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Does Previous Open Nephrolithotomy or Failed Extracorporeal Shock Wave Lithotripsy Therapy Affect Percutaneous Nephrolithotomy Performance and Outcome?

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What's known on the subject? and What does the study add?

There are publications reporting that percutaneous nephrolithotomy is safe and effective after failed extracorporeal shock wave lithotripsy (ESWL) and a history of open surgery patients. Fluoroscopy time and hemoglobin drop are important parameters for percutaneous nephrolithotomy surgery. Most of the studies in the literature mentioned that the failed ESWL prolonged the fluoroscopy time, and open surgery history was linked to a significant drop in hemoglobin levels in patients that underwent percutaneous nephrolithotomy. In our study, it was found that percutaneous nephrolithotomy could be performed safely without prolonging the fluoroscopy time in the failed ESWL patients and without significant hemoglobin drops in the history of open nephrolithotomy patients.

Abstract

Objective: This study aimed to summarize our experience with patients undergoing percutaneous nephrolithotomy (PNL) with a previous history of extracorporeal shock wave lithotripsy (ESWL) treatment or open nephrolithotomy and compare them with patients who underwent PNL alone.

Materials and Methods: A total of 565 patients were treated with PNL from 2012 to 2022 at our center. These patients who underwent PNL were divided into three groups: Group 1 consisted of patients who had no medical history of previous ESWL or open kidney stone surgery, Group 2 consisted of those who had a history of previous ESWL, and Group 3 included patients with a history of previous open kidney stone surgery.

Results: Regarding age, there were no notable differences between the three groups, body mass index, gender, laterality, and stone density in Hounsfield Units. Group 3 had a significantly higher total operation fluoroscopy time than the other two groups, and Group 2 had a significantly lower total operation time than the other two groups. Regarding the postoperative parameters of all three groups, including hospital stay, time to nephrostomy removal, urinary leakage, hemoglobin decrease, blood transfusion, and stone-free rates, no statistically significant differences were found.

Conclusion: Our study demonstrates that PNL can be safely performed with a similar success rate and without a higher risk of problems in patients who have undergone open nephrolithomy or ESWL, as well as in primary PNL patients who have not undergone any previous interventions.

Keywords: Kidney stones, open stone surgery, extracorporeal shock wave lithotripsy, percutaneous nephrolithotomy

Introduction

Kidney stones are a significant cause of morbidity worldwide and are a common urological illness that affects approximately 10-15% of the global population (1). Currently, the available management alternatives for the treatment of kidney stones include ureterorenoscopy (URS), percutaneous nephrolithotomy (PNL), extracorporeal shockwave lithotripsy (ESWL), open surgery, and laparoscopy. Nevertheless, depending on new technological and surgical advancements, open surgery has been replaced by less invasive procedures such as PNL (2,3). However, open kidney surgery has been performed in centers

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where there is a lack of experience or inadequate equipment for minimally invasive procedures (4).

In the guidelines provided by the European Association of Urology (EAU), ESWL is suggested as the first-line treatment method for stones smaller than 20 mm, whereas PNL is typically performed for stones larger than 20 mm (5). On the other hand, according to the EAU guidelines, if ESWL fails after 3 to 5 sessions of treatment, PNL is recommended as the next step (5). PNL is also performed for stones fragmented by ESWL but not suitable for spontaneous passage (6).

Nephrolithiasis is a recurrent and lifelong disease, and approximately half of the patients with nephrolithiasis will have a second renal colic attack within 10 years (7,8). A recent retrospective cohort study in Olmstead County, involving over 2.200 individuals who developed kidney stones for the first time, reported that the recurrence rates at 2, 5, 10, and 15 years were 11%, 20%, 31%, and 39%, respectively (9). Today, PNL is required in patients who have previously undergone ESWL or open nephrolithotomy. In patients who have previously undergone open stone surgery, there is often the presence of retroperitoneal scar tissue around the kidney, disruption of the pelvicalyceal anatomy, and in some cases, displacement of the intestines. Generally, when operating in a previously surgically treated anatomical region, the surgeon can expect technical challenges that may be associated with a longer surgical duration, higher complication rate, and potentially lower success rate (4).

Similarly, repeated ESWL can contribute to long-term fibrotic degeneration and impairment of the collecting system (6,10).

The objective of this study was to summarize our experiences with patients who underwent PNL after previous ESWL treatments (failure in stone fragmentation or stone clearance, and recurrences) and open nephrolithotomy and to compare them with patients who underwent PNL alone.

Materials and Methods

The study comprised 403 patients who received PNL at our clinic between 2012 and 2022. Three groups were created from the individuals who underwent PNL. Patients in Group 1 had never undergone ESWL or open kidney stone surgery, whereas those in Group 2 had undergone prior open kidney stone surgery and those in Group 3 had undergone prior ESWL. Patients under the age of 18, anatomical anomalies such as a duplicated collecting system or an obstruction at the ureteropelvic junction, skeletal deformities, impaired kidney function, a history of bleeding disorders, the presence of a solitary kidney, and patients who do not attend routine follow-up appointments are all excluded.

All patients underwent a routine preoperative evaluation, including a detailed history and physical examination, and laboratory tests such as blood biochemistry, urinalysis and culture. Non-contrast and contrast-enhanced abdominal tomography were performed. The stone burden of the patients was calculated using the Ackerman formula (volume = 0.6 x π x r2), where r represents half of the largest diameter of the stone. Demographic characteristics, such as stone burden and position, severity of hydronephrosis, number of tracts, past treatments for renal calculi, average length of the operation, average X-ray exposure, stone-free rates, hemoglobin levels, blood transfusion rates, and intraoperative and postoperative complications were compared among the groups. All patients underwent a follow-up evaluation with non-contrast computed tomography at one month after surgery. The indicators of operation success were the absence of stone or the presence of stone particles less than 4 mm. The Clavien-Dindo classification system, which has five grades, was used to classify complications (11). Grade 1 and 2 problems do not require surgical or radiological procedures; however, Grade 3 complications must. Total parenteral feeding and blood transfusion were categorized as Grade 2 problems.

We defined fluoroscopy time (FT) as the whole operation FT from the insertion of the needle to the implantation of the nephrostomy catheter because the term is used differently in the literature.

Surgical Technique

An open-ended 5 F ureteral catheter (MarflowTM, Marflow AG, Switzerland) was placed in the ureter and guided by cystoscopy with the patient in the lithotomy position under general anesthesia. After placement, the patient was moved to the prone position. All patients were operated on in the prone position. The anatomy of the pelvicalyceal system was visualized with radio-opaque material instilled using the ureteral catheter under C-arm fluoroscopy. A 19.5-gauge percutaneous needle (Percutaneous Access Needle, Boston Scientific Corporation, MA, USA) was introduced into the appropriate calyx system of the kidney. Fluoroscopy was used to place a guidewire (ZebraTM Niti- nol Guidewire, Boston Scientific Corporation, MA, USA) in the collecting system The tract was dilated up to 30 F using semirigid Amplatz dilators (Boston Scientific Microvasive Amplatz Tract- master TM, Boston Scientific Corporation, MA, USA), and an Amplatz sheath was inserted into the collecting system. Stone fragmentation was performed using a pneumatic lithotripter (CalculithTM Lithotripter, PCK, Turkiye) through a 28 F rigid nephroscope (Karl StorzTM Endoscopy-America Inc.) in all groups. Stone fragments were collected using forceps, and the operations were ended after the placement of a 14 F nephrostomy catheter.

Statement of Ethics

Ethical approval was obtained from the University of Health Science Turkiye, Kocaeli Derince Training and Research Hospital Ethics Committee (ethical number: 2022-110, date: 13.10.2022).

Written informed consent was obtained from all patients. All procedures related to humans abide by all applicable national laws, institutional guidelines, and tenets of the Declaration of Helsinki.

Statistical Analysis

SPSS for Windows was used for statistical analysis. v. 20.0 (SPSS Inc., Chicago, IL) of the Statistical Package for the Social Sciences. The Kruskal-Wallis test was used in the statistical analysis to assess differences, and the Mann-Whitney U test was used in paired comparisons (for independent non-parametric data). To compare categorical values between the groups, the chi-square test, performed. P 0.05 was chosen as the cutoff value for statistical significance.

Results

The data of 403 patients who were eligible for inclusion were analyzed in this study. Three groups of patients were created. Group 1 comprised primary PNL patients without a history of previous ESWL and open nephrolithotomy. Group 2 included patients with a history of previous ESWL who underwent PNL. Group 3 comprised patients with a history of previous open nephrolithomy who also underwent PNL. Group 1 had 275 patients (68.20%), Group 2 had 104 patients (25.81%), and Group 3 consisted of 24 patients (5.96%) (Figure 1).

Of the 403 patients divided into three groups, 305 (75.68%) were male and 98 (24.32%) were female, with a mean age of 47.29±13.44. There were no notable variations among the three groups in terms of age, body mass index, gender, laterality, and stone density in Hounsfield Units (p>0.05). However, when analyzing stone location, "pelvis and calyx" stone sizes were found to be much larger compared with group 2 (p=0.028). In terms of stone burden, Group 2 had a significantly lower stone burden than the other two groups (p=0.001). The preoperative data of the research groups and their statistical analyzes are presented in Table 1.

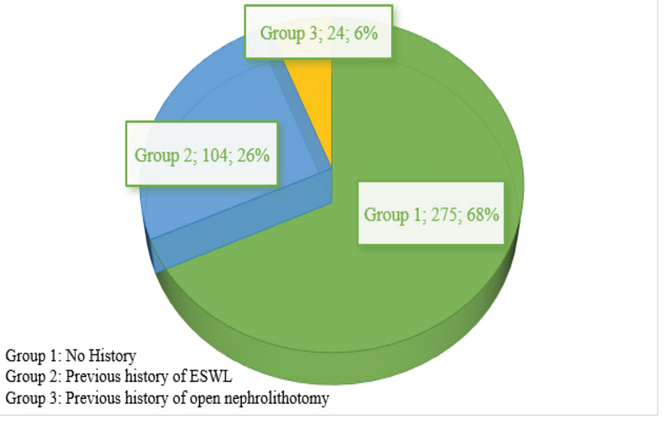

Figure 1. Number of patients in study groups

ESWL: Extracorporeal shock wave lithotripsy

Table 1. Demographic data and study group stone parameters

	Group 1	Group 2	Group 3	p
	No History	Previous history of ESWL	Previous history of open nephrolithotomy	
	(n=275)	(n=104)	(n=24)	
Age, mean ± SD (M)	46.93±13.78 (47)	47.85±12.85 (48)	48.92±12.15 (50.50)	0.638[1]
Gender (n)				0.850[3]
Male	209 (76.00%)	77 (74.04%)	19 (79.17%)	
Female	66 (24.00%)	27 (25.96%)	5 (20.83%)	
BMI (kg/m^2), mean ± SD, (M)	24.77±2.76 (25)	24.21±2.73 (24)	24.88±3.13 (24)	0.459[1]
Laterality (n)				0.329[3]
Right	140 (50.91%)	45 (43.27%)	10 (41.67%)	
Left	135 (49.09%)	59 (56.73%)	14 (58.33%)	
Stone location (n)				0.023[3]*
One calix	34 (12.36%)	22 (21.15%)	6 (25%)	
Pelvic	88 (32%)	38 (36.54%)	3 (12.5%)	
Multiple calyces	12 (4.36%)	8 (7.69%)	-	
Pelvic and calix	110 (40%)	30 (28.85%)	12 (50%)	
Staghorn	31 (11.27%)	6 (5.77%)	3 (12.5%)	
Stone burden mm^2, mean ± SD (M)	602.43±539.37 (423)	445.95±386.85 (287.5)	754.83±651.04 (570.5)	0.001[1]*
Statistical analysis	Group 1 vs Group 2	Group 1 vs Group 3	Group 2 vs Group 3	
p	0.002[2]*	0.051[2]	0.001[2]*	
Stone density in Hounsfield Units, mean ± SD, (M)	1240.65±386.39 (1218)	1251.86±343.44 (1278)	1221.71±412.74 (1160)	0.556[1]

ESWL: Extracorporeal shock wave lithotripsy, BMI: Body mass index, SD: Standard deviation, M: Median, [1]Kruskal-Wallis H test, [2]Mann-Whitney U test [3]Chi-square test, *: Statistically significant (p<0.05)

A statistically significant difference was observed among the study groups according to total operation FT (p=0.003). Group 3 had a significantly higher total operation FT than the other two groups (p=0.031; p=0.003; Table 2). However, no change that was statistically significant was found in the total operation FT between Group 1 and Group 2 (p=0.064).

Regarding the total operation time, there was a statistically significant difference among the study groups (p=0.020). Group 2 had a significantly lower total operation time than the other two groups (p=0.001; p=0.020; Table 2, Figure 2). However, no statistically significant difference was discovered in total operation time between Group 1 and Group 3 (p=0.338).

When examining grade 1 complications, postoperative fever was observed in 9 patients in Group 1, 4 patients in Group 2, and 1 patient in Group 3. Regarding grade 2 complications, urinary tract infection was observed in 7 patients in Group 1 and 2 patients in Group 2. All patients were treated with appropriate antibiotic therapy. Additionally, 21 patients in Group 1, 7 patients in Group 2, and 1 patient in Group 3 required blood transfusion.

In terms of grade 3 complications, ureterorenoscopy was performed for 6 patients in Group 1, 3 patients in Group 2, and 1 patient in Group 3 because of stone migration into the ureter. Double-J stent insertion was performed in 4 patients in Group 1, 2 patients in Group 2, and 1 patient in Group 3 because of prolonged urinary leak after nephrostomy catheter removal. Selective angioembolization was performed for 2 patients in Group 1 due to uncontrolled bleeding. Colon perforation occurred in one patient each in Groups 1 and Group 2 and these patients were followed up with tube colostomy and discharged without any issues. One patient in Group 1 experienced continued bleeding and hematoma in the postoperative follow-up, leading to nephrectomy, whereas two patients developed pneumothorax and required chest tube insertion after discharge without complications. No Grade 4 or 5 complications were observed in any of the three groups (p=0.862) (Table 3).

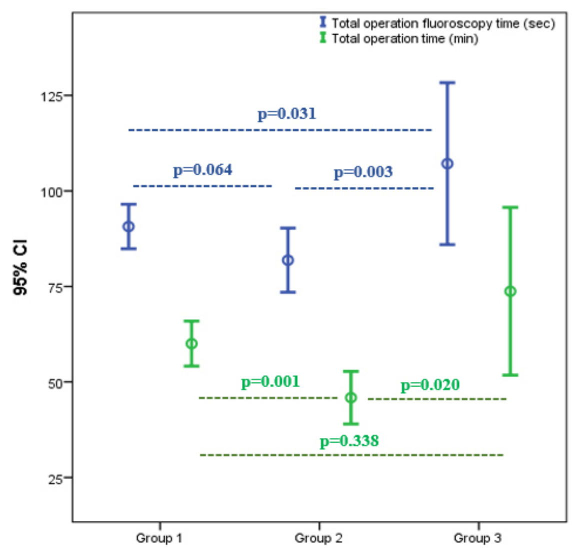

Figure 2. Fluoroscopy and operation times of the study groups

CI: Confidence interval

Discussion

Our research is consistent with the current literature, showing that prior open surgery or ESWL for kidney stones does not significantly affect the subsequent outcomes of PNL in the same kidney. Studies in this area have compared the efficacy of PNL in primary patients with patients who have previously undergone open surgery. In a study which made by Tugcu et al. (12), PNL outcomes in 55 patients who had former open surgery compared with 105 patients who had no prior intervention and found no significant difference in success and complication rates, except for longer operation duration. The outcomes of PNL in 142

Table 2. Fluoroscopy and operation times of the study groups

	Group 1	**Group 2**	**Group 3**	
	No History	**Previous history of ESWL**	**Previous history of open nephrolithotomy**	**p**
	(n=275)	**(n=104)**	**(n=24)**	
Total operation fluoroscopy time[a] (sec), mean ± SD, (M)	90.69±40.79 (M: 81)	81.88±36.5 (M: 76)	107.14±47.82 (M: 98)	0.003[1]*
Statistical analysis	Group 1 vs Group 2	Group 1 vs Group 3	Group 2 vs Group 3	
p	0.064[2]	0.031[2]*	0.003[2]*	
Total operation time[b] (min) mean ± SD, (M)	65.93±38.71 (55)	52.61±29.46 (45)	75.5±47.71 (67)	0.020[1]*
Statistical analysis	Group 1 vs Group 2	Group 1 vs Group 3	Group 2 vs Group 3	
p	0.001[2]*	0.338[2]	0.020[2]*	

[a]total operation fluoroscopy time/[b]total operation time: (from the insertion of the needle to the nephrostomy catheter placement), ESWL: Extracorporeal shock wave lithotripsy, SD: Standard deviation, M: Median, [1]Kruskal-Wallis H test, [2]Mann-Whitney U test, *Statistically significant (p<0.05)

Table 3. Postoperative parameters of the study groups

	Group 1	Group 2	Group 3	
	No History	Previous history of ESWL	Previous history of open nephrolithotomy	p
	(n=275)	(n=104)	(n=24)	
Time to nephrostomy catheter removal (day), mean ± SD, (M)	2.80±1.99 (3)	2.63±1.14 (3)	2.61±0.84 (3)	0.759[1]
Urinary leakage after nephrostomy removal (hour), mean ± SD (M)	6.12±9.40 (4)	5.35±7.57 (4)	8.75±14.96 (4)	0.529[1]
Hospital stay (day), mean ± SD (M)	3.77±1.50 (4)	3.49±1.39 (3)	4.17±2.43 (4)	0.216[1]
Haemoglobin drop in g/dL, mean ± SD (M)	1.50±1.19 (1)	1.44±1.08 (1)	1.58±1.35 (1)	0.946[1]
Blood transfusion, n (%)	21 (7.64%)	7 (6.73%)	1 (4.17%)	0.801[2]
Complications, n (%)				0.862[2]
Clavien grade 1	9 (3.27%)	4 (3.85%)	1 (4.17%)	
Clavien grade 2	28 (10.18%)	9 (8.65%)	1 (4.17%)	
Clavien grade 3	16 (5.82%)	6 (5.77%)	2 (8.33%)	
Stone free patients, n (%)	231 (84.00%)	88 (84.62%)	17 (70.83%)	0.233[2]

ESWL: Extracorporeal shock wave lithotripsy, SD: Standard deviation, M: Median, [1]Kruskal-Wallis H test, [2]Chi-square test

patients who had undergone open surgery in the past were compared with those in 186 patients who had not previously received treatment by Kurtulus et al. (13), who discovered no significant difference in the success of PNL. The results of patients who underwent PNL after open nephrolithomy were examined in a meta-analysis published in 2016 (4). PNL after open surgery was linked to a significant drop in hemoglobin levels, a greater need for angiographic embolization, and potentially longer operation times (4). In our research, statistically no significant drop was seen in hemoglobin levels in the group that underwent PNL after open nephrolithotomy. Except two patients in the primary PNL group, none of the patients required angiographic embolization due to the uncontrolled bleeding. Furthermore in PNL after open nephrolithotomy group, the operation durations were significantly longer than those in the primary PNL patients.

To the best of our knowledge, there are few studies in the literature that investigate PNL performed after open surgery or ESWL with similar study designs. According to Resorlu et al. (10) there were no appreciable differences in terms of these parameters between patients with a history of prior open surgery or failed ESWL when it came to operation duration (minutes), time needed to access the renal collecting system, FT, adverse PNL outcomes, and length of hospital stay. Yuruk et al. (6) evaluated the effectiveness of PNL after ESWL and found no significant differences except for prolonged FT in PNL following ESWL. Contrary to their findings, our study did not uncover a statistically significant difference between Groups 1 and 2 when compared with one another, although Group 2 had the shortest overall operation time. Türk et al. (3) found that PNL after ESWL treatment increased the amount of bleeding and the need for blood transfusion. However, in our study, no significant differences were found in terms of both hemoglobin decrease and transfusion rates.

One remarkable result of our study is that it is influenced by the stone 's size. Despite guidelines on the management of kidney stones, the widespread use of ESWL in non-academic centers does not always align with these guidelines. The approximately 4 cm stone size observed in the group with a history of failed ESWL is the best example of this.

Study Limitations

This study has a few limitations, such as being an individual center study and being retrospective.

Conclusion

Our study demonstrates that PNL can be safely performed with a similar success rate to PNL without a higher risk of complications in patients with a history of open nephrolithotomy or ESWL, as well as in patients who have not undergone any previous interventions. We believe that in such cases, instead of repeated ESWL applications, PNL should be performed or patients should be referred to centers where PNL is performed.

Ethics

Ethics Committee Approval: Ethical approval was obtained from the University of Health Science Turkiye, Kocaeli Derince Training and Research Hospital Ethics Committee (ethical number: 2022-110, date: 13.10.2022).

Informed Consent: Written informed consent was obtained from all patients.

Peer-review: Externally and internally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: Ö.M., O.K., Concept: Ö.M., Design: Ö.M., O.K., Data Collection or Processing: Ö.M., O.K., Analysis or Interpretation: Ö.M., Literature Search: Ö.M., O.K., Writing: Ö.M., O.K.

Conflict of Interest: No conflict of interest was declared by the authors.

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