AIM OF THE WORK

The objectives of the present work is to compare the efficacy and safety of percutaneous nephrolithotomy and retrograde intrarenal surgery as treatment modalities for large, branching and/or multiple kidney stones in pediatric age group presented to Urology Department, Alexandria University.

PATIENTS

This prospective randomized clinical study was carried out at the department of Urology, Alexandria University between May 2011 and February 2014. We studied 38 consecutive pediatric patients (43 renal units) ranged from 1 to 16 years, both male and female that had undergone minimal invasive endoscopic surgeries for large upper urinary tract stones (>2cm)

Using bowel randomization method, Patients were randomized into 2 groups:

Group A:

Twenty-one renal units (17 children) underwent RIRS.

Group B:

Twenty-two renal units (21 children) underwent PCNL

- **Inclusion Criteria:**
  - Male and female children below 18 years old.
  - Single, multiple, branching and Staghorn stones > 2cm in largest diameter.
  - All types of stones above the L3 Vertebra.
- **Exclusion Criteria:**
  - Single stones < 2cm.
  - Stones below L3 Vertebrae.
  - Current urinary tract infection.
  - Children with uncorrected bleeding diathesis.
  - Renal insufficiency.

All patients' families approved the study, and informed consent was obtained from all parents before the procedure.

METHODS

❖ Patient evaluation:

I. Data including patients' criteria (age, sex, predisposing factors, symptoms at presentation, family history of urolithiasis) and Stone criteria (stone length and width, number, location and site) were collected.

II. All patients were subjected preoperatively to:

a. History taking including age, sex, family history, geography, socioeconomic status, clinical symptoms, presence of associated metabolic or anatomic abnormalities and history of prior surgical operation e.g. augmentation cystoplasty.

b. Clinical examination for palpable abdominal swelling and evaluation of the spine for dimples or other defects.

c. Routine laboratory investigations:

- Complete blood picture (CBC): including hemoglobin (HB%), HCT, WBC, Platelets.
- Coagulation studies
  - Bleeding and coagulation times (BT-CT).
  - Prothrombin time and activity.
- Blood urea & serum creatinine.
- Serum uric acid.
- General liver profile.
- Serum electrolytes.
- Complete urinalysis, culture and sensitivity.

d. Radiological evaluation including:

- Plain X-ray abdomen and pelvis (KUB); antero-posterior with or without lateral view.
- Abdominal ultrasonography (US).
- Non-contrast spiral CT was performed for all cases including radiolucent stones, and for quantitative assessment of the stone burden, location and density.
- Intravenous urography (IVU) was limited to specific indications such as complex anatomical abnormalities

❖ Preoperative patient preparation:

Preoperative antibiotics are required. Sterile urine is mandatory before the procedure. This was achieved by the urine analysis followed by culture and sensitivity and administration of specific antibiotics for 5 to 7 days prior to surgery. Even in patients with documented urine sterility, preoperative antibiotic prophylaxis was administrated.

❖ RIRS:

All procedures were done in lithotomy position under general anesthesia. Routine prophylactic antibiotics were administrated according to the child weight. We usually gave a third generation cephalosporin and gentamycin immediately before the procedure; and this is continued for several days after the procedure.

A diagnostic cystoscopy was usually done. After identifying ureteric orifice (UO), ureteroscopy was performed using 4.5 semirigid self-dilating Ureteroscope by Richard Wolf ®. No balloon dilatation was used to in all cases. Ureteroscope passes uretero-vesical junction (UVJ) helped by hydrodilatation. If not applicable as narrow orifice, the ureteroscope was introduced over a 0.025 Hydrophilic coated guide wire in a Monorail fashion and finally with oscillated movements allowing a rotation of tip of instrument, looking for center of the ureter.

The semirigid ureteroscopy was advanced all the way to the kidney to inspect and dilate the ureter (Figure 8). As soon as the scope was in the kidney, the guide wire was changed to a 0.035 hydrophilic-coated stiffer wire for access sheath introduction. Access sheath (9.5-11.5) was used in most of the cases, to minimize intrarenal pressure all along the procedure (Figure 9). If failed to introduce the sheath, a 6.9 Fr semirigd ureteroscope by Karl Storz® was introduced for further dilatation of the ureter. Then the access sheath was introduced easily afterwards.

In cases of access sheath introduction failure, either the flexible scope was advanced over the guide wire under C-arm guidance, or just a JJ stent was left for passive dilatation of the ureter, and the patient was readmitted after 10 days for the procedure. This was dictated by surgeon preference for the procedure and the requirement for multiple entries by the scope.

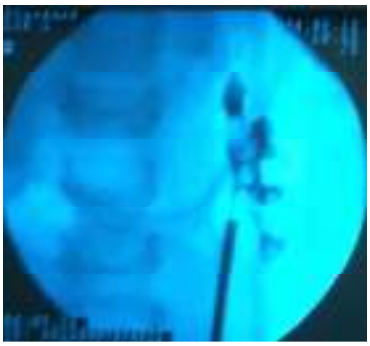

Figure (8): Semirid ureteroscope in the kidney

Figure (9): FURS through Access sheath (9.5-11.5) by Cook Urology.

In most cases, FURS Flex X2 by Karl Storz® (Figure 10) was used; with its distal tip diameter of 6.5 Fr and deflection of 270 degree both directions, access to the entire collecting system of pediatric kidney was achievable. Some of the cases we used URP5 by Olympus company (Figure 11) (5.9 Fr distal diameter with 275 degree ventral and 180 degree dorsal deflection).

Figure (10): Flex X2 by Karl Storz

Figure (11): URP 5 by Olympus

The ureteroscope is then advanced through the access sheath, or over the 0.035 stiff glide wire in cases of access sheath introduction failure. At reaching the stone, holmium: YAG laser was used for stone disintegration. Using the vaporization technique by moving the laser fiber over the stone surface that results in stone vaporization and fragmentation (Figure 12). A laser fiber of 200 um was utilized. The laser energy of (0.6–0.8 J) at a pulse rate of (6–10 Hz) with maximum power of 8 W was applied. Stones fragmented into powder and smaller pieces regardless to its size without any trial for gravels removal.

At the end of the procedure a 1.9 Fr dormia basket was introduced through the scope for extraction of some fragments for analysis. Stones retrieved at the end of the procedures were examined by chemical analysis and infrared spectroscopy

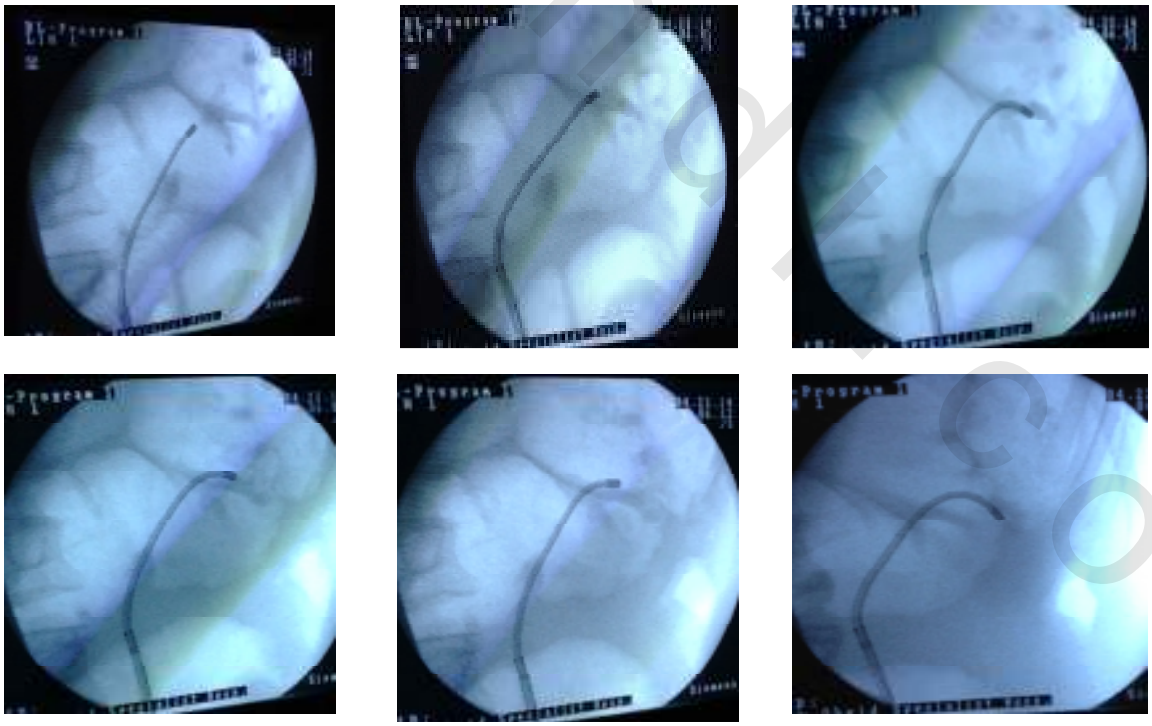

Figure (12): C-arm view for laser fragmentation process of staghorn stone using FURS (Flex X2)

The FURS was removed and a guidewire is inserted through the access sheath under C-arm guidance. A JJ stent was left postoperatively in all cases, with sizes of 3, 4.8 and 6 Fr and length varies according to the age and height of the child.

❖ PCNL:

All the procedures were performed in prone position under general anesthesia. After the insertion of a 6 Fr open-ended ureteric catheter in lithotomy position, contrast material was injected into the catheter for retrograde opacification of the collecting system under fluoroscopic guidance. The patient was then put in prone position. A Rolled towel was used to support contra lateral side. Puncture was performed under C-arm guidance in a preselected calyx guided by CT images and or IVU. Multiple punctures were performed whenever possible and a guide wire was left in each calyx that might be used during the procedure (Figure 13). Only one tract was dilated, subsequent ones as needed.

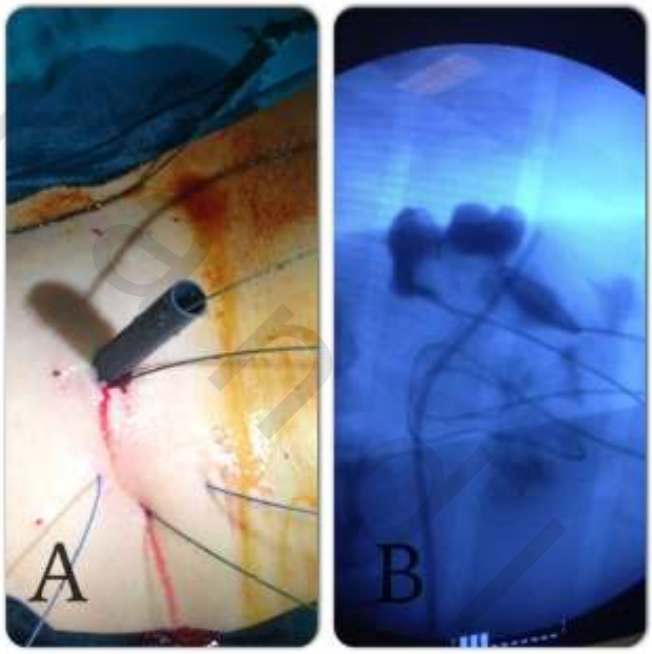

Figure (13): **A.** Cutaneous view for multiple puncture wires in different calyces, **B**. C-Arm view

Serial dilatation of the tract was done using Alken's metal dilators. Some cases (non recurrent cases) were dilated using single step Amplatz Dilator (18 Fr) after facial dilators to 14 Fr. After tract was dilated to 18 Fr, a 20 Fr Amplatz sheath was placed. A 17 Fr Karl Storz pediatric nephroscope was used in all cases (Figure 14). Pneumatic lithotripsy was used for stone disintegration and forceps for stone extraction. Flexible Nephroscope by Gyrus-ACMI (ACN-2) (15 Fr outer diameter) was used in all cases either for checking or extraction of residual stones with basket at the end of the procedure.

Figure (14): Pediatric Nephroscope in 19 Fr Amplatz sheath

Irrigation fluid (saline) was kept at body temperature to avoid hypothermia. Putting a tube, tubeless or total tubeless was dictated by intraoperative events and according to each case individually.

A plain X-ray of the abdomen and pelvis was performed on the first postoperative day and if no residual fragments were encountered, the nephrostomy was removed (in cases of tubed PCNL). Plain X-ray chest was also performed in patients who had a supracostal puncture whenever hydrothorax was suspected. Follow up was performed every month for 3 months by ultrasound and urine culture. Then patients were instructed to come back annually for follow up.

Type of endoscopic equipment used and energy source, operative time, radiation exposure time and technique, postoperative outcome, hospital stay, ancillary procedures and complications were recorded. Extracted stones were sent for analysis.

❖ Follow up:

Same operative day

Patients had chest x-ray soon after recovery from anesthesia if there was suspicious hydrothorax by fluoroscopy or distressed respiration by auscultation.

- ✓ Fluoroscopy was considered positive for fluid when a distinct demarcation of fluid from lung could be identified laterally along the chest wall.
- ✓ Upright chest x-ray was considered positive when the costophrenic angle was blunted and/or diaphragm was obscured by fluid density.

Before discharge

Stone clearance was assessed on a plain abdominal X-ray (KUB) before discharge (1 or 2 days after surgery).

One month later

Plain abdominal X-ray was done one month later to evaluate stone passage and residual. A non-contrast spiral CT was used for radiolucent stones cases.

Three months later

Ultrasound was done at patients last visit after 3 months period to evaluate backpressure. If backpressure encountered, VCUG and/or IVU was done to document any ureteral stricture or reflux.

Stone-free status is confirmed by the absence of any stone fragments in follow up imaging. Stone fragment < 4 mm considered insignificant residual not necessitated secondary intervention

❖ Stone analysis and metabolic evaluation

Stones retrieved at the end of the procedures were examined by chemical analysis and infrared spectroscopy. Patients were subjected to the following:

1) Urine analysis, urine culture and antibiotic sensitivity.
2) Urinary calcium: creatinine ratio after an overnight fasting.
3) Oral calcium challenge test in case of hypercalciuria
4) Assessment of serum levels of blood urea nitrogen, creatinine, calcium, phosphorus, sodium, potassium, uric acid, blood pH, HCO3 and anion gap.
5) Urinary 24-h collections were done for volume, calcium, oxalate, citrate and uric acid.
6) Serum parathyroid hormone level was obtained only if serum calcium or ionized calcium was elevated.
7) Screening for cystinuria by examination of the freshly voided morning urine for cystine hexagonal crystals and by cyanide-nitroprusside test.

❖ Statistical analysis of the data[114]

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0 [115]. Qualitative data were described using number and percent. Quantitative data were described using Range (minimum and maximum), mean, standard deviation and median. Comparison between different groups regarding categorical variables was tested using Chi-square test. When more than 20% of the cells have expected count less than 5, correction for chi-square was conducted using Fisher's Exact test or Monte Carlo correction. The distributions of quantitative variables were tested for normality using Kolmogorov-Smirnov test, Shapiro-Wilk test and D'Agstino test. Also Histogram and QQ plot were used for vision test. If it reveals normal data distribution, parametric tests was applied. If the data were abnormally distributed, non-parametric tests were used. For normally distributed data, comparison between two independent population were done using independent t-test also paired t-test is used to analyze two paired data. For abnormally distributed data, comparison between two independent populations were done using Mann Whitney test. Significance of the obtained results was judged at the 5% level.

RESULTS

Thirty-eight pediatric patients (43 renal units) with upper ureteric and kidney stones were included in this study. They were randomized into 2 groups according to the procedure. Some patients who had bilateral stones disease were included in both groups as they were treated in each side with a different procedure.

Group A: Seventeen children (21 renal units) underwent RIRS.

Group B: Twenty-one children (22 renal units) underwent PCNL.

Age:

The mean age of patients in both groups was comparable; being 6.44 and 6.93 in group A and B respectively, ranged from (1 year and 5 months to 16 years) (Table 2).

Sex:

Sex distribution was not different in both groups. The study included 14 male (66.7%) and 7 female (33.3%) in group A, and 14 male (63.6%) and 8 female (36.4%) in group B (Table 2).

Side & laterality:

- In Group A: 9 patients (42.9%) underwent RIRS on the right side, and 12 patients (57.1%) on the left side.
- In Group B: 10 patients (45.5%) underwent percutaneous surgery on the right side, and 12 patients (54.5%) on the left side (Table 2).

Stone recurrence:

3 (14.3%) and 4 cases (18.2%) in Group A and B respectively were recurrent stone formers after primary endoscopic intervention (Table 2).

Serum creatinine was elevated in only one patient of the PCNL group B, was 4.4 mg/dL. Patient's elevated serum creatinine was medical rather than stone reason. The preoperative characteristics of the groups are summarized in Table 2.

Table 2: Comparison between the studied groups according to demographic data

	RIRS (n=21)		PCNL (n=22)		Test of Sig.	p
	No.	**%**	**No.**	**%**		
Sex						
Male	14	66.7	14	63.6	χ^2=0.043	0.835
Female	7	33.3	8	36.4		
Age						
Min. – Max.	1.67 – 16.0		1.42 – 13.0		t=0.374	0.710
Mean ± SD.	6.44 ± 4.84		6.93 ± 3.55			
Median	5.0		8.0			
Side						
Right	9	42.9	10	45.5	χ^2=0.029	0.864
Left	12	57.1	12	54.5		
Recurrence						
No	18	85.7	18	81.8	χ^2=0.120	^{FE}p=1.000
Yes	3	14.3	4	18.2		

χ^2: Chi square test
FE: Fisher Exact test
t: Student t-test

Stones size, shape, locations and degree of hydronephrosis: (Table 3)

- **Average stone size:**

The stone burden was calculated by adding the length of the longest axis of each stone. Ranged from 20 to 62 mm in group A with a mean of 32.86 ± 10.77, and 22 to 60 mm in group B with a mean of 39.95± 12.47.

- **The shape of the stones:**
  - In RIRS group A: there were 5 staghorn stones (1 of them was partially staging), 11 multiple kidney stones, 4 large stones (over 2 cm in largest diameter), and one neglected calcified JJ stent.
  - In PCNL group B: there were 3 staghorn stones (including 2 partial stag), 17 multiple kidney stones, and 2 large stones.
- **Number of calyces involved with stones** ranged from 1 to 6 calyces in RIRS group A, and 1 to 7 calyces in PCNL group B with a mean of 3.38 ± 1.60 and 3.91 ± 1.69 calyx respectively.
- **Degree of calyceal dilatation** ranged from 0 to Grade 4 hydronephrosis, with a mean dilatation of 1.95 ± 1.10 in group A, and 2.59 ± 1.01 in group B

There was no statistically significant difference regarding any of the above variants between both groups

Table 3: Comparison between the studied groups according to Stone Size, Shape of stone, N. Calyces involved and Dilatation

	RIRS (n=21)		PCNL (n=22)		Test of Sig.	p
	No.	%	No.	%		
AV. Stone Size (mm)						
Min. – Max.	20.0 – 62.0		22.0 – 60.0			
Mean ± SD.	32.86 ± 10.77		39.95 ± 12.47		t = 1.994	0.053
Median	30.0		41.0			
Shape of stone						
Partial stag	1	4.8	2	9.1		
Stag	4	19.0	1	4.5		
Multiple	11	52.4	17	77.3	χ^2=4.892	0.267
Large	4	19.0	2	9.1		
Calcified JJ	1	4.8	0	0.0		
N. Calyces inv						
Min. – Max.	1.0 – 6.0		1.0 – 7.0			
Mean ± SD.	3.38 ± 1.60		3.91 ± 1.69		Z = 1.124	0.261
Median	3.0		4.0			
Dilatation						
Min. – Max.	0.0 – 4.0		1.0 – 4.0			
Mean ± SD.	1.95 ± 1.10		2.59 ± 1.01		t=1.972	0.056
Median	2.0		3.0			

χ^2: Chi square test
t: Student t-test
Z: Z for Mann Whitney test

Stone distribution within the collecting system: (Table 4) (Figure 15)

The primary stone location within a kidney with multiple stones mostly being the pelvis of the kidney, followed by lower and anterior portion of the kidney, than middle and lastly upper portion of the kidney.

Table 4: Comparison between the studied groups according to stone location

	RIRS (n=21)		PCNL (n=22)		χ^2	p
	No.	%	No.	%		
Upper Ureter	4	19.0	1	4.5	2.326	^{FE}p=0.185
Renal Pelvis	13	61.9	18	81.8	2.146	^{FE}p=0.185
Upper Anterior	3	14.3	8	36.4	2.751	0.097
Upper Posterior	1	4.8	3	13.6	1.003	^{FE}p=0.607
Mid Anterior	6	28.6	11	50.0	2.064	0.151
Mid Posterior	7	33.3	8	36.4	0.043	0.835
Lower Anterior	11	52.4	21	95.5	10.471*	0.001*
Lower Posterior	8	38.1	15	68.2	3.909*	0.048*

χ^2: value for Chi square
FE: Fisher Exact test

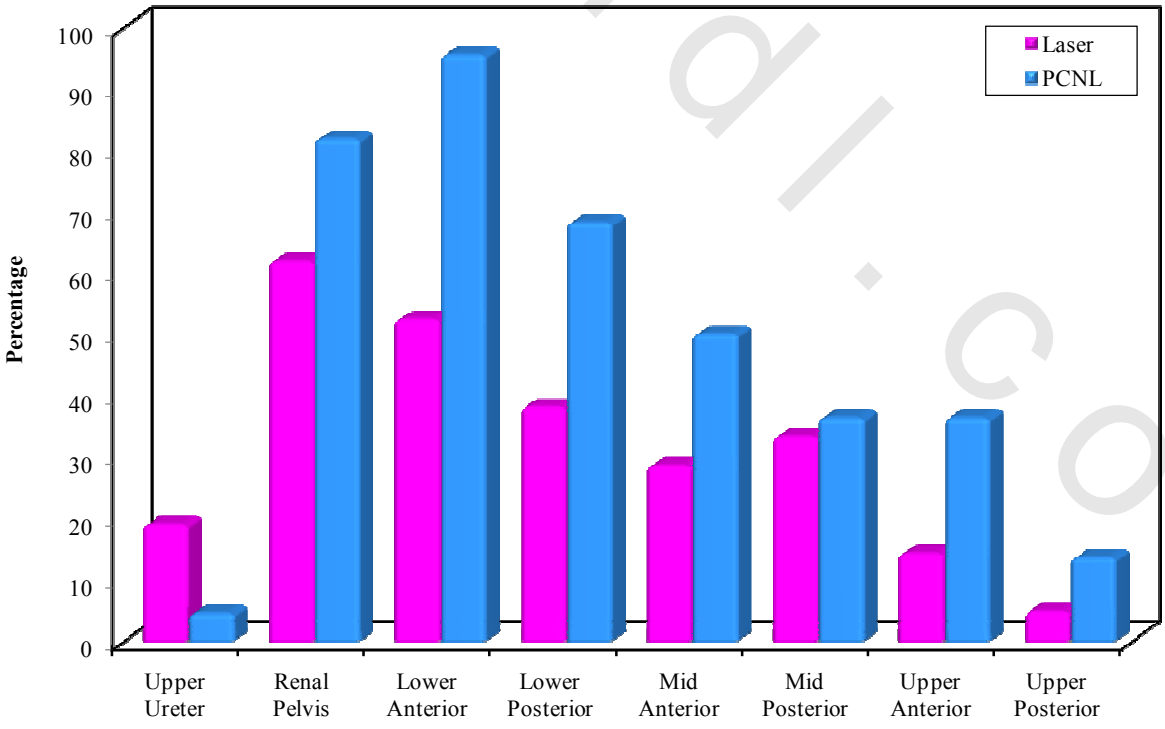

Figure (15): Comparison between the studied groups according to stone location

Percutaneous puncture and collecting system site of entrance in PCNL group: (Table 5)

During PCNL procedure, an upper or middle calyceal puncture was preferred. A single calyceal puncture was performed for all renal units. Only one renal unit with multiple kidney stones required two punctures (lateral middle calyceal puncture in addition to the original upper calyceal one), despite the aid of flexible nephroscope for complete clearance of the stones.

In PCNL group there were 7 patients had a supracostal 12th rib puncture (31.8%), and 15 patients had a subcostal puncture (68.2%).

In most PCNL cases a posterior middle calyx puncture was used to access main stone bulk (59%), 7 patients had a posterior upper calyx puncture (32%), and 2 patients had a posterior lower calyx puncture (9%).

Table 5: Distribution of studied sample according to level and puncture site in PCNL

	No.	%
Costal		
Sub	15	68.2
Supra	7	31.8
Primary puncture site		
Posterior lower	2	9.1
Posterior Mid	13	59.1
Posterior upper	7	31.8

Access sheath and pre-stented Ureters in RIRS group: (Table 6)

Access sheath was preferably used in most flexible ureteroscopies. The use of access sheath was dictated by doctor preference and difficulty of introduction. Access sheath was used in 14 patients (66.7%). 3 patients faced difficult ureteric dilatation and access sheath introduction, as a result a JJ stent was inserted for passive dilatation and patient was readmitted after 10 days for the procedure.

Five patients had a pre-stented ureter before the procedure, 3 of them was due to difficult dilatation as previously mentioned, and the other 2 was for the relief of old standing obstruction by the presented stone.

Two patients no access sheath were used; only the scope was introduced over the wire in monorail fashion under C-arm guidance. In these last two cases, introduction of the scope was limited to only single entry.

Table 6: Distribution of studied sample according to access sheath and pre-JJ in FURS group

	No.	%
Access Sheath	14	66.7
Pre-JJ	5	23.8

Operative time, radiation time and hospital stay: (Table 7)

- **The mean operative time** ± SD in minutes was longer in RIRS group comparing to the PCNL group, being 79.05 ± 30.36 in the RIRS group A, and 69.77 ± 29.58 in the PCNL group B. There was no statistically significant difference, (*p =0.316)*.
- **The mean radiation** time ± SD in minutes was 1.62 ± 0.82 in RIRS group, and 3.07 ± 1.03 in PCNL group. The difference was statistically significant, *p <0.001*.
- **The mean hospital stay** ± SD in days was 1.05 ± 0.52 and 2.59 ± 1.98 in the RIRS group and PCNL group respectively, with a longer hospital stay time in the PCNL group. Again this difference was statistically significant, *p <0.001*.

Table 7: Comparison between the studied groups according to Operative time (min) radiation time (min) and Hospital stay

	RIRS (n=21)	PCNL (n=22)	Test of Sig.	p
Operative time (min)				
Min. – Max.	30.0 – 135.0	15.0 – 140.0		
Mean ± SD.	79.52 ± 29.45	69.77 ± 29.58	t=1.083	0.285
Median	85.0	70.0		
Radiation time (min)				
Min. – Max.	1.0 – 4.0	2.0 – 6.0		
Mean ± SD.	1.62 ± 0.82	3.07 ± 1.03	Z=4.388*	<0.001*
Median	1.50	3.0		
Hospital stay				
Min. – Max.	0.50 – 2.0	1.0 – 9.0		
Mean ± SD.	1.05 ± 0.52	2.59 ± 1.98	Z=4.091*	<0.001*
Median	1.0	2.0		

t: Student t-test
Z: Z for Mann Whitney test
*: Statistically significant at p ≤ 0.05

Postoperative outcomes: (Table 8)

There was a statistically significant difference between the two studied groups regarding primary stone free rate (Table 6).

In the RIRS group A, 15 (71.4%) out of the 21 patients had a complete clearance, 6 patients with residual stones underwent secondary procedures. Two patients had immediate intervention of percutaneous access. On the other hand, in the PCNL group B, there were 21 patients (95.5%) with complete clearance, only 1 patients needed a 2nd session PCNL.

The stone clearance rate was higher in the PCNL group than in the RIRS group. This difference was statistically significant.

Table 8: Comparison between the two studied groups according to Stone free and Auxiliary procedure

	RIRS (n = 21)		PCNL (n = 22)		χ^2	p
	No.	%	No.	%		
Stone free						
Free	**15**	**71.4**	**21**	**95.5**	4.551*	FEp= 0.046*
No	**6**	**28.6**	**1**	**4.5**		
Auxiliary procedure						
2nd session	2	9.5	1	4.5		
Prone PCNL same setting	1	4.8	0	0.0	2.635	MCp= 1.000
Supine PCNL at same setting	1	4.8	0	0.0		
Dissolution therapy	2	9.5	0	0.0		

χ^2: value for Chi square
FE: Fisher Exact test
MC: Monte Carlo test

Complication: (Table 9)

There was no major complication in our series. No patient had hypothermia during RIRS or PCNL, as reported by the anesthesiologist's report. PCNL group B has a statistically significant more complication rate comparing to RIRS group A (*p=0.018*). Only 2 patients (9.5%) in RIRS group encountered moderate pyrexia (<39C). Fever was controlled by intravenous antibiotics and antipyretics. On the other hand, in PCNL group B, complication rate was 41%. Including 3 patients had intraoperative bleeding required blood transfusion, 4 patients had postoperative moderate pyrexia, 1 patient had ileum injury necessitated open repair and 1 patient who had a supracostal puncture developed hydrothorax. The hydrothorax was resolved spontaneously without the need of chest tube placement.

Table 9: Comparison between the two studied groups according to Postoperative complications

	RIRS (n = 21)		PCNL (n = 22)		χ^2	p
	No.	%	No.	%		
Postoperative complications						
No	**19**	**90.5**	**13**	**59.1**	5.559*	0.018*
Yes	**2**	**9.5**	**9**	**40.9**		
Bleeding required blood transfusion	0	0.0	3	13.6		
Fever	2	9.5	4	18.2		
Hydrothorax	0	0.0	1	4.5		
Ileum injury	0	0.0	1	4.5		

χ^2: Chi square test
*: Statistically significant at $p \leq 0.05$

Hemoglobin and hematocrit: (Table 10,11)

Postoperative Hemoglobin and Hematocrit drop was higher in PCNL group, ranged from 0.5 to 5.0 g/dL for hemoglobin and 1.1 to 15.7 % for hematocrit. In RIRS group hemoglobin drop ranged from 0 to 1.3 g/dL and hematocrit drop ranged from 0.9 to 5.7 %. There was a statistically significance between the two studied group regarding the drop. *(p=0.012)*

Table 10: Comparison between the two studied groups according to Hemoglobin (g/dl)

Hemoglobin (g/dl)	RIRS (n = 21)	PCNL (n = 22)	Test of sig.	p
Pre				
Min. – Max.	9.50 – 12.0	8.90 – 13.40		
Mean ± SD	10.93 ± 0.87	11.92 ± 1.52	t = 1.845	0.079
Median	11.25	12.40		
Post				
Min. – Max.	9.10 – 11.50	7.70 – 12.10		
Mean ± SD	10.40 ± 0.83	10.26 ± 1.61	t = 0.247	0.808
Median	10.30	10.80		
p_1	0.001*	0.003*		
Drop				
Min. – Max.	0.0 – 1.30	0.50 – 5.0		
Mean ± SD	0.53 ± 0.35	1.60 ± 1.43	Z = 2.498*	0.012*
Median	0.45	1.40		

t: Student t-test
Z: Z for Mann Whitney test
p_1: p value for Paired t-test for comparing between pre and post
*: Statistically significant at $p \leq 0.05$

Table 11: Comparison between the two studied groups according to HCT

HCT	RIRS (n = 21)	PCNL (n = 22)	Test of sig.	p
Pre				
Min. – Max.	29.20 – 40.50	27.40 – 40.70		
Mean ± SD	35.13 ± 3.95	35.33 ± 3.91	t = 0.122	0.904
Median	35.30	35.70		
Post				
Min. – Max.	27.50 – 39.20	23.0 – 34.90		
Mean ± SD	32.90 ± 4.16	28.60 ± 3.98	t = 2.420*	0.026*
Median	32.35	27.80		
p_1	0.002*	0.001*		
Drop				
Min. – Max.	0.90 – 5.70	1.10 – 15.70		
Mean ± SD	2.23 ± 1.67	6.74 ± 4.43	Z = 2.679*	0.007*
Median	1.50	5.80		

t: Student t-test
Z: Z for Mann Whitney test
p_1: p value for Paired t-test for comparing between pre and post
*: Statistically significant at $p \leq 0.05$

Tube, tubeless and total tubeless: (Table 12)

Most of our PCNL cases ended up with only a JJ stent without a nephrostomy tube (45.5%). Total tubeless procedure was adopted in 27.3% of PCNL patients.

Table 12: Distribution of studied sample according to Tube PCNL

	No.	%
Tube PCNL		
Tube	6	27.3
Tubeless	10	45.5
Total tubeless	6	27.3

Follow up: (Table 13)

Stone free rate increased to be 95.2% and 100% in group A and B respectively after 2ry procedures. One patient in group A had insignificant residual fragments (< 4 mm) in 1 month follow up CT scan.

None of the patients in both groups developed stricture in 3 months follow up IVU. Only 1 patient in RIRS group developed G I reflux in 3 month follow up, which was resolved spontaneously in 1 year follow up period.

Table 13: Comparison between the two studied groups according to 1 month follow up (CT) and 3 months follow up (IVU)

	RIRS (n = 21)		PCNL (n = 22)		χ^2	^{FE}p
	No.	%	No.	%		
1 month follow (CT)						
Free	20	95.2	22	100.0	1.073	0.488
Insig. Residual	1	4.8	0	0.0		
3 month follow (IVU)						
Stricture	0	0.0	0	0.0	-	-
Reflux	1	4.8	0	0.0		

χ^2: value for Chi square
FE: Fisher Exact test
*: Statistically significant at $p \leq 0.05$

Stone composition and analysis: (Table 14)

All the retrieved stones were examined by chemical analysis and infrared spectroscopy. **Figure 13** shows the distribution of the major components of the urinary stones in both groups which were; calcium oxalate in 17 cases (39.5%), calcium phosphate in 7 cases (16.2%), pure uric acid stones in 8 cases (18.6%), cystine stones in 7 cases (16.2%) and struvite (magnesium ammonium phosphate) in 3 cases (6.9%). Mixed uric acid with Ca oxalate stones occurred in 1 case (2.3%). **Table 14** shows distribution of stone composition in each group.

Table 14: Comparison between the two studied groups according to Stone analysis (χ^2: value for Chi square, MC: Monte Carlo test)

	Laser (n = 21)		PCNL (n = 22)		χ^2	^{MC}p
	No.	%	No.	%		
Stone analysis						
Calcium oxalate	7	33.3	10	45.5	6.204	0.175
Calcium phosphate	2	9.5	5	22.7		
Uric acid	5	23.8	3	13.6		
Cysteine	4	19.0	3	13.6		
Sturvite	2	9.5	1	4.5		
Mixed	1	4.8	0	0.0		

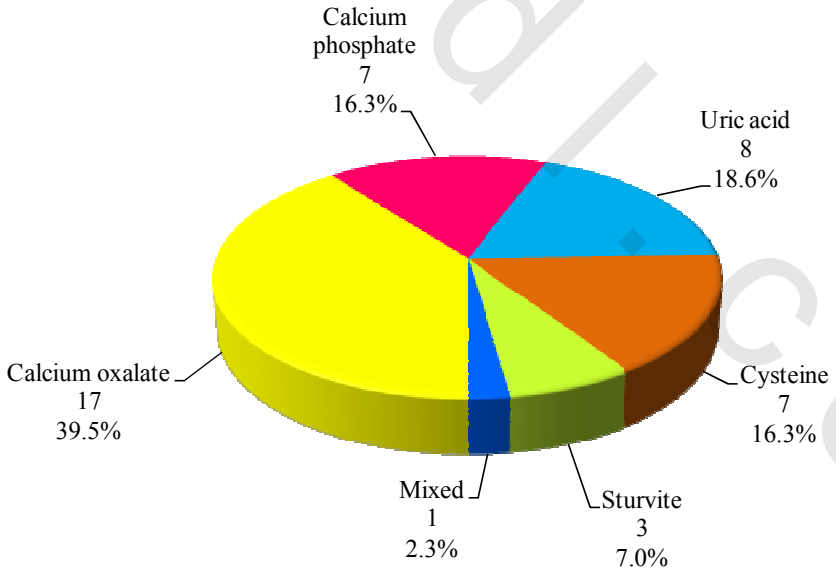

Figure (16): Comparison between the two studied groups according to Stone analysis

RIRS CASES (GROUP A)

Fig (a)

Fig (b)

Fig (c)

Fig (d)

Fig (e)

Fig (f)

Figure (17): 2 years old boy under went FURS for bilateral Staghorn stones
(a) Coronal plan of a reconstructed non contrast CT scan showing bilateral Staghorn stones
(b) & (c) Postoperative CT scan after left FURS and bilateral JJ insertion
(d) Oblique coronal reconstructed CT scan after 1 month of left FURS and bilateral JJ insertion
(c) 3 months follow up IVU after right FURS and bilateral JJ removal
(d) Voiding film showing right side G I reflux

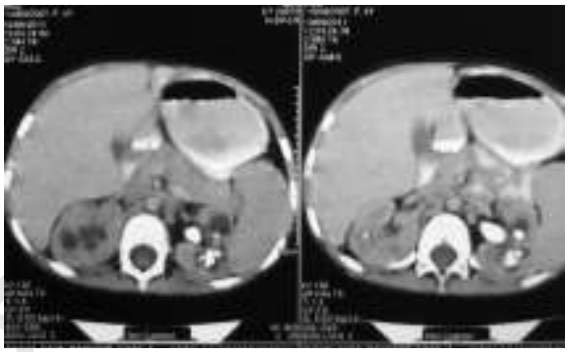

Fig (a)

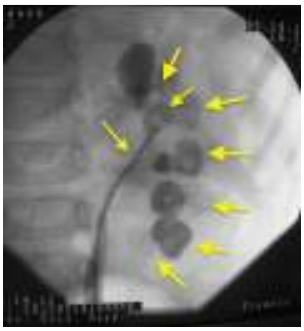

Fig (b)

Fig (c)

Fig (d)

Fig (e)

Figure (18): 4 years old girl underwent FURS for multiple left kidney stones
(a) Preoperative Non-contrast CT showing multiple left kidney stones.
(b) C-arm view showing stones distribution (filling defects) within the kidney (yellow arrows).
(c) Postoperative KUB 2 days after left FURS with left JJ in place.
(d) Postoperative CT (coronal view) 2 days after left FURS showing residual fragments with JJ in place.
(e) 1 month follow up plain KUB free of stones after dissolution therapy and JJ extraction.

Fig (a)

Fig (b)

Fig (c)

Fig (d)

Fig (e)

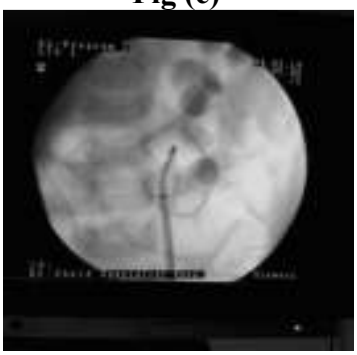

Fig (f)

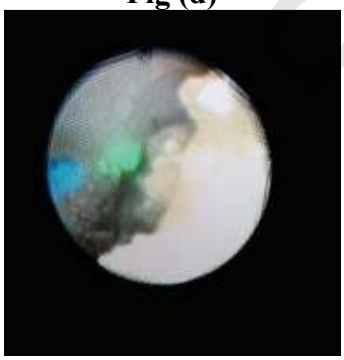

Fig (g)

Fig (h)

Figure (19): 2 years old boy underwent bilateral FURS for left Staghorn stone and neglected calcified Right JJ
(a) & (b) Non contrast CT showing left Staghorn stone and Right Calcified JJ.
(c) 9.5-11.5 Access sheath was used to access the kidney for both sides.
(d) & (e) Fluoroscopic view for right kidney inspection after calcified JJ removal.
(f) & (g) Fluoroscopic and endoscopic view for left kidney stone treatment.
(h) Postoperative KUB stone free after 1 month of the 2 sessions procedures.

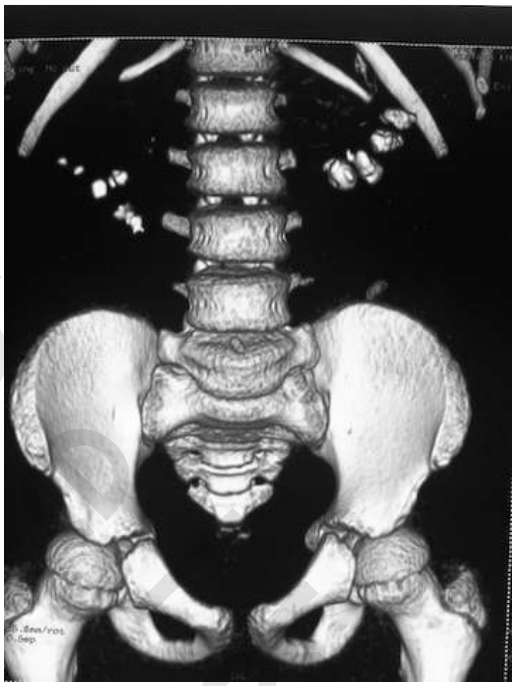

Fig (a)

Fig (b)

Fig (c)

Fig (d)

Fig (e)

Figure (20): 11 years old boy with recurrent bilateral multiple kidney stones underwent FURS for left side. (PCNL was done for the right side)
(a) & (b) Preoperative non contrast CT showing stone burden and distribution.
(c) Preoperative KUB.
(d) Postoperative KUB after left FURS and bilateral JJ stents fixation, with residual fragments (yellow arrow).
(d) 1 month follow-up KUB showing passage of residual fragments.

Fig (a)

Fig (b)

Fig (c)

Figure (21): 5 years old boy with 2 cm pelvic stone in left kidney underwent FURS

(a) Plain film showing radiopaque shadow in the left kidney region
(b) IVU showing position of the stone in the left kidney
(c) Postoperative plain film free of stone with JJ stent in place

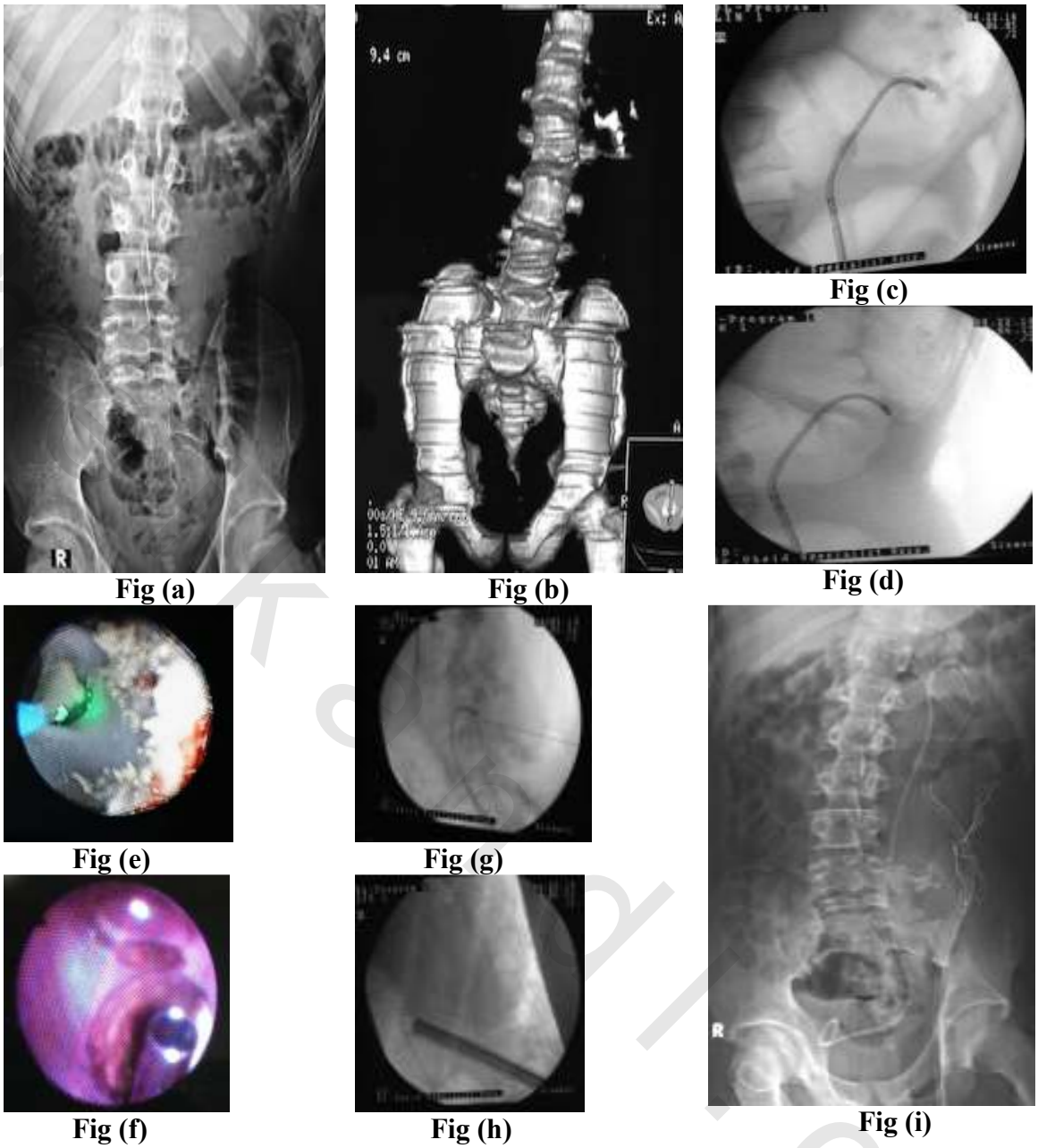

Figure (22): 14 years old boy with kyphoscoliosis had a partial staghorn stone underwent FURS and supine PCNL after failure to access lower calyx stone with FURS alone.
(a) & (b) KUB and reconstructed CT for left partial staghorn stone.
(c) &(d) Fluoroscopic view showing flexible ureteroscopy at time of laser disintegration and after completion of stone fragmentation.
(e) Endoscopic view during laser disintegration.
(f) & (g) Endoscopic and Fluoroscopic view for 18 gauge needle introduced into the collecting system, guided by ureteroscope and fluoroscopy in supine position.
(h) Fluoroscopic view after introduction of nephroscope in supine position.
(i) Postoperative KUB free of stones with JJ stent and nephrostomy tube in place.

Fig (a)

Fig (b)

Fig (c)

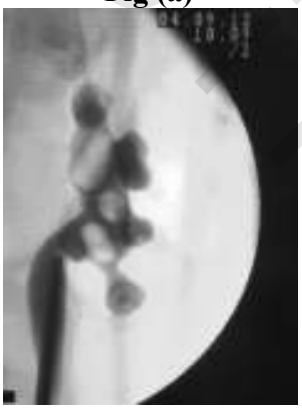

Fig (d)

Fig (e)

Fig (f)

Fig (g)

Figure (23): 2 years old boy with multiple left kidney stones underwent FURS
(a) (b) & (c) reconstructed, sagittal and coronal view respectively of a non contrast CT showing multiple left kidney stones.
(d) Fluoroscopic view showing stones distribution within the kidney (filling defects).
(e) Endoscopic view during the process of stone disintegration.
(f) Postoperative KUB free of stones and JJ in place.
(g) 1 month follow-up reconstructed CT with insignificant stone fragment with JJ stent in place.

PCNL CASES
(GROUP B)

Fig (a)

Fig (b)

Fig (c)

Figure (24): 3 years old boy with multiple right kidney stones underwent PCNL

(a) Preoperative Plain KUB showing stone burden

(b) Preoperative IVU showing stone distribution within the kidney and site of entrance (X) of the nephroscope

(c) Postoperative KUB showing residual stones (yellow arrow) and double J stent in place

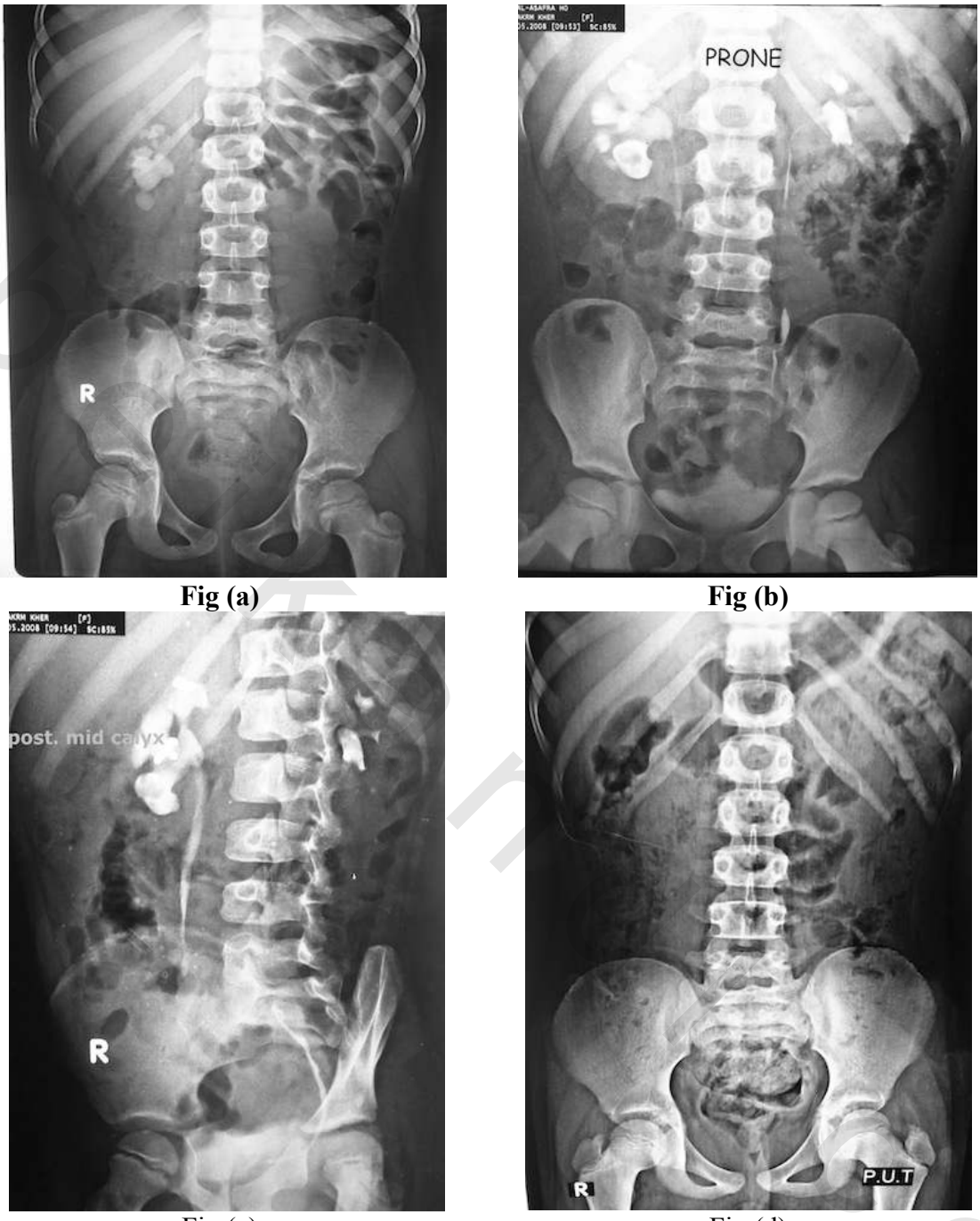

Fig (a) **Fig (b)**

Fig (c) Fig (d)

Figure (25): 8 years old girl with multiple right kidney stones underwent PCNL
(a) Plain KUB showing stone burden.
(b) IVU antro-posterior view showing stone distribution within the kidney.
(c) IVU oblique view showing site of kidney entrance (X).
(d) 1 month Postoperative KUB free of stones.

Fig (a)

Fig (b)

Fig (c)

Fig (d)

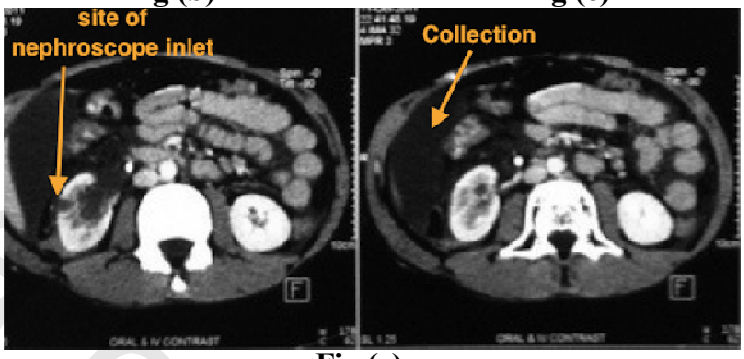

Fig (e)

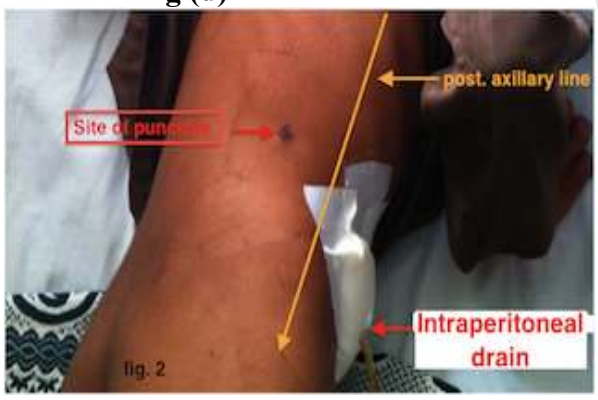

Fig (f)

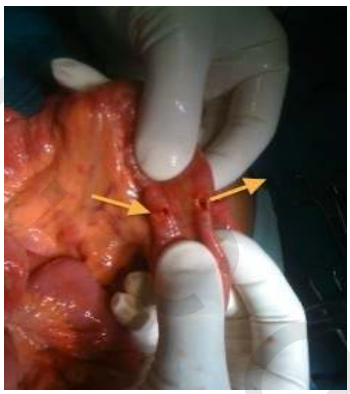

Fig (g)

Figure (26): 10 years old boy with multiple right kidney stones underwent PCNL
(a) & (b) Preoperative Plain and IVU
(c) Postoperative KUB free of stones with ureteric catheter in place.
(d) Postoperative chest x-ray showing air-fluid level under the diaphragm
(e) Postoperative contrast CT scan showing site of nephroscope inlet within the kidney (Ant. Lower calyx) and intraperitoneal fluid collection.
(f) Figure showing site of percutaneous puncture related to post. Axillary line.
(g) Figure taken at time of open exploration and repair of distal ileum injury.

Fig (a)

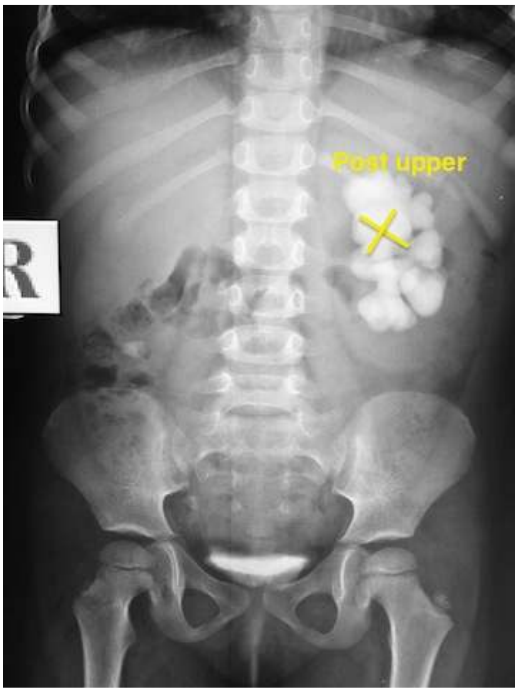

Fig (b)

Fig (c)

Figure (27): 7 years old girl with large and multiple left kidney stones underwent PCNL.

(a) Plain KUB showing large and multiple left kidney stones.

(b) IVU of the same patient showing stone distribution and site of kidney entrance (Post. Upper calyx puncture).

(c) Postoperative KUB showing patient free of stone with ureteric catheter in place.

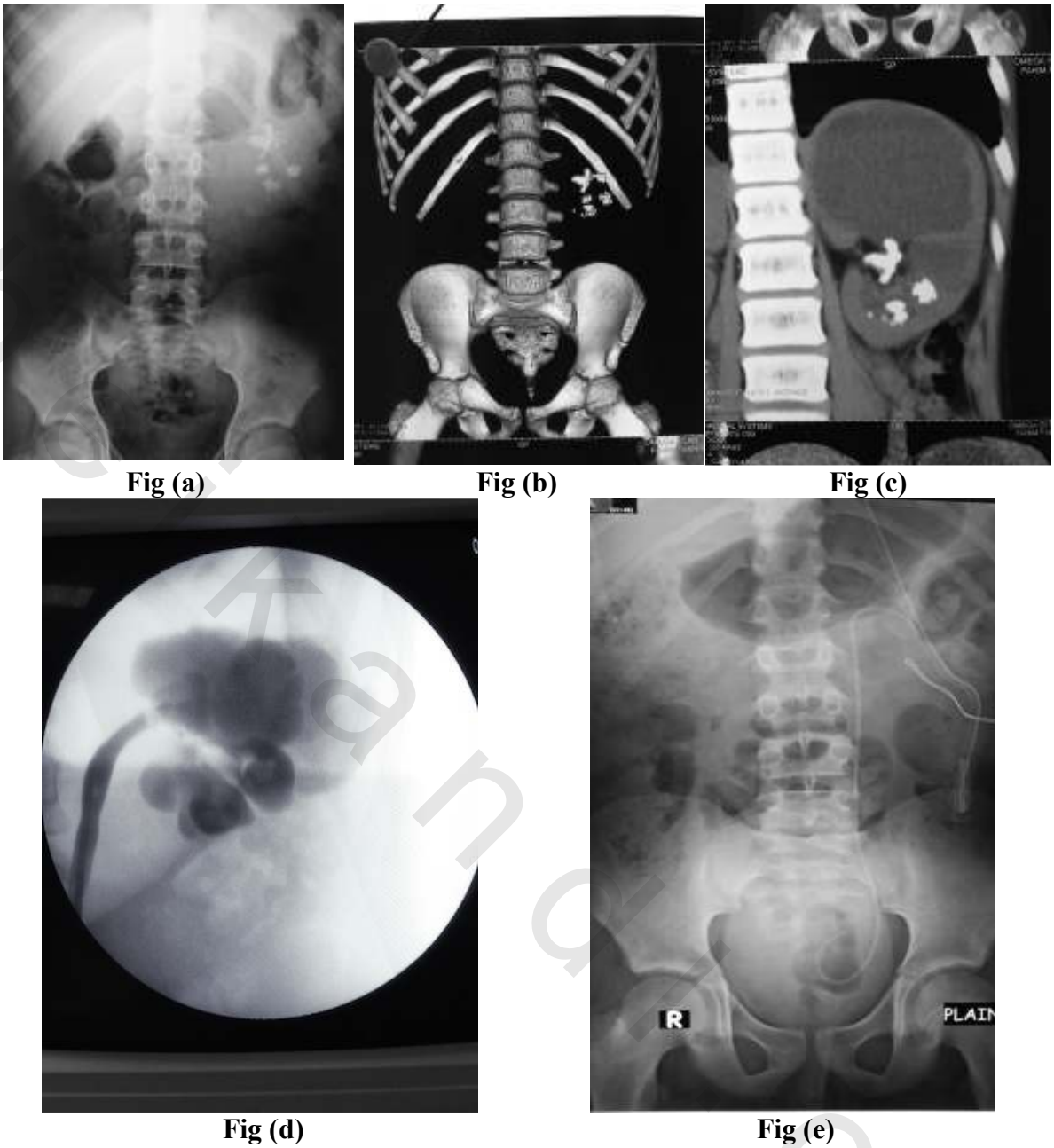

Fig (a) **Fig (b)** **Fig (c)**

Fig (d) **Fig (e)**

Figure (28): 13 years old boy with Ventricular septal defect with multiple left kidney stones underwent PCNL.

(a) Plain KUB showing multiple left kidney stones.
(b) & (c) CT scan showing stone burden and distribution within the kidney.
(d) Fluoroscopic view of the retrograde opacification of the collecting system showing intra calyceal anatomical distortion.
(e) Postoperative KUB free of stones with a nephrostomy tube and a JJ stent in place.

Fig (a)

Fig (b)

Fig (c)

Fig (d)

Figure (29): 12 years old boy with history of old leukemia underwent PCNL for right multiple kidney stones

(a) & (b) Reconstructed and coronal view of a CT scan showing 2 stones in the right kidney.

(c) Postoperative KUB free of stones; tubeless with JJ stent in place.

(d) Postoperative chest x-ray at the second day showing asymptomatic hydrothorax that was resolved spontaneously without chest tube drainage.