Original Article

The Evaluation of Renal Parenchymal Scarring Using Static Renal Scintigraphy after Percutaneous Nephrolithotomy Operationsw

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ABSTRACT

Objective: To analyze whether operative techniques and other variables related to patient and renal stone characteristics affect potential renal parenchymal damage. **Materials and Methods:** The study population comprised 64 patients who underwent percutaneous nephrolithotomy operations (PCNL). Data of the operated renal units, renal stone burden, route and number of entries, dilation techniques, duration of surgery, preoperative and postoperative glomerular filtration rate (GFR) and relative dimercaptosuccinic acid (DMSA) uptakes, as well as the changes in hemoglobin values, were recorded and analyzed for all patients. **Results:** The mean age of the patients was 44 years. In 11 (17.1%) cases, renal cortical defects in the 3rd month were detected on DMSA scintigraphy. When the patients with and without renal cortical defect were compared regarding their preoperative and postoperative GFR values, no statistically significant difference was noticed between the groups ($P > 0.05$). Similarly, when postoperative relative DMSA uptakes were compared with preoperative relative DMSA uptakes of the same kidneys, no statistical significance was seen. When preoperative relative DMSA uptake values between groups with and without renal scarring were compared, no statistically significant difference was observed ($P > 0.05$). **Conclusion:** We did not observe any significant difference in scintigraphic parameters and GFR values. Hence, in the current trial, significant loss in renal function after PCNL operations was not observed. Thus, PCNL operations should be regarded as safe, but still, the risk of loss of kidney function should always be considered.

Keywords: *Percutaneous nephrolithotomy, renal scar, renal scintigraphy, renal stone*

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Introduction

The risk of developing stone disease at any stage of a person's life is between 1% and 15%.[1] The majority of stones in the urinary system pass spontaneously, but in circumstances, they may require different interventions including percutaneous nephrolithotomy (PCNL). Currently with the increase in endourologic applications, only 0.7-4% of urinary system stones were treated with open surgery.[2,3] PCNL, widely used to treat kidney stones, provides a stone-free rate of nearly 95%.[4]

While there are sufficient clinical studies and data on the technique and results of PCNL, there is a lack of sufficient data and studies on the effect on renal functions and morphology. Studies in the literature include contradictory results.[5,6]

This prospective clinical study is aimed to analyze whether operative techniques and other variables related to patient and renal stone characteristics affect potential renal parenchymal damage. In addition, degree of possible damage in PCNL operations was also evaluated using scintigraphic imaging techniques.

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Materials and Methods

Patients

All patients with PCNL operation planned between June 2012 and April 2014 were evaluated for inclusion criteria. A total of 64 patients who met the inclusion criteria were included in the study. The inclusion criteria of the study were determined as: No scarring of renal parenchyma

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on preoperative Tc-99m dimercaptosuccinic acid (DMSA) scintigraphy; no intervention such as surgery, extracorporeal shock wave lithotripsy (ESWL), or PCNL insertion by the renal unit performing the procedure; no known additional diseases such as chronic renal failure and renovascular hypertension; and no history of acute pyelonephritis attacks. Solitary kidneys were excluded from the study.

All cases had hemogram, full urine, urine culture, blood chemistry, hemorrhage, and clotting time completed with standard laboratory methods in the preoperative period. Patients were evaluated with intravenous pyelography and/or noncontrast abdominal spiral tomography. Demographic and disease-related data of patients were recorded. The stone was classified as a staghorn stone if a renal pelvic stone had calyceal branching into the major calyx. Preoperative DMSA scintigraphy, DMSA uptake percentage, and glomerular filtration rate (GFR) values were recorded. On preoperative X-ray examination, stone size and width were multiplied to calculate stone load in millimeter square (mm^2). All cases had renal units, stone load, entry locations, number of entries, form of dilatation (mechanical/balloon), duration of operation, and hemoglobin variation values in preoperative and postoperative period during PCNL procedure were recorded.

Patients were divided into subgroups stone size (above and below 600 mm^2), form of dilatation (mechanical and balloon), and duration of operation (more or less than 60 min). All patients had hemogram, GFR, noncontrast spiral tomography, static renal scintigraphy (Tc-99m DMSA), and relative DMSA uptake evaluated in the 3rd month postoperative period. Residual stone fragment is explored via tomography and stone-free rates are noted. Residual stone fragments below 4 mm are ignored. The study obtained permission from the Local Ethics Committee. Each patient voluntarily participating in the study signed a consent form before the study.

Operation technique

After general anesthesia, patients are inserted a 5 F ureter catheter via cystoscopy and are then moved to prone position. Patients are operated by two different surgeons. For standardization, all patients included in the study have renal parenchyma dilatation up to 30 F with a 30 F Amplatz sheath due to lack of lower calibrate instruments. In order to compare the effects of two techniques, we applied balloon and mechanical dilatation. One surgeon selected balloon dilator and the other surgeon selected mechanical dilatation. Balloon dilatator was used for 39 patients (60%), with mechanical dilatator used for 25 patients (40%). At the end of the operation for nephrostomy, a 16 F Foley catheter was used. The opaque material was administered from the nephrostomy to note location and then skin was sutured. Intraoperative and postoperative complications are noted using modified Clavien classification system. Patients had hemogram and renal panel checkup on the postoperative 1st day and urinary system X-rays were taken to see the presence of residual stones. The urinary catheter was removed on the 1st day, while the nephrostomy was removed on the 2nd day for all cases. Patients without complications were given appropriate activity and diet recommendations on the 3rd postoperative day and were advised to come to clinical checkup 2 weeks later and discharged.

Dimercaptosuccinic acid technique

All cases had 5mCi Tc-99m DMSA scintigraphic evaluation. Four hours after injection, a Sophy Camera-C (Sopha Medical-France) gamma camera (http://www.auntminnie.com/index.aspx?sec=ser&sub=def&pag=dis&ItemID=1996), with 256 × 256 matrix and 7 min durations, was used to take planar renal images in the posterior and right and left postero-oblique positions while the patient had been lying in supine position on the device. Images were evaluated for renal parenchyma scarring [Figure 1].

Statistical analysis

Statistical analyses were completed using the SPSS version 22.0 program for Windows (SPSS Inc., Chicago, IL, USA). The results were given as mean ± standard deviation and $P < 0.05$ value was accepted as statistically significant. The distribution of the variables was checked with the Kolmogorov-Smirnov test. For quantitative data analysis, the independent samples *t*-test and Mann-Whitney U-test were used. For qualitative data analysis, the Chi-square test was used. Fischer's exact test was used for data that did not comply with Chi-square conditions. For correlation analysis, the Spearman correlation analysis was used. $P < 0.05$ was considered statistically significant.

Results

The study included a total of 64 patients (37 males, 27 females) with a mean age of 45.2 ± 13.5 years (19-75

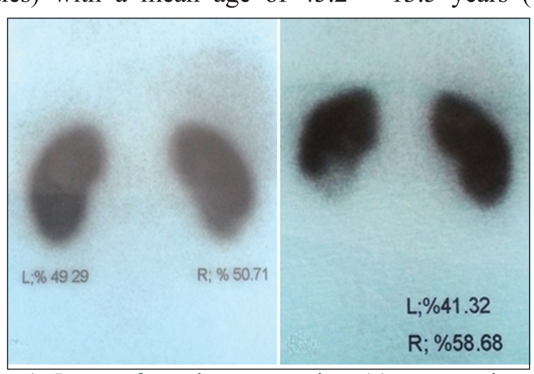

Figure 1: Images from the same patient (a) preoperative normal scintigraphic image and (b) postoperative scar image in the lower pole of the left kidney

Table 1: Data of stone size, localization, number of entries, entry place, and stone-free rate

Parameter	Explanation	*n* (%)
Kidney with stone	Right	26 (40.6)
	Left	38 (59.4)
Stone localization	Calyx	4 (6.2)
	Pelvis	35 (54.7)
	Staghorn	25 (39,1)
Number of puncture	I	59 (92.2)
	II	5 (7.8)
Entry place	Lower pole	46 (15.6)
	Lower pole and middle pole	4 (37.5)
	Middle pole	13 (25)
	Upper pole	1 (9.4)
Stone-free rate, %		86.5

Table 2: Relationship between renal cortical defect and parameters

Parameter	Mean±SD/*n* (%)		*P*
	Renal cortical defect (–)	Renal cortical defect (+)	
Age	45.5±13.5	43.8±13.8	0.711
Sex			
Female	23 (43.4)	4 (36.4)	0.667
Male	30 (56.6)	7 (63.6)	
Stone size, mm^2	522±171	563±232	0.551
Stone size, mm^2			
≤600	39 (73.6)	6 (54.5)	0.208
>600	14 (26.4)	5 (45.5)	
Hemoglobin			
Preoperative	14.2±1.8	13.9±1.7	0.599
Postoperative	11.9±1.8	11.9±1.6	0.981
P	0.001	0.001	
GFR			
Preoperative	105±34	107±35	0.834
Postoperative	107±35	105±27	0.832
P	0.326	0.646	
Relative DMSA uptake			
Preoperative	43.9±9.5	42.9±9.1	0.756
Postoperative	44.4±10	40.7±6.7	0.255
P	0.480	0.273	
Duration of operation, min	69.7±25.4	75.6±19.5	0.277
≤60	25 (47.2)	3 (27.3)	0.226
>60	28 (52.8)	8 (72.7)	
Number of entries			
I	49 (92.5)	10 (90.9)	1
II	4 (7.5)	1 (9.1)	
Form of dilatation			
Amplatz	19 (35.8)	6 (54.5)	0.247
Balloon	34 (64.2)	5 (45.5)	

GFR=Glomerular filtration rate; SD=Standard deviation; DMSA=Dimercaptosuccinic acid

Table 3: Complications using modified Clavien classification system

	n (%)
Grade 1	
Nausea/vomiting	6 (9.3)
Postoperative fever (>38.0°C) managed by observation without antibiotics	5 (7.8)
Urine leakage (12 h>) from puncture site managed by watchful waiting	7 (10.9)
Bradycardia	1 (1.5)
Tachycardia	2 (3.1)
Transiently deranged renal function managed by intravenous fluid	4 (6.2)
Hematuria/bleeding managed using intravenous fluid or nephrostomy clamping	6 (9.3)
Grade 2	
Bleeding requiring blood transfusion	5 (7.8)
Pneumonia	1 (1.5)
Symptomatic UTI managed with antibiotics	2 (3.1)
Grade 3a	
Ureteric obstruction	3 (4.6)

*No Grade 3b or Grade 4 complication is observed. UTI=Urinary tract infection

years). DMSA scan was administered 16.3 ± 4.3 days before the operation. Stones were in the right kidney in 26 cases (40.6%) and in the left kidney in 38 cases (59.4%). The stone-free rate in patients included in the study was 86.5%. Data related to stone size and localization, number of entries, and entry place are summarized in Table 1.

According to the 3rd month DMSA scintigraphy after surgery, 11 patients (17.1%) had renal cortical defect. When the groups with anwd without renal cortical defect were compared, there was no statistically significant difference observed in terms of patient age and sex distribution ($P > 0.05$). There was no statistically significant difference found between the cortical defect situation groups in terms of stone size was compared ($P > 0.05$). In the two patient groups, postoperative hemoglobin values were significantly lower when compared to the preoperative period ($P < 0.05$).The amount of variation in the hemoglobin values of postoperative period compared to the preoperative period was not found to be different in the two subgroups ($P > 0.05$). In terms of preoperative and postoperative GFR values, there was no statistically significant difference when each group was compared with each other ($P > 0.05$). Similarly in two patient groups, there was no statistically significant difference identified in postoperative relative DMSA uptake percentage, when compared to the preoperative period ($P > 0.05$).In addition, the relative DMSA uptake percentage was similar when compared to the preoperative period in the groups with and without renal cortical defect ($P > 0.05$). Data related to the duration of operation, number of entries, and form of dilatation in the groups with and without renal cortical defect are given in Table 2.

Complications are summarized in Table 3.

Discussion

There are numerous studies related to PCNL and its effect on renal functions and morphology in the literature but with a very low number of sample groups.[7-9] This prospective study has been attempted to determine whether the dilatation technique and patient and stone parameters have affected the possible damage to renal parenchyma due to PCNL, using scintigraphic imaging methods.

Many studies have shown that PCNL acutely affects renal function and these negative effects were repaired in time.[7-9] The first comprehensive study on animal subjects was published by Fitzpatrick and Webb in 1985.[5] PCNL was inserted in dogs and functional and morphological effects of this method on the kidney were evaluated. Pathologic evaluation 6 weeks after the procedure showed a small capsular defect and linear scar tissue in the nephrostomy tract in renal parenchyma. Similarly, Wilson *et al*. divided swine into four groups as pyelotomy, nephrotomy, ESWL, and PCNL. They found that PCNL group had statistically significant more scar tissue compared to other groups.[8] Mayo *et al*. performed PCNL on cases with infection stones with infection brought under control with antibiotic treatment, and found that though renal function loss may be observed in the early period, in the later period a clear increase in function was identified and reported that PCNL protected renal functions and provided improvement in renal functional disorders. Basiri *et al*. evaluated sixty patients with DMSA scintigraphy before and 6 months after PCNL procedure and they found an increase in the renal functions.[9] An evaluation with computed tomography and Tc-99m DMSA scintigraphy in the postoperative period after PCNL by Marberger *et al*. identified the thickening of the renal capsule in the region of the nephrostomy tract with subcapsular hematoma and thickening of perirenal tissue. Correspondingly, these patients were evaluated as normal on DMSA scintigraphy.[10] Chatham *et al*. evaluated PCNL patients with 99mTc-MAG3 renography and they found that that renal function is preserved and often improved after percutaneous stone removal for complex renal calculi.[11] Moskowitz *et al*. investigated 88 patients undergoing unilateral PCNL for staghorn stones using Spect 99mTc-DMSA scintigraphy. They did not identify a difference between the operated kidney and contralateral kidney in terms of preoperative and postoperative scintigraphic evaluation. They observed a statistically significant decrease in total functional volume in the operated kidneys and in functional volume of the operated poles.[12] Similarly, Pérez-Fentes *et al*. evaluated kidney function after PCNL procedure with 99mTc-DMSA single-photon emission computed tomography-computed tomography. They found that PCNL has a minimal impact on the global kidney function, which is mainly located in the region of percutaneous access. They also concluded that the advent of perioperative complications increases PCNL functional damage, whereas the stone-free status does not show any meaningful effect.[13]

In our study, we excluded the patients who have renal cortical defect. However, our patients' preoperative DMSA uptake was slightly low. Akman *et al*. investigated long terms of PCNL in patients with chronic kidney disease. At long-term follow-up, they observed that renal function was maintained or improved in > 80% of the patients.[14] However, Sairam *et al*. found higher complication and retreatment rates and lower stone-free rates with Grade 4/5 chronic kidney disease.[15] We did not include Grade 4/5 chronic kidney disease patients in our study.

In general, in the literature, the stone-free success rate of PCNL varies between 76% and 100%.[1] In our study, the stone-free rate was found to be 86.5% and this supports the available data.

Dilatation for PCNL is completed mechanically or with a balloon dilatator. Renal scar formation and hemorrhage potential of mechanical and balloon dilatation have been compared in some animal experiment or clinical studies. In their experimental trial, Clayman *et al*. applied mechanical dilatation up to 24 Fr to the right kidney of swine with the Seldinger technique and they applied balloon dilatation to 36 Fr to the left kidney. The dilatators were left in the kidney for 10 min and the procedure ended before inserting a nephrostomy catheter. After pathological investigation, there was no statistically significant difference in terms of renal scarring rates.[16] In a clinical study published by Akman *et al*., they divided PCNL patients into three groups according to dilatation methods (balloon dilatation, amplatz dilatation, and metal coaxial dilatation), and compared the preoperative and postoperative 3rd and 6th month renal cortical defects of patients with DMSA. In a total of nine patients (18%), focal cortical defect was identified and in six patients (12%), the defect localization was in accordance with the PCNL entry location. The mean relative DMSA uptake values of these patients were 42.2% and 44.1% preoperatively and postoperatively, respectively. Although an increase was identified, it was not found to be statistically significant. They found that the metal dilatator and amplatz dilatator groups required blood transfusions while the balloon dilatator group did not require blood transfusion.[17] Another similar study with 143 patients stated that the balloon dilatator required fewer blood transfusions compared to the mechanical dilatator.[18] In our study, we identified 11 patients with renal scarring, but there was no significant difference in terms of renal cortical defects between dilatation methods. Our mean relative DMSA uptake rose from 43.9% to 44.4% but this difference was not statistically significant. Again, in our study in terms of preoperative and postoperative hemoglobin values in mechanical and balloon dilatation groups, though a statistically significant difference was not observed, there was a significant decrease in postoperative hemoglobin values in both groups when compared to the preoperative hemoglobin values. We did not observe Grade 4 and Grade 3b complication according to modified Clavien classification system. Only 1 Grade 3a complication occurred; ureteric obstruction required double J stent.[19]

In our study, when the operation duration of groups with and without renal cortical defects was compared, there was more renal scar in patients whose operation durations is more than 60 min. However, this difference was not statistically significant. The oxidative stress triggered by lengthened surgery durations may be another factor affecting the renal scar formation.[20]

Our study presents short-term effects of PCNL. On the long term, we could face lower renal cortical defect rates due to regeneration. In the future, we want to publish the 2-year DMSA results of these patients in order to overcome this problem. Other main disadvantage of our study is the usage of 30 F amplatz sheath due to lack of lower calibrate instruments. We could encounter lower renal cortical defect rates if we have used lower calibrate instruments. Whereas, we excluded previous renal cortical defects from our study, patients' preoperative DMSA uptakes are slightly low. It is not clear that if this finding affects the results or not. Moreover, this calls accuracy of qualitative assessment of renal function into question.

Conclusion

Although some other studies indicated that PCNL affected renal function in terms of scintigraphic parameters and GFR values, we did not observe any significant difference. Hence, in the current trial, significant loss in renal function after PCNL operations was not observed. Thus, PCNL operations should be regarded as safe, but still, the risk of loss of kidney function should always be considered, and this possibility should be minimized with optimum care in PCNL surgeries.

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Conflicts of interest

There are no conflicts of interest.

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