	28.1 ± 10.2
Mean fluoroscopy time (sec)	5.27 ± 1.8
Stone-free rate, no. (%)	63 (82.9)
Clinically insignificant residual fragments, no. (%)	7 (9.2)
Rest (unsuccessful), no. (%)	6 (7.9)
Double J stent insertion, no. (%)	67 (88.2)
Ureteral access sheath insertion, no. (%)	65 (85.5)
Complications, no. (%)	5 (6.5)
Urinary tract infection	2 (2.6)
Fever	1 (1.3)
Hematuria	1 (2.6)
Ureteral mucosal injury	1 (1.3)

was not routinely performed, but some residual fragments were removed by nitinol baskets for stone analysis. The decision to place a ureteral stent was made by the surgeon intraoperatively. Stent placement was performed with endoscopic visualization over a guide-wire. If a ureteral stent was placed at the end of the procedure, it was removed approximately 14 to 21 days postoperatively.

Follow-up

For all cases, the patient demographics, fluoroscopic imaging and fluoroscopy time (FT) operative and postoperative parameters were evaluated. The results were classified as stone-free, clinically insignificant residual fragments (CIRFs) and unsuccessful. CIRFs were defined as ≤ 4 mm, non-obstructing, non-infectious and asymptomatic residual fragments.[6] The patients with a complete absence of residual fragments were accepted as stone-free. The first follow-up evaluation was performed on the first day following the operation. Second evaluation was performed postoperatively first month, after which patients were seen every 3 months during the first year. In postoperative first day, plain radiography, and abdominal ultrasonography were performed to all patients. In postoperative firs mount, CT scan was performed to all patient.

RESULTS

The mean age of the patients was 39.9 ± 13.8 years (range 19 to 75 years). The mean stone size was 14.1 ± 4.1 mm (range 7 to 26 mm). The stone localization was in the upper, middle, pelvic or lower poles or in multiple calices in 12, 15, 24, 17 and 8 patients, respectively. Multiple stones were present in 15 (19.7%) patients. Preoperative stents were present in 17 (22.3%) patients. Of the patients, 43 (56.5%) were previously treated by SWL, but the results were unsuccessful by means of stone clearance. The demographic data of the patients are summarized in Table 1.

The mean operation time was 58.5 ± 16.1 minutes (range 35 to 120 min.), and the mean hospitalization time was 28.1 ± 10.2 hours (range 16 to 48 hours). In the first postoperative month, stone-free status was accomplished in 63 (82.9%) patients. A ureteral access sheath was placed in 65 (85.5%) patients. A double J stent was inserted using endoscopic vision in 65 (88.2%) patients. Additional procedures including SWL, PNL and ureterorenoscopy (URS) were performed in 3 (3.9%) patients (one patient SWL, one patient PNL and one patient URS). A re-treatment was needed for 2 (2.6%) patients. The operative and postoperative outcomes are given in Table 2.

There were 5 (6.5%) non-severe complications in the patients. Two patients (2.6%) had urinary tract infections detected by urine cultures in the postoperative period. These patients were treated properly with antibiotics. One (1.3%) patient had a fever postoperatively, which resolved spontaneously. Persistent hematuria (which did not decrease the hemoglobin level) occurred in one patient. In this patient, the hematuria spontaneously improved postoperatively. A ureteral mucosal injury, which was observed under the ureteroscope, occurred in one patient. The double J stent was inserted in this patient. There were no major intraoperative complications during the operations.

Fluoroscopic imaging (additional singe-shots) was required for only 4 (5.2%) patients. The mean fluoroscopy time was 5.27 ± 1.8 seconds in 2 patients, C-arm fluoroscopic screening was used to find and confirm the stone location in a dilated collecting system. In 2 patients, fluoroscopic screening was needed to assess the anatomy of the collecting system, in which the calyceal stones underwent renal surgery (for mapping of the collecting system with severe dilation).

DISCUSSION

Over the years, fluoroscopic imaging during ureteroscopy has become a necessary tool in urologic practices. Recently, fluoroscopy has been standardly used in SWL, PNL and RIRS and provides a significant contribution to these surgical methods. RIRS or flexible ureterorenoscopy (FURS) are used for the treatment of kidney stones with a small or medium diameter. Traditionally, fluoroscopic imaging in RIRS was necessary and increased safety and the success rate of the procedure. In this study, we performed a reduced radiation fluoroscopy protocol of RIRS and discussed the necessity of fluoroscopy during the RIRS procedure.

Recent studies have emphasized the risk of secondary malignancies associated with ionizing radiation from diagnostic imaging.(9,10) The cumulative cancer risk of the radiation exposure from diagnostic methods is estimated at 0.4-0.9% in United States.(10,11) Fluoroscopic imaging plays a major role in endourology. Fluoroscopy is commonly used during ureteroscopy (flexible or rigid) to place the guide-wires, to detect the stone location and renal anatomy, for ureteral balloon dilatation and for placement of the ureteral stents. Little long term data exist that describe the incidence of secondary malignancies in urologists. The development of ureteroscopic and endoscopic techniques and the common use of fluoroscopic imaging with these techniques will increase the radiation exposure to the patient, surgeon and operating room staff during the procedure. The effect of ionizing radiation may be dangerous for urologists in the long-term. In this study, we performed a RIRS technique including reduced radiation fluoroscopy protocol for kidney stones to decrease the effects of fluoroscopy induced ionizing radiation.

Krupp and colleagues(10) concluded that the radiation emitted from fluoroscopy devices during URS should not be disregarded. In this study, organ-tissue-specific radiation doses were measured during the simulation of ureteroscopy on cadavers. On the one hand, fluoroscopy for ureterorenoscopy (URS) uses a relatively low dose of radiation,(4,12) but on the other hand, the cumulative effects of fluoroscopy can theoretically cause an increased risk of cancers. Hellawell and colleagues detected that surgeons received a mean of 11.6 μGy per urologic case.(12) Although this radiation dose is low, a high-volume surgeon, who may perform up to 500 cases per year, would receive 5.8 mGy per year. This dose is more than half of the effective dose of a non-contrast CT scan of the abdomen. The effect of fluoroscopy during ureteroscopic procedures should be seriously considered. In the literature, there are several limited studies investigating the effect of fluoro-less or low dose fluoroscopy techniques during ureteroscopic procedures. Mandhani and colleagues(13) reported the results of distal ureteric stones treated with a fluoro-less URS technique. In their series, fluoroscopic imaging was needed for only 6 patients (4.0%). Ureteric balloon dilatation and placement of the double J stent were performed under endoscopic vision. The authors reported that there were no severe complications during the fluoroless URS. Tepeler and colleagues reported the outcomes of 93 patients with distal or proximal ureteral stones treated with URS without fluoroscopic imaging.(2) They reported that fluoroscopic imaging was required for 7 patients, with a mean fluoroscopy time of 9 ± 4.72 seconds, and the URS was successfully performed in 86 patients (92.4%) without the need for fluoroscopic imaging. There were no major complications in this series. The authors also emphasized surgical experience in their study and concluded that the treatment of ureteral stones can be safely and effectively performed in experienced hands with limited or no usage of fluoroscopy. However, this study did not include patients with kidney stones, whereas our study did include patients with kidney stones treated by RIRS.

Greene and colleagues[4] published a series of uncomplicated ureteroscopies in which the fluoroscopy protocol reduced the radiation. In this series, the operation time and stone-free rate were similar in the patients with the lower fluoroscopy dose protocol and the conventional fluoroscopy protocol. In their single-center, retrospective study, the authors concluded that the reduced fluoroscopy protocol resulted in an 82% reduction in fluoroscopy time without altering patient outcomes, and these simple radiation-reducing techniques are safe and improve the safety of the patient, surgeon and operating room staff by reducing radiation exposure.

In another study, Hsi and colleagues[3] presented 162 patients (94 renal stones, 26 proximal/mid ureteral stones and 49 distal ureter stones) who underwent retrograde intrarenal surgery. In their study, the authors described fluoro-less ureterorenoscopy that used no fluoroscopy during the entire ureteroscopic proportion of the procedure. In their study, ureteral access, placement of wire, placement of the double-j stent and other ureteroscopic parts of the procedure were performed utilizing tactile and endoscopic guidance. They found that, excluding fluoroscopy usage to confirm ureteral stent placement, 75% of the patients did not require any fluoroscopy time (fluoro-less) and 85% required 2 seconds or less of fluoroscopy. In their study, the authors concluded that the reduced fluoroscopy protocol resulted in minimal fluoroscopy time and radiation exposure, which was significantly lower than reported in the literature, and that fluoro-less ureteroscopy is safe and feasible. In our study, we defined fluoro-less RIRS as a procedure with only single-shot screening by fluoroscopy during the operation. We performed the procedure in all patients without fluoroscopic imaging. Only 4 patients needed fluoroscopy (additional single-shot screening) during the procedure. According to our outcomes, this RIRS technique (reduced fluoroscopy protocol), in which there is a reduced fluoroscopy time and radiation exposure, is a safe and feasible technique for patients with kidney stones.

Studies have demonstrated that radiation-reducing and fluoro-less ureteroscopy protocols have no impact on an operation's success, time or complication rates and do not increase the technical difficulty.[2-4,8,13] In our study, the URS procedure was successfully performed without the need for fluoroscopy in all patients. We successfully performed the low-dose radiation ureteroscopy technique in kidney stone patients.

Reducing the fluoroscopy time is a necessity for the endoscopic interventions. Avoiding from irradiation is very important for both patient and health workers. During the endoscopic procedures some techniques such as tactile clues, insertion of guides by direct vision through the cystoscope, experienced surgery staffs, preferring advanced fluoroscopic devices (laser guided etc.), covering the extraurinary areas of the body with lead aprons may reduce the fluoroscopy time.[4] On the other hand, awareness of the surgeons own fluoroscopy time and have opportunity for comparison with other surgeons may reduce the fluoroscopy time.[14]

Many authors reported that RIRS is a safe and effective method for the treatment of renal stones. In the literature, the success rate of this method has been reported to range from 65-92%.[16-20] In our study, we detected similar results in the stone-free and success rates. In this study, the stone-free rate was 82.9%, and the complication rate was 6.5%. There were no major complications in our series.

Our study has some limitations and shortcomings. The major limitations of the present study are its retrospective, multi-centered and non-randomized nature. Fluoroscopy was used for single-shot imaging during the procedures, and the duration of the fluoroscopic screening was not measured. The lack of information regarding the amount of radiation exposure is another limiting factor of this study.

CONCLUSION

As a conclusion, fluoroscopic imaging has an essential role during RIRS procedures. It is important to consider the amount of radiation patients, surgeons and operating room staffs are exposed to from fluoroscopy during RIRS for kidney stones. The reduced radiation fluoroscopy protocol of RIRS for kidney stones can be performed in the majority of cases. In this study, we demonstrated that RIRS with low-dose radiation (or the reduced fluoroscopy protocol) for kidney stones can be safely and effectively performed. This technique adds no difficulty and may improve the procedure's safety in terms of radiation exposure to the patient, surgeon and operating room staff.

CONFLICT OF INTEREST

None declared.

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