

Original Article

# Variation of Fluoroscopic Radiation Dose during Endourological Procedures for Renal Stones

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## ABSTRACT

**Introduction:** Fluoroscopic guidance is routine for endourological procedures like percutaneous nephrolithotomy and retrograde intrarenal surgery in vast majority of centers. It is used for the initial retrograde ureteral access to define the pelvicalyceal system, puncture of the desired calyx and dilatation of the tract, aid navigation of stones and calyces, and placement of guide wires and stents. Both the patient and operating staffs are exposed to the radiation during surgery. The purpose of this study is to measure that exposed fluoroscopic radiation dose during these procedures and make operating surgeons aware of their fluoroscopic habit.

**Materials and Methods:** This is prospective observational study, who underwent percutaneous nephrolithotomy (n=60) and retrograde intrarenal surgery (n=43) in our institute between December 2017 and August 2018. Percutaneous nephrolithotomy was done in prone position with prior insertion of ureteric catheter. Retrograde intrarenal surgery was carried out with or without insertion of ureteral access sheath. Fluoroscopic time was taken from the insertion of the ureteric catheter or UAS to the completion of the procedure with double J stenting.

**Results:** For percutaneous nephrolithotomy and retrograde intrarenal surgery group, mean stone size were 21.89 mm and 10.56 mm; mean fluoroscopic time were 117.95 s (range 24-350) and 31.83 s (range 3-103); mean fluoroscopic dose were 29.71 mGy and 6.19 mGy respectively.

**Conclusions:** Among the endourological procedures for renal stones, retrograde intrarenal surgery was associated with less fluoroscopic hazard than percutaneous nephrolithotomy. Awareness of fluoroscopic exposure duration and experience of a surgeon can minimize the radiation hazard during endourological procedures.

**Keywords:** Fluoroscopic dose; Fluoroscopic time; Percutaneous nephrolithotomy; Retrograde intrarenal surgery

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## INTRODUCTION

Fluoroscopic guidance is usually a routine for endourological procedures like percutaneous nephrolithotomy (PCNL) and retrograde intrarenal surgery (RIRS).<sup>1</sup> Limiting the time of exposure, maximizing the distance from the fluoroscopy and shielding mainly adhere in reduction of the fluoroscopic exposure.

Shielding is the standard practice. Distance is an unmodifiable factor for the surgeon although the dose rate is inversely proportional to the square of the distance from the source.<sup>2</sup> So, the only modifiable factor is the time of exposure which depends upon the habit and experience of the operating surgeon.

Adhering to the principle of ALARA (As Low As Reasonably Achievable), radiation exposure during fluoroscopy can be minimized. Increasing surgeons awareness about their fluoroscopy time, can change their fluoroscopy manner and reduces radiation exposure significantly.<sup>3</sup>

We hypothesize that, knowing the fluoroscopic exposure appropriate endourological procedure with less radiation hazard can be chosen. Meanwhile, making the operating surgeon aware about his operating habit, the fluoroscopic time and dose can be reduced.

## MATERIALS AND METHODS

This prospective clinical observational study was conducted in the Department of Urology, Bir Hospital, between December 2017 and August 2018, after approval from the Institutional Review Board of National Academy of Medical Sciences. Patients of renal stone diseases were recruited from the Urology outpatient department. On the basis of European Guidelines 2018 and depending upon the interest of patients and surgeon, they were admitted for PCNL and RIRS one day prior to surgery fulfilling all the departmental protocols.

During endourological procedures all the staffs in the operating room wore 0.5 mm thickness lead apron and thyroid shields. The operating surgeon, assistant and scrub nurse wore additional lead goggles. Personal dosimeter was kept inside the lead apron.

PCNLs were conducted in prone position with prior retrograde placement of 6F ureteric catheter in the desired ureter. Fluoroscopy was used since the placement of the ureteric catheter to the termination of the procedure with the placement of double J stent and/or nephrostomy tube.

RIRS were performed in the lithotomy position. Fluoroscopy was used since the insertion of the Ureteric Access Sheath (UAS) to the termination of the procedure by double J stent placement. Intraoperative stone clearance in PCNL has been defined as the absence of residual stones while in RIRS, the conversion of stone into fine sand or stone particles smaller than the size of the 200 micron fiber. At the end of the procedure, fluoroscopic time and dose of each procedure were recorded from the left of the displaying panel of our fluoroscopic unit (Seimens, Cios Select).

We excluded children, supine PCNL, staged and bilateral procedures from our study. PCNL requiring more than one puncture and RIRS requiring opacification of the pelvicalyceal system, were excluded. Similarly, the procedures in which fluoroscopic time and dose couldn't be recorded due to various reasons, were also excluded.

Mid-term analysis of the data was done with the operating surgeon in the mid of March 2018. They were made aware of their fluoroscopic habit in terms of fluoroscopic time and dose. Analysis of data were done in Microsoft Excel 2016. Baseline

characteristics were compared with Student's t-test for continuous data. p-value <0.05 was considered to be statistically significant.

## RESULTS

Sixty out of one hundred and forty-six PCNLs and forty-three out of ninety-nine RIRS were included in our study. PCNL were done by 4 surgeons. Two of them were novice with experience of < 2 years and other two were experienced one with at least 5 years of experience in endourology. All RIRS were performed by single experienced surgeon. The general variables have been shown in the table 1. Stones sizes in RIRS were significantly smaller than in PCNL. The fluoroscopic time and dose in RIRS were significantly lower than in PCNL, shown in table 2.

**Table 1: General variables among study population**

Variables	PCNL	RIRS	p-value
Age	38.8 ±11.8	37.7 ± 13.9	0.3459
Gender			
Male	39	28	
Female	21	15	
Stone Size (mm)	21.89 (6.9-42.2)	10.56 (7-15)	0.0001
Location			
Pelvis	19	8	
Upper	11	5	
Middle	8	7	
Lower	8	16	
Multiple	14	7	
Density (HU)	1037.233 ± 331.29	924.92 ± 247.39	0.1617

**Table 2: Fluoroscopic time and dose according to the procedure**

Variables	PCNL	RIRS	p-value
Fluoroscopic time (sec)	117.95 (24-350)	31.83 (3-103)	<0.0001
Fluoroscopic dose (mGy)	29.71 (3.3-116.2)	6.19 (0.5-25.6)	<0.0001

Based on the experience of surgeon, novice have significantly longer fluoroscopic time and greater fluoroscopic dose than that of experienced ones in PCNL as shown in table 3.

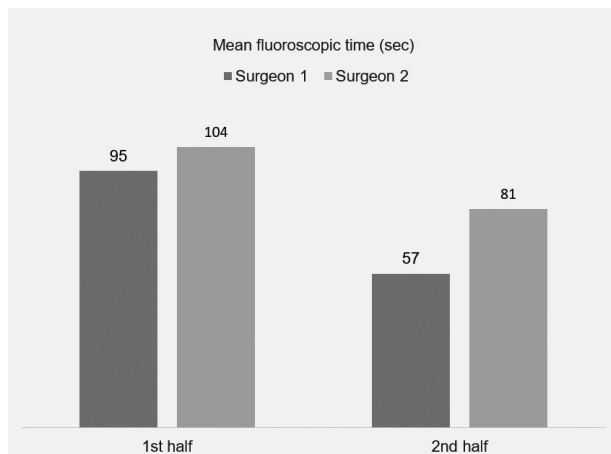
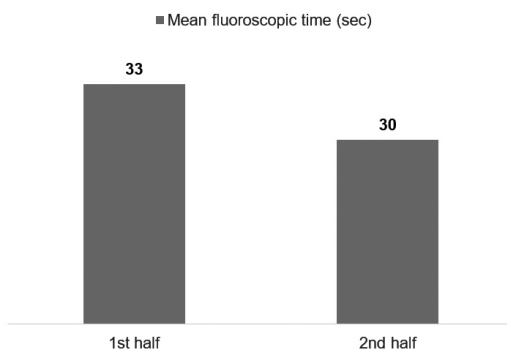
Fluoroscopic exposure and stone burden are interrelated to each other, as larger stone usually has significantly more fluoroscopic exposure and this group of patients also had residual stone, shown in Table 4. But unlike PCNL, in RIRS stone burden was comparatively smaller and similar among its cleared and residual groups.

Variables	PCNL	RIRS	p-value
Fluoroscopic time (sec)	149.66±80.49	81.63±43.64	0.0032
Fluoroscopic dose (mGy)	36.02±23.79	22.10±19.92	0.0303

**Table 4: Fluoroscopic time and dose according to the stone clearance in PCNL and RIRS**

Procedures	Variable	Cleared	Residual	p-value
PCNL	Fluoroscopic time (sec)	102.89±65.13	178.16±84.47	0.0060
	Fluoroscopic dose (mGy)	26.45±21.93	42.75±29.75	0.0483
RIRS	Fluoroscopic time (sec)	31.91±19.28	31.55±8.20	0.4671
	Fluoroscopic dose (mGy)	5.32±3.89	9.46±8.04	0.0842

Among the stone cleared patients in PCNL, performed by experienced surgeons, when they were aware of their fluoroscopic habit, done in our mid-term analysis, the fluoroscopic exposure in second half tends to decrease by 40% and 22% in Surgeon 1 and 2 respectively, as shown in Figure 1. But there was a reduction in fluoroscopic time only by 9% in RIRS, as shown in Figure 2.

**Figure 1: Fluoroscopic habit of experienced surgeons in PCNL****Figure 2: Fluoroscopic habit of surgeon in RIRS**

## DISCUSSION

PCNL and RIRS have become highly accepted and most commonly performed endourological procedures in the current era because of its minimally invasive nature and high stone clearance. One of the drawbacks of these procedures is radiation exposure hazard to the operating personnel and the patient. Although sporadic reports of fluoroscopy-free endourological procedures have been reported, still a vast majority of surgeons all around the world use fluoroscopy as an integral part of these procedures. With adherence to the ALARA principle like collimating the image, placing the intensifier as close to the patient, pulsed fluoroscopy, and last

image hold, the cumulative radiation exposure can be reduced to some extent.<sup>4</sup> But ultimately, it is the habit and experience of operating surgeon upon which this hazard depended and also modifiable.

In a study by Demirci et al.<sup>5</sup> within 5 months, 20 PCNL and 45 RIRS were performed by different surgeons with at least 10 years of experience in endourology. The mean fluoroscopic time and dose in PCNL and RIRS were 337 seconds/142 mGy and 37 seconds/8.3 mGy respectively. Nouredin et al.<sup>6</sup> reported 103 PCNL conducted by a single surgeon and assisted by Post-Graduate Year (PGY) 4 and 5 trainees within 3 years. Their mean fluoroscopy time was 120±5 seconds and it was significantly less in PGY-5 trainees than PGY-4 trainees.

Maajidpour HS<sup>7</sup> measured fluoroscopic time in 100 PCNL and the mean value was 4.5 minutes (range 1-8 minutes). He found that the exposure was maximum to the legs and minimum to the eyes. With the increasing experience of the operating surgeon, the exposure decreased. The assistant received less exposure than the surgeon while the other floor staff, including the attending nurse, received an insignificant amount of radiation.

The recommended occupational exposure to the medical personnel according to The National Council on Radiation Protection and Measurements, is 50 mSv per year. However, Hellawell G.O. et al.<sup>8</sup> proposed that even for an annual workload of 50 PCNLs, with an average fluoroscopic screening time of 10 minutes, the operating surgeon would receive less than 2% of the annual dose limit. Performing 35 cases of PCNLs per month remains within the safe limits.<sup>9</sup> Despite that, the appropriate shielding by the operating staff, maintain the distance of at least 5 feet from the fluoroscopic beam<sup>9</sup>, and the use of personnel dosimeters are of paramount importance in calculating the absorptive dose, which is beyond the scope of this study.

In a study by Tepeler A et al.<sup>10</sup> among 282 PCNLs, the mean fluoroscopic screening time was 10.19±6.3 (range: 3–50) minutes. He concluded that the multiple accesses in large stones lead to a significant increase in fluoroscopy screening time. So, they should be managed only by experienced surgeons, resulting in a significant decrease in radiation exposure. Our result also correlates with the fact that experienced surgeons get significantly less fluoroscopic screening time, compared to that of the novice ones.

A study by Kumari G et al.<sup>11</sup> included 50 PCNLs and the exposure was measured by lithium fluoride thermoluminescent dosimeter chips (TLD chips, TLD 100) at different distances from the X-ray tube. The mean fluoroscopic time and the fluoroscopic doses were 6.04 minutes and 56 mGy respectively. At least 4 feet distance from the x-ray tube was advised to maintain by the floor staff not involved in the surgery.

Ritter M et al.<sup>12</sup> analyzed 402 endourological interventions among which 27 cases were PCNLs, within 1 year. Those interventions were performed by a group of 5 experienced (with more than 2 years of endourological experience) and 3 inexperienced surgeons. But all the PCNLs were performed by only experienced surgeons. The median fluoroscopic time during PCNL in the first and second parts of the study was 7.3 minutes and 6.2 minutes respectively. The decrease in fluoroscopic time in the second half was noticed by both inexperienced and experienced surgeons but they were not significant. We also obtained similar results in the case of RIRS and stone cleared PCNL performed by experienced surgeons. But the number of cases in the second half is less than that of the first half, which may be the drawback of our results.

Similar experience-based reduction in fluoroscopic time in RIRS was noted in a study by Sfoungaristos S et al.<sup>13</sup> They included 92 cases within a year performed by an experienced endourologist

and an Endourology fellow. The mean fluoroscopic time ranges from 12.9 seconds to 298.8 seconds, comparable to our study.

The limitation of our study is driven by the limited number of sample sizes and non-randomization in terms of stone size and surgeons. The lesser number of cases in the second half of our study and inequality of cases among the surgeons were also major drawbacks.

## CONCLUSIONS

Among the endourological procedures for renal stone within similar sizes, RIRS was associated with less fluoroscopic hazard than PCNL. Awareness of fluoroscopic exposure duration and experience of a surgeon can minimize the radiation hazard during endourological procedures.

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