Comparision of Percutaneous Nephrolithotomy and Retrograde Intrarenal Surgery For The Treatment of Multicalyceal and Multiple Renal Stones

Arif Demirbas[1]*, Veli Mert Yazar[1], Erim Ersoy[1], Demirhan Orsan Demir[1], Serkan Ozcan[1], Tolga Karakan[1], Omer Gokhan Doluoglu[1], Berkan Resorlu[1], Ahmet Metin Hascicek[1], Kadir Omur Gunseren[2]

Purpose: Comparison of efficiency and reliability of percutaneous nephrolithotomy (PNL) and retrograde intrarenal surgery (RIRS) in treatment of multicalyceal and multiple renal stones in the same renal unit.

Materials and Methods: Between 2011 and 2015, records of patients who underwent surgery for renal stone were retrospectively reviewed. Patients who had multiple stones located in different calices in the same renal unit were included. The patients that underwent PNL and RIRS were defined as Group I and Group II, respectively. Patient criteria (age,sex); the stone characteristics; time of procedure, fluoroscopy and hospitalization; stone-free and complication rates of groups were evaluated between the treatment groups.

Result: There were no significant differences in terms of age, gender, BMI, laterality, number of stones, number of stone localization, hounsfield units and surface area characteristics of the stone between the PNL (n = 47) and RIRS (n = 35) groups ($P = .558$, $P = .278$, $P = .375$, $P = 0.051$, $P = .053$, $P = .064$, $P = .642$, $P = .080$, respectively). Stone free rate was 59.6% (n=28) in PNL, and 88.6% (n=31) in RIRS (P=.004). 1st or 2nd degree complications according to Modified Clavien Classification developed in 10 patients (21.3%) in Group I and 1 patient (2.9%) in Group II ($P = .015$). The 3A or 3B complications were similar in groups ($P = .077$). Time of procedure, fluoroscopy and hospitalization were significantly lower in Group II ($P < .001$, $P < .001$ and $P < .001$, respectively).

Conclusion: RIRS is more effective and more reliable procedure than PNL with higher stone-free and lower complication rates in treatment of multicalyceal and multiple stone in the same renal unit.

Keywords: multiple renal stones; multicalyceal stones; percutaneous nephrolithotomy; retrograde intrarenal surgery.

INTRODUCTION

The technological development of surgical instrumentation used in treatment of renal stones and research into less invasive and safer techniques are major topics in endourology today(1-3). Percutaneous nephrolithotomy (PNL) and retrograde intrarenal surgery (RIRS) are the primary technical choices in treatment of moderate- to large-sized renal stones that are not compatible with shock wave lithotripsy (SWL), and these procedures have been compared in many studies of various conditions(1,4-7).

Meta-analyses have shown that PNL and RIRS methods are effective with high stone-free rate, are safe for medium and large size stones and are alternative procedures to each other(8,9). It has been reported that localization of stones affects the success of the treatment option as much as stone sizes and therefore efficacy and reliability could be changed(10-13). It is known that in cases with multiple stones there is a decrease in stone-free rates after procedures and that treatment of solitary stones is more effective than treatment of multiple stones with similar stone burden in RIRS(14,15).

Although PNL and RIRS have been compared with each other in terms of size and localization of stones, the knowledge relating to multiple stones in the same renal unit is limited. In this study, we aimed to compare efficiency and reliability of RIRS and PNL in treatment of multicalyceal and multiple renal stones in the same renal unit. In the current literature, no previous study has examined RIRS and PNL for these specific conditions.

MATERIALS & METHODS

Between 2011 and 2015, records of patients who underwent surgery for renal stone were retrospectively reviewed after approval by the local ethics committee. The renal stones were classified by localization as lower pole, middle pole, upper pole and pelvic. Patients who had multicalyceal stones (>1 localization) and multiple stones (>1 number of stone) in the same renal unit were included in the present study.

Patients with congenital renal anomaly, coagulopathy, obesity (BMI > 30 kg/m^2), skeletal deformity, previous renal surgery and untreated urinary tract infection were excluded from the present study. Patients who were included in the study and underwent PNL were referred to as Group I, and underwent RIRS were referred to as Group II.

For PNL, patients were placed in the prone position.

[1]Department of Urology, Ankara Training and Research Hospital, Ankara, Turkey.
[2]Department of Urology, İnegöl State Hospital, Bursa, Turkey.
*Correspondence: Ankara Training and Research Hospital, Ankara, Turkey.
Phone: +905322500072. E mail: demirbas-arif@hotmail.com.
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Table 1. Demograhic data and stone characteristics.

	Group I	Group II	*p* value
Patients (n)	47	35	
Age (years)	47.46 ± 16.4	49.4 ± 13.28	0.558[t]
BMI (kg/m^2)	24.4 ± 4.1	23.8 ± 5.0	0.375[t]
Male/female	36/11	23/12	0.278[t]
Stone laterality			
Right/left	22/25	9/26	0.051[t]
Number of Stone	3 (2-8)	2 (2-7)	0.053[m]
Number of Stone Localisation	2 (2-4)	2 (2-3)	0.064[m]
Stone location			
Pelvis	51	37	
Upper pole	23	14	
Middle pole	19	15	
Lower pole	20	16	
Mean stone size (mm^2)	345.11 ± 184.85	281.25 ± 141.72	0.080[t]
Hounsfield units	658.40 ± 184.39	701.76 ± 192.81	0.642[t]

$P < 0.05$, statistically significant difference.
t: *T* test (mean ± std deviation)
m: Mann-Whitney *U* test (median, min-max)

Using multidirectional C-arm fluoroscopic guidance (Ziehm Vision R C-arm, Orlando, USA), a calyxial puncture at the appropriate calyx was performed with a 18-gauge Skinny Needle (Cook Medical, Bloomington, IN, USA). A flexible 0.035-inch Terumo guidewire (Boston Scientific Corp., Miami, FL, USA) was inserted into the ureter or an upper-pole calyx through the renal pelvis. The skin and fascia were incised and a 24 to 30-Fr amplatz renal dilatator set (Boston Scientific Corp. USA) was used. A 22-Fr Nephroscope (Olympus, Hamburg, Germany) and flexible nephroscope (Richard Wolf, Chicago, USA) were inserted inside the sheath and the renal stones were fragmented by pneumatic/ultrasonic lithotripter or holmium:YAG laser with a 365-µm fiber (Lisa Laser USA, Sphinx Family). Stone fragments were retrieved using an alligator or 5-Fr grasping forceps. After the stone fragments were removed, a percutaneous nephrostomy tube was inserted if necessary. All PNL operations were performed with single access.
For RIRS, patients were positioned in the dorsal lithotomy position. Before RIRS, diagnostic rigid ureterorenoscopy (URS) (6.5/8.5 Fr) (Richard Wolf, Knittlingen, Germany) was done with the same procedure routinely used for passive dilatation. After that a 9.5- or 11.5-Fr ureteral access sheath (Cook Medical) was placed in position. A 7.5-Fr Flex-X2 flexible ureteroscope (Karl Storz) was inserted through the access sheath. A 272-µm laser fiber was used for treatment of the stones. Holmium laser power was set to 10 W. Fragmented stones were not removed with any stone basket. Following completion of fragmentation, ureter was visualized all along its length to see any ureteral injury. JJ stent was not routinely placed after the procedure, and it was placed if there was mucosal edema, injury or the duration of the procedure was long. The ureteral JJ stent was usually removed within 2 to 4 weeks postoperatively. Both operation techniques were performed from two different surgeons who had sufficient experience in this regard.
The patients' criteria (age, sex, BMI), the stone characteristics (side and number of stones, number of localizations, hounsfield units, stone surface area), and procedure time, fluoroscopy time, and hospitalization time were evaluated between the treatment groups. Stone-free status and complications in the groups were also compared to determine efficiency and reliability of RIRS and PNL.
Low-dose non-contrast computed tomography (CT) and intravenous urography (IVU) were performed before the operation to determine the number, localizations, hounsfield units (HU) and surface area of stones. "Stone surface area = length x width x 0.25 x □" formula was used to calculate the surface area of stones from CT[1,16].
The stone-free status was evaluated one month after PNL or RIRS by non-contrast CT. The Absence of a stone at any size was considered as the stone-free status. Complications were defined and graded according to the modified Clavien classification[17].
Statistical analysis
The data analysis was performed by using SPSS for Windows, version 11.5 (SPSS Inc., Chicago, IL, United States). The normality of the distribution was tested with Shapiro-Wilk and Kolmogorov-Smirnov tests. Descriptive statistics for variables with a non-normal variables, normal variables and nominal variables were shown as median (min - max), mean ± standard deviation and number of cases and (%), respectively. The differences between independent groups regarding continuous variables were evaluated using the Mann-Whitney U test and Student t-test. For categorical comparisons, Chi-square or Fisher's exact test were used whenever convenient. $P < 0.05$ was regarded as statistically significant.

RESULTS

The characteristics of the patients including age, gender, BMI, and the laterality of the stones were similar in Group I (n=47), and in Group II (n=35) (*P* = .558, *P* = .278, *P* = .375 *P* = .051, respectively) (**Table 1**). There were also no differences in number of stone localizations, number of stones and mean HU of stones (P=.064, P=.053, 0.642, respectively) (**Table 1**). Mean stone surface area was 345.11 ± 184.85 mm2 in Group I and 281.25 ± 141.72 mm2 in Group II. These outcomes were also similar (*P* = .080) (**Table 1**).
Of 47 patients who underwent PNL 28 were stone-free and of 35 patients who underwent RIRS 31 were stone-free. RIRS effectuated higher stone-free rates than PNL (88.6%, 59.6%, respectively) and this difference was

Table 2. Comparison of operative and postoperative data.

	Group I	Group II	*p* value
Stone free rate (%)	28 (59.6%)	31 (88.6%)	0.004[c]
Mean residual stone size (mm^2)	120.14 ± 80.34	49.25 ± 40.18	0.012 [t]
Complication, clavien I-2 (%)	10 (%21.3)	1 (%2.9)	0.015[c]
Complication, clavien 3A-3B (%)	9 (%19.1)	2 (%5.7)	0.077[c]
Median fluoroscopy time (s)	150 (55-650)	12 (4-245)	< 0.001[m]
Mean procedure time (min)	89.76 ± 29.07	62.8 ± 17.57	< 0.001[t]
Median hospitalization time (day)	4 (2-15)	1 (1-7)	< 0.001[m]

$P < 0.05$, statistically significant difference.
t: *T* test (mean ± std deviation)
m: Mann-Whitney *U* test (median, min-max)
c: Chi Square test

statistically significant ($P = .004$). The mean residual stone sizes were also statistically different ($P = .012$) (**Table 2**). The reason were unaccessible calyx in all patients who had residual stone. When the complications were compared, it was seen that 1st or 2nd degree complications according to Modified Clavien Classification developed in 10 patients (21.3%) in Group I and 1 patient (2.9%) in Group II. This was also statistically significant ($P = .015$) (**Table 2**). Complications of 3A or 3B degree developed in 9 patients (19.1%) in Group I and 2 patients (5.7%) in Group II (**Table 2**). The difference was similar between groups ($P = .077$). No 4th and 5th degree complications were seen in any patient (**Table 2**).
When the operation data were evaluated, procedure time and fluoroscopy time in Group II were significantly lower ($P < .001$ and $P < .001$) (**Table 2**). The median hospitalization time for RIRS was 1 (1-7) day, while it was 4 (2-15) days for PNL. This value was statistically significant ($P < .001$) (**Table 2**).

DISCUSSION

Recently minimal invasive techniques have replaced open surgical methods in renal stone treatment; however there is an ongoing discussion in endourology about choice of optimal technique. PNL and RIRS are the most important techniques in this field and their success rates have been frequently compared in the literature[1-9]. After definition of percutaneous stone extraction[18], the PNL procedure has replaced open surgery in treatment of moderate- to large-sized stones and its efficacy has been researched in many studies[19,20]. Since it was first performed by Huffmann et al.[21], RIRS has become an important treatment modality for urinary stone disease using flexible devices and holmium laser[22].
Though PNL technique results in high stone-free rates for moderate- to large-sized renal stones, there has been a search for alternative treatment methods due to its morbidity and mortality rates[23,24]. Increased experience with the RIRS technique revealed that it has high stone-free rates even for large-sized stones and lower morbidity rates when compared with PNL[8,9]. When two meta-analysis studies comparing PNL and RIRS are taken into account, Shuba De et al. found that PNL has higher stone-free rates, complication rates and blood loss[9]. Another meta-analysis published in 2014 proposed RIRS as an alternative to PNL since RIRS has similar stone-free rates when compared to PNL even for stones larger than 2 cm along with lower complication rates and shorter hospital stay periods[8].
When localization of stones is taken into account, lower pole stones result in different stone-free rates and the PNL procedure was found to be more successful than RIRS[25,26]. A meta-analysis study, published in 2015, reviewed 6 randomized and 8 non-randomized studies comparing PNL, RIRS and SWL techniques for lower pole stones and found that PNL results in higher stone-free rates when compared to RIRS and SWL[27].
It is known that presence of more than one stone decreases the success rates of treatment in kidney stone disease. Cass et al.[28] reviewed 13,864 SWL cases and found that the stone-free rate was 69.5-72.1% in single stone cases, whereas it was lower than 50% in multiple stone cases for same renal unit. A study of pediatric cases and SWL showed that average stone number of cases was 1.87 for patients with stone-free treatment, whereas it was 2.81 for cases where treatment could not provide stone-free state in the same renal unit and they concluded that stone number influences success of SWL[29]. Meanwhile, Ozgor et al.[15] reported that RIRS technique resulted in lower stone-free rates in patients with multiple renal stones when compared to patients with solitary renal stone even though both groups have similar stone burden (83.8% and 89.2%, respectively). When PNL is performed for multiple renal stones located in more than one calyx, more than one access may be required and it is known that multiple access may cause serious bleeding complications and loss of kidney function from previous studies[15,30].
With regard to previous studies in the literature, we aimed to compare efficiency and reliability of RIRS and PNL for treatment of moderate- to large-sized multicalyceal and multiple renal stones in the same renal unit. To the best of our knowledge this is the first such study in the literature. Postoperative stone-free rate, which is considered as the most important parameter for evaluating efficacy, was 88.6% for RIRS and 59.6% for PNL and this difference was statistically significant ($p = .004$). Complications were defined and graded according to the modified Clavien classification. We found that grade 1 or 2 complications were encountered more frequently with the PNL technique and this finding was statistically significant; however there was no statistically significant difference between the two techniques with regard to major complications such as grade 3A or 3B ($P = .015$ and $P = .077$, respectively). Higher complication rates for the PNL technique is compatible with previous studies[8,9]. It was noteworthy that stone-free rates for this special patient group, performed PNL, were lower than previous literature data. However, stone-free rate for staghorn and partial staghorn

(located in minimum two calyces) was reported to be 53.9% in a recent study[31]. A United Kingdom-based prospective study of 1000 renal units reported that stone-free rate was seen to be 68% for PNL[32]. Despite there seems to be a contradiction between recruitment of flexible devices in our PNL operations and resultant low stone-free rates, we think that was due to degree of flexion of flexible devices moving to another calyx as calyceal access via flexible equipment is more difficult than reaching a calyx with pelvic access. Moreover, it is known that a flexible nephroscope has limitations with respect to field of view due to bleeding complications in PNL[33]. From this point of view, we think that RIRS is more advantageous than PNL.

When each group is examined according to data of during operation; RIRS was found to be superior to PNL with respect to procedure time, fluoroscopy time and hospitalization time ($P < .001$, $P < .001$, $P < .001$, respectively). These findings were also compatible with the previous literature[9,26].

When limitations of our study are considered, first of all it is retrospectively designed. Another limitation is that although multicalyceal stones were operated in our study, only one access was used for PNL. However, based on previously reported high complication rates in PNL operations performed with multiple access[15,30], we prefer single access in our department. To the best of our knowledge our study is the first to compare efficacy and reliability of PNL and RIRS techniques in this specific patient group that poses difficulties for treatment.

CONCLUSIONS

In conclusion, RIRS is superior to PNL with respect to both efficacy and reliability for multicalyceal and multiple renal stones in the same renal unit. Moreover RIRS is advantageous when fluoroscopy time and hospitalization time periods are taken into account. Therefore we think that RIRS should be the first choice of treatment in this specific patient group when their stone burden is considered. However, in order to support our conclusion, randomized controlled trials and meta-analyses are needed, as the principles of evidence-based medicine necessitate.

CONFLICT OF INTEREST

The authors declare that they have no competing interests.

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