Micropercutaneous Nephrolithotomy: First 66 Cases Experience

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Abstract

Objective: To present the initial experience with micro-percutaneous nephrolithotomy (micro-PNL) in patients with kidney stones.

Methods: Medical records of 66 patients with kidney stones who underwent micro-PNL between December 2012 and March 2015 were retrospectively reviewed. The demographic data; stone side, location and size; operation and fluoroscopy time; intraoperative and postoperative complications; preoperative and postoperative hemoglobin levels and hematocrit; and operation success of the patient were evaluated.

Results: The mean age of the patients was 46.62 ± 13.94 years, and their mean body mass index was 25.77 ± 2.62 kg/m^2. The mean stone size was 186.7 ± 34.23 mm^2. The mean operation and fluoroscopy times were 80.46 ± 43.67 min and 10.78 ± 7.14 min, respectively. The mean hemoglobin drop was 0.86 g/dL. Twenty-four intraoperative and 17 postoperative complications were observed. An overall success rate of 95% (including clinically insignificant residual fragments) was achieved.

Conclusion: Micro-PNL is a feasible, safe, and effective minimally invasive treatment modality for patients with small kidney stones.

Keywords: Micro-percutaneous nephrolithotomy, kidney stone, minimally invasive treatment, complication, endourology

Introduction

Urinary tract stone disease is a health problem that has existed since ancient Egyptian civilization; this disease is showing a gradual increase, with a significant lifetime risk of stone formation (1). The United States has the highest prevalence of this disease (13%); the prevalence in Europe is 5%–9%, and Asia has the lowest prevalence, 1%–5% (2). The prevalence of this disease has increased since the last quarter of the 20th century; it varies depending on age, gender, and race (3). Stones that do not cause complaints have also contributed to the increase in prevalence; this is due to the increasingly frequent use of radiological examination and the increase in imaging capabilities in parallel with advancing technology. Urinary tract stone disease is 1.5 times more common in men than in women and is often seen in people between 20 and 40 years of age with low socio-economic status and educational level (4).

Factors causing a higher prevalence of urinary tract stone disease are physical inactivity and poor eating habits, which are facets of modern life. According to a study conducted in 1991 on urinary tract stones, the prevalence of this disease in our country was reported to be 14.8% (4). This high prevalence of urinary stone disease in our country is due to the environmental conditions of our geographically hot climate zone and the high hypocitraturia rate (5).

The first treatment method (8) recommended by current treatment guidelines for the treatment of stones larger than 2 cm is percutaneous nephrolithotomy (PNL), especially in kidneys with a narrow infundibulopelvic angle, a lower calyx infundibulum shorter than 5 mm, and a lower calyx pole longer than 10 mm (7). PNL, which involves percutaneous entry (6) and was first described in 1955 by Goodwin, was conducted for the first time in 1976 by Fernstorm and Johannson. Although standard PNL has a success rate of 78%–95% (9) for the treatment of kidney stones, complication rates for this operation have been reported to vary between 29% and 83% (10). Generally, hemorrhage is one of the most serious complications; it arises because dilation must be performed to enable entry of nephroscopes with widths of up to 26 Fr. Therefore, to avoid wide dilation and to reduce trauma, the development of fine instruments is required. In particular, retrograde intrarenal surgery (RIRC) and mini-PNL methods are currently being used to minimize damage to renal parenchyma during treatment of cases in which shock wave lithotripsy (SWL) failed to treat small-scale pole stones (11, 12).

Furthermore, micro-PNL, the newest PNL method, enables visual entry in a single session via a special puncture needle, called an "all-seeing needle", by means of a micro-optical imaging system; this method does not require dilation because the nephroscope can be as fine as 4.8 Fr (13, 14). This new method not only avoids dilation, which may cause complications such as hemorrhage and perforation, but also shortens operation and fluoroscopy times (14).

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In this study, we aimed to demonstrate the feasibility, effectiveness, and reliability of the micro-PNL technique by presenting our first 66-case series.

Methods

Study population:

In our clinic, data obtained from 45 male and 21 female patients (total: 66) on whom micro-PNL was performed between December 2012 and March 2015 were evaluated retrospectively after obtaining the approval of the hospital's ethics committee. Micro-PNL was administered to patients whose kidney stones were smaller than 1 cm and whose stones could not be crushed by SWL; it was also performed on patients with symptomatic kidney stones larger than 1 cm for whom RIRC was unsuccessful. Additionally, micro-PNL was applied to patients with probable low SWL success rates due to calyx-located 1–2 cm stones with narrow lower and middle pole infundibula. Patients were informed in detail about the operations and alternative treatment methods. Informed consent forms were then signed by the patients. Demographic data of the patients, such as age, gender, body mass index (BMI), and previous kidney stone operations, were recorded.

Before the operation, following detailed history-taking and physical examination of the patients, routine biochemical analysis, coagulation tests, urine cultures, and complete blood counts were conducted. Then, ultrasound and intravenous urography and/or unenhanced computed tomography (CT) imaging were requested. According to direct urinary system radiography images, the stone zone was calculated via the following formula: maximum length×width×π×0.25 (15). Patients with positive urine cultures were started on appropriate antibiotic therapy based on their culture antibiograms; the operation was postponed until their urine culture results were negative. Prophylactic antibiotics were administered during the operation.

Operation and fluoroscopy times were recorded for each patient. Perioperative complications were recorded in the patients' files. On the first day after the operation, the patients' ureteral catheters and catheters were removed. Blood loss was assessed through hemogram values. To demonstrate the success of the operation, direct urinary system radiography was conducted to ensure that no residue remained. If no complications developed, the patients were then discharged. In the first postoperative month, direct urinary system radiography was performed as a follow-up. Suspected cases were verified via unenhanced CT. Stones smaller than 4 mm were considered clinically insignificant.

Surgical technique:

Under general anesthesia, in the lithotomy position, a 5 Fr ureteral catheter was inserted for all patients. Then, the patient was placed in a prone position that was suitable for fluoroscopy. The collecting duct system was viewed by fluoroscopy with contrast material that was administered via the ureteral catheter. PNL entry was performed by experienced surgeons using a 4.8 Fr "all-seeing needle" accompanied by direct vision under the control of fluoroscopy using a micro-optical system (Polydiagnost; Pfaffenhofen, Germany) as described in the literature (13, 14). After entry was complete and the collecting duct system was reached, urine output was verified; then, the inside of the needle was removed, and a 3-way connector apparatus was installed at the end of the needle. The optical system was attached to the middle duct of the 3-way apparatus; the other ducts were used to provide isotonic solution for irriga-

tion and to enable entry of the laser fiber that was used to crush the stone, respectively. The stones were completely fragmented using a 200 μm holmium: YAG laser fiber. Removal of the crushed stone fragments from the collecting duct system and sharper images were provided by the irrigation fluid pump system, which was under the control of the surgeon. The differences between the isotonic liquid used during irrigation and the fluid volumes exiting from the ureteral catheter were observed.

For patients whose stone volumes were large, after performing entry via a 4.8 Fr needle, a sensor guide wire was introduced into the collecting duct system. Aided by fluoroscopy, the needle was changed to a 8 Fr needle; thus, a laser fiber with a larger diameter and more irrigation fluid could be used, and sharper images could be obtained.

Statistical analysis

Statistical analysis was performed using a software package (Stata 11, College Station, TX). Data are given as mean±standard deviation (SD). To compare the patients' preoperative and postoperative hemoglobulin and hematocrit values, the paired sample t-test was used. P values <0.05 were considered to be significant.

Results

The average age of the patients was 46.62±13.94 years. The average BMI of the patients was calculated to be 25.77±2.62 kg m^2. The average stone zone was 186.7±34.23 mm^2. The demographic and operative data of the patients is summarized in Table 1. 18 patients underwent unsuccessful SWL, and 4 patients underwent unsuccessful RIRC. 4 fails in the SWL and 18 patients had failed RIRC story. No anatomical difficulty was observed in any of the patients. Of the stones, 40 were localized in the lower pole, 6 were localized in the pelvis, 10 were localized in the pelvis and middle pole, 6 were localized in the middle pole, and 6 were in multiple locations. The average operation time was 80.46±43.67 minutes, and the average fluoroscopy time was 10.78±7.14 minutes.

While 54.5% of the patients were found to be stone-free, when stones that were considered clinically insignificant were included, the success rate was as high as 95.5%. 24 of the patients developed intraoperative complications, and 18 patients experienced postoperative complications (Table 2). In 16 patients, hemorrhage that was detrimental to perioperative imaging was observed. Although the patients' intraoperative and postoperative hemoglobulin (0.86 g/dL) and hematocrit (2.7%) values were not clinically insignificant, statistical differences were detected (hemoglobulin: p=0.001; hematocrit: p=0.021). None of the patients required blood transfusions. Two of the patients experienced renal pelvis perforation during the operation; in one of these two patients, contrast extravasation was observed. One patient was diagnosed with abdominal fluid leak during the first operation due to the development of distension; a percutaneous drain was placed into the periton. Minimal hydrothorax and postoperative pneumothorax were observed in the same patient. A postoperative chest tube was inserted. Four patients experienced perioperative ureteral stone migration. One patient had a fever, and two patients experienced urinary incontinence during their postoperative periods; these patients received double-J (DJ) stents on the first day. Additionally, the number of fragments in two patients was excessive due to abnormal stone bulk, and urinary incontinence was observed; these patients received DJ stents. Patients with ongoing urethral and urethral catheter hemorrhage were discharged on the fourth day at the latest without any intervention. The DJ stents that were placed during

Table 1. Demographic and operational parameters of the patients

	n
Renal unit (n)	66
Side (right/left)	28/38
Gender (M/F	45/21
Age (years)	46.62±13.94
BMI (kg/m²)	25.77±2.62
Stone zone (mm²)	186.7±34.23
Location of the stone	
Lower pole	40
Pelvis	6
Pelvis+lower pole	10
Middle pole	4
Multiple	6
Preoperative Hb (g/dL)	14.14±1.65
Preoperative Htc (%)	43.85±4.8
Postoperative Hb (g/dL)	13.28±1.47
Postoperative Htc (%)	41.11±3.83
Duration of the operation (minutes)	80.46±43.67
Duration of fluoroscopy (minutes)	10.78±7.14
Stone-free rate (%)	95

BMI: body mass index; Hb: hemoglobin; Htc: hematocrit

Table 2. Complications according to Satava and Clavien classifications

	Complications (n)		Satava degree	Clavien degree
Intraoperative	Hemorrhage	16	1	1
	Renal pelvic perforation	2	1	1
	Contrast extravasation	1	1	1
	Stone in the ureter	4	1	2
	Hydrothorax and abdominal extravasation	1	3	3A
Postoperative	Hemorrhage	9	1	1
	Urine incontinence	4	1	1
	Pneumothorax	1	1	3A
	Fever	2	1	2
	Hydrothorax	1	1	3A

the operation were removed under local anesthesia approximately one week later. None of the patients developed adjacent organ injuries or complications requiring open surgical procedures.

Discussion

The treatment of urinary stone disease, which is quite common in our country, has evolved from open surgery to minimally invasive techniques due to technological advancements and the increasing accumulation of endourology knowledge. Therefore, open surgery, which was formerly the only option for the treatment of kidney stones, is now applied almost exclusively to a limited group of patients. The endoscopic methods used in kidney stone surgeries cause fewer complications due to the use of tools with smaller diameters; consequently, morbidity and mortality rates are lower. As a result of these developments, PNL has become a become standard procedure for kidney stones larger than 2 cm (8).

Percutaneous nephrolithotomy was first described as percutaneous entry in 1955 and was applied for the first time in 1976 (6, 7). Hemorrhage-related (16) morbidity and mortality is one of the most frequent and serious complications in PNL, and its rate is reported to be between 0.4% and 23% in the literature. To address this, the diameter of the tool was decreased; mini-PNL, using needles with sizes of 12–20 Fr, was developed (17). It has been demonstrated that compared to standard PNL, mini-PNL results in lower hemorrhage rates and shorter hospital stays (11, 18). Furthermore, Bader et al. (13) have provided a reliable and effective method for direct entry into kidney stones under direct vision by means of an "all-seeing needle," which is the optical imaging system with the smallest diameter. In this system, entry is similar to that in standard PNL; however, because the instruments used are smaller in size, complications that occur during standard PNL, such as hemorrhage and adjacent organ injuries, are less frequent.

In contrast, micro-PNL, which was developed by Desai et al. (14), differs from the standard and mini-PNL methods. Unlike other PNL operations, the 4.8 Fr "all-seeing needle" enables entry under direct vision without any dilation. Therefore, once entry is performed, by inserting the laser fiber through a side duct of a 3-way apparatus, the stone is completely fragmented under vision. By including clinically insignificant stones and stones that were fragmented via 200 μm holmium: YAG laser fiber, we obtained a clinical success rate of 95.5%. In the literature, in the first study presented by Desai et al. (14) on this subject, the success rate was reported to be 89% when clinically insignificant stones were excluded. Subsequent studies have reported stone-free rates between 85% and 93%, demonstrating the success of this new technology (19, 20). In a recent study that compared the success rates of micro-PNL and RIRC, it was found that the stone-free rate was 80% in patients who underwent micro-PNL treatment, whereas the stone-free rate for RIRC was 86.2% (p=0.47) (21). When the methods were compared in terms of complications, it was reported that micro-PNL caused fewer complications (13.3%) than RIRC (16.6%); however, the difference between these two groups was not statistically significant (p=0.675). When micro-PNL was compared with mini-PNL, another minimally invasive method, it was reported that the success rates were 87.3% and 93.6%, respectively (22). In addition to similar success rates, other advantages of micro-PNL over mini-PNL reported in the same study were that micro-PNL results in smaller decreases in hemoglobin levels and shorter hospital stays.

Apart from the success rates of percutaneous surgery, when complications are considered, the most important complication is hemorrhage. The occurrence of hemmorhage is reported to be between 0.8% and 45% in the literature (23-25). Especially when entry is performed with a needle, hemorrhage occurs more frequently during dilatation, stone crushing, and searching for the crushed pieces (23, 25-27). In studies on micro-PNL, the differences between preoperative and postoperative hemoglobin values were reported to be between 0.8 and 1.4 g/dL (14, 19, 20). Also in our study, a low level of average hemoglobin decrease of 0.86 g/dL was determined; as a result, none of our patients required blood transfusions.

Other advantages of micro-PNL over standard PNL are shorter duration of operation, shorter hospital stay, and time of fluoroscopy use (19). Performing entry via "all-seeing needle" under direct vi-

sion and without requiring dilatation shortens both the duration of the operation and the fluoroscopy time (19). In our study, the average operation time was 80.46±43.67 minutes, and the average time of fluoroscopy use was 10.78±7.14 minutes. The important factor that shortened these periods was that the stones were fully fragmented by holmium: YAG laser. The fragments were left to fall spontaneously; thus, no additional time was spent collecting the pieces. However, fragments that are left sometimes become lodged in the ureter during or after the operation; this may lead to renal colic, which is another complication. It was observed during the operation on four of our patients that stone fragments fell into the ureter. Upon observing postoperative fever in two of the patients and urine incontinence in all four, 4.8 Fr DJ stents were placed in the patients. Another complication that should be taken into consideration during surgery is fluid leakage in the abdomen or chest. Therefore, the amount of liquid taken in and discharged should be monitored. In our first case, fluid leakage that was observed through distension development in the abdomen during the operation was resolved by ultrasound-guided percutaneous drainage. Hydrothorax development was observed in the same patient, and a thorax tube was placed in the patient postoperatively.

Conclusion

Compared to standard PNL, the micro-PNL method is a reliable and effective option, especially for the treatment of small and symptomatic kidney stones that cannot be successfully treated by SWL and RIRC.

References

1. Lopez M, Hoppe B. History, epidemiology and regional diversities of urolithiasis. Pediatr Nephrol 2010; 25: 49-59. **[CrossRef]**
2. Tzortzis V, Mamoulakis C, Rioja J, Gravas S, Michel MC, de la Rosette JJ. Medical expulsive therapy for distal ureteral stones. Drugs 2009; 69: 677-92. **[CrossRef]**
3. Curhan GC. Epidemiology of stone disease. Urol Clin North Am 2007; 34: 287-93. **[CrossRef]**
4. Akinci M, Esen T, Tellaloglu S. Urinary stone disease in Turkey: an updated epidemiological study. Eur Urol 1991; 20: 200-3.
5. Öner A. Üriner sistem taş hastalığı. İÜ Cerrahpaşa Tıp Fakültesi Sürekli Tıp Eğitimi Kurulu İstanbul: İÜ Cerrahpaşa Tıp Fakültesi. 2009.
6. Casey WC, Goodwin WE. Percutaneous antegrade pyelography and hydronephrosis; direct, intrapelvic injection of urographic contrast material to secure a pyeloureterogram after percutaneous needle puncture and aspiration of hydronephrosis. J Urol 1955; 74: 164-73.
7. Fernstrom I, Johansson B. Percutaneous pyelolithotomy. A new extraction technique. Scand J Urol Nephrol 1976; 10: 257-9.
8. Turk C, Petrik A, Sarica K, Seitz C, Skolarikos A, Straub M, et al. EAU Guidelines on Interventional Treatment for Urolithiasis. Eur Urol 2016; 69: 475-82. **[CrossRef]**
9. de la Rosette JJ, Tsakiris P, Ferrandino MN, Elsakka AM, Rioja J, Preminger GM. Beyond prone position in percutaneous nephrolithotomy: a comprehensive review. Eur Urol 2008; 54: 1262-9. **[CrossRef]**
10. El-Assmy AM, Shokeir AA, El-Nahas AR, Shoma AM, Eraky I, El-Kenawy MR, et al. Outcome of percutaneous nephrolithotomy: effect of body mass index. Eur Urol 2007; 52: 199-204. **[CrossRef]**
11. Mishra S, Sharma R, Garg C, Kurien A, Sabnis R, Desai M. Prospective comparative study of miniperc and standard PNL for treatment of 1 to 2 cm size renal stone. BJU Int 2011; 108: 896-9. **[CrossRef]**
12. Knoll T, Jessen JP, Honeck P, Wendt-Nordahl G. Flexible ureterorenoscopy versus miniaturized PNL for solitary renal calculi of 10-30 mm size. World J Urol 2011; 29: 755-9. **[CrossRef]**
13. Bader MJ, Gratzke C, Seitz M, Sharma R, Stief CG, Desai M. The "all-seeing needle": initial results of an optical puncture system confirming access in percutaneous nephrolithotomy. Eur Urol 2011; 59: 1054-9. **[CrossRef]**
14. Desai MR, Sharma R, Mishra S, Sabnis RB, Stief C, Bader M. Single-step percutaneous nephrolithotomy (microperc): the initial clinical report. J Urol 2011; 186: 140-5. **[CrossRef]**
15. Tiselius HG, Andersson A. Stone burden in an average Swedish population of stone formers requiring active stone removal: how can the stone size be estimated in the clinical routine? Eur Urol 2003; 43: 275-81. **[CrossRef]**
16. Resorlu B, Kara C, Oguz U, Bayindir M, Unsal A. Percutaneous nephrolithotomy for complex caliceal and staghorn stones in patients with solitary kidney. Urol Res 2011; 39: 171-6. **[CrossRef]**
17. Monga M, Oglevie S. Minipercutaneous nephrolithotomy. J Endourol 2000; 14: 419-21. **[CrossRef]**
18. Giusti G, Piccinelli A, Taverna G, Benetti A, Pasini L, Corinti M, et al. Miniperc? No, thank you! Eur Urol 2007; 51: 810-4; discussion 5. **[CrossRef]**
19. Armagan A, Tepeler A, Silay MS, Ersoz C, Akcay M, Akman T, et al. Micropercutaneous nephrolithotomy in the treatment of moderate-size renal calculi. J Endourol 2013; 27: 177-81. **[CrossRef]**
20. Tepeler A, Armagan A, Sancaktutar AA, Silay MS, Penbegul N, Akman T, et al. The role of microperc in the treatment of symptomatic lower pole renal calculi. J Endourol 2013; 27: 13-8. **[CrossRef]**
21. Bas O, Dede O, Aydogmus Y, Utangac M, Yikilmaz TN, Damar E, et al. Comparison of Retrograde Intrarenal Surgery and Micro-percutaneous Nephrolithotomy in Moderately size Pediatric Kidney Stones. J Endourol 2016; 30: 765-70. **[CrossRef]**
22. Karatag T, Tepeler A, Silay MS, Bodakci MN, Buldu I, Daggulli M, et al. A Comparison of 2 Percutaneous Nephrolithotomy Techniques for the Treatment of Pediatric Kidney Stones of Sizes 10-20 mm: Microperc vs Miniperc. Urology 2015; 85: 1015-8. **[CrossRef]**
23. Michel MS, Trojan L, Rassweiler JJ. Complications in percutaneous nephrolithotomy. Eur Urol 2007; 51: 899-906; discussion 906. **[CrossRef]**
24. Kukreja R, Desai M, Patel S, Bapat S, Desai M. Factors affecting blood loss during percutaneous nephrolithotomy: prospective study. J Endourol 2004; 18: 715-22. **[CrossRef]**
25. de la Rosette J, Assimos D, Desai M, Gutierrez J, Lingeman J, Scarpa R, et al. The Clinical Research Office of the Endourological Society Percutaneous Nephrolithotomy Global Study: indications, complications, and outcomes in 5803 patients. J Endourol 2011; 25: 11-7. **[CrossRef]**
26. Akman T, Binbay M, Sari E, Yuruk E, Tepeler A, Akcay M, et al. Factors affecting bleeding during percutaneous nephrolithotomy: single surgeon experience. J Endourol 2011; 25: 327-33. **[CrossRef]**
27. Seitz C, Desai M, Hacker A, Hakenberg OW, Liatsikos E, Nagele U, et al. Incidence, prevention, and management of complications following percutaneous nephrolitholapaxy. Eur Urol 2012; 61: 146-58. **[CrossRef]**