

Treatment of Moderate Sized Renal Pelvis Calculi: Stone Clearance Time Comparison of Extracorporeal Shock Wave Lithotripsy and Retrograde Intrarenal Surgery

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Purpose: To compare the stone clearance times in patients undergoing extracorporeal shock wave lithotripsy (SWL) or retrograde intrarenal surgery (RIRS) for single radiopaque renal pelvis stones 10-20 mm in size. The results of this study may guide urologists and patients and aid in selecting the optimal preoperative treatment.

Materials and Methods: Between January 2013 and February 2015, we conducted a retrospective study and collected data from 333 patients treated with SWL (n = 172) or RIRS (n = 161). We included successfully treated patients with a single radiopaque renal pelvis stone 10-20 mm in size to calculate stone clearance times.

Results: The average stone size for the SWL group was 14.62 ± 2.58 mm and 14.91 ± 2.92 mm for the RIRS group. The mean Hounsfield unit (HU) of the patients was 585.40 ± 158.39 HU in the SWL group and 567.74 ± 186.85 HU in the RIRS group. Following full fragmentation, the mean stone clearance time was 26.55 ± 9.71 days in the SWL group and 11.59 ± 7.01 days in the RIRS group ($P < .001$).

Conclusion: One of the most overlooked parameters in urinary stone treatments is stone clearance. We believe this study will shed light for those who aim to conduct larger randomized prospective studies.

Keywords: lithotripsy; methods; kidney calculi; surgery; treatment outcome; retrospective studies; ureteroscopy.

INTRODUCTION

With the advancements in endourologic technology, in the last 30 years, renal stone treatment has dramatically changed, and minimally invasive treatment options, such as extracorporeal shock wave lithotripsy (SWL), percutaneous nephrolithotomy (PCNL), mini-PCNL, retrograde intrarenal surgery (RIRS) or laparoscopy, have replaced open surgery.⁽¹⁾ The primary aim of all of these procedures is to maximize the removal of stones with minimal morbidity. Although, minimally invasive treatment modalities have an excellent stone fragmentation rate, the clearance of stone fragments may not be immediate and can occur for any time after the intervention. Additionally, clearance of stone fragments may not have an immediate clinical concern but are likely to affect the patient's well-being in the long term.^(2,3) If the spontaneous passage of the stone fragments is prolonged, additional procedures, labor loss and hospital admittance due to renal colic episodes, increase. Thus, the total cost caused by the condition and treatment increases and treatment compliance dra-

atically decreases.⁽⁴⁾

The European Association of Urology (EAU) guidelines,⁽⁵⁾ recommends PCNL for renal pelvic stones greater than 2 cm, and SWL is suggested primarily for stones less than 1 cm in size. Although SWL, RIRS and PCNL are all presented as treatment options for stones between 1 and 2 cm in size, which application is a matter of preference. The choice of treatment decision usually depends on many factors, such as patient/doctor preference, success rate, patient's comorbidities, complications of the treatment, treatment costs, existing surgical equipment, stone clearance time, and patient's compliance. In the decision-making process, patients are informed about each procedure's success rates, possible complications, invasiveness, the need for anesthetics, and hospital stay. However, there is no clear information for the patient regarding the amount of time taken to clear the stones from the urinary system after treatment. Although stone clearance times for ureteral stones are widely studied,⁽⁶⁻⁸⁾ few reports have studied the elimination of renal stones after SWL,^(9,10)

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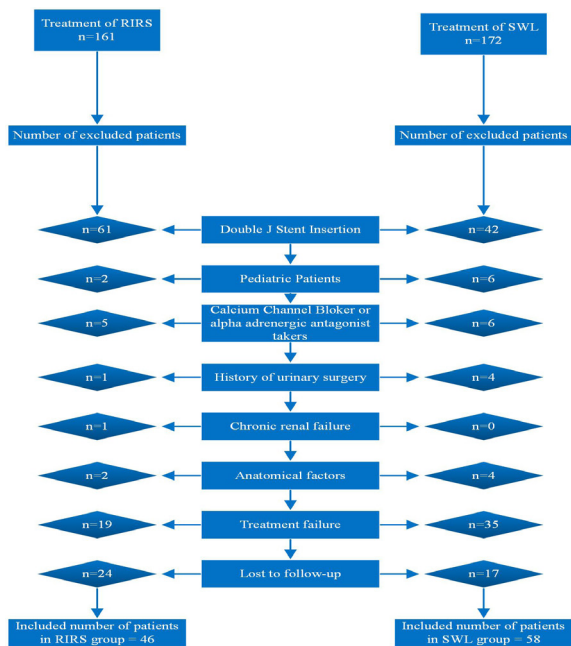


Figure 1. Flow diagram of the study with exclusion criteria.

Abbreviations: SWL, extracorporeal shock wave lithotripsy; RIRS, retrograde intrarenal surgery; DJ, double J.

and no study has evaluated or compared clearance after RIRS. Thus, we compared the stone clearance times in patients who had undergone SWL or RIRS for single radiopaque renal pelvic stones 10-20 mm in size. The results of this study can serve as a guide for urologists and patients trying to decide the best optimal treatment preoperatively.

MATERIALS AND METHODS

Study Population

Between January 2013 and February 2015, we conducted a retrospective study on 333 patients treated with SWL ($n = 172$) or RIRS ($n = 161$). Patients with a single radiopaque renal pelvis stone in size 10-20 mm were included the study. Treatment method was chosen according to the patient's preference. Patients with pediatric age group, those with multiple stones, obstruction in the urinary system (ureteropelvic or ureterovesical junction obstruction etc.), taking alpha blocker or calcium channel blocker medication, a history of renal or ureter surgery, creatinine level $> 2\text{mg/dL}$, anatomic anomaly of the urinary system (duplicated collecting system, kidney rotation anomalies etc.), irregular followed patients and those with non-radiopaque stones were excluded to provide highest compliance among groups. Patients with preoperative and/or peroperative double J (DJ) stent placement in RIRS group and pre-SWL DJ stent placement in SWL group were also ex-

cluded. Additionally, only successfully treated patients with completely stone free or clinically insignificant residual fragments (CIRFs) ($< 3\text{ mm}$) at the end of the follow-up were included in the study. A total of 104 patients met these criteria and were divided into 2 groups according to the procedure performed; SWL group ($n = 58$), and RIRS group ($n = 46$). Flow diagram of the study with exclusion criteria are summarized in **Figure 1**.

We did not consider patients with treatment failure. We accepted stone-free status or CIRFs ($< 3\text{ mm}$), which we detected on kidney-ureter bladder (KUB) radiography or ultrasonography (USG) or non-contrast computerized tomography (NCCT) as a treatment success in both groups. We defined treatment failure as residual fragments ($\geq 3\text{ mm}$) or insufficient fragmentation of a stone after three sessions in the SWL group. In the RIRS group, we defined treatment failure as the need for additional interventions, residual fragments ($\geq 3\text{ mm}$) and technical failure (such as failure of the access sheath placement).

We evaluated patients with KUB radiography, USG or intravenous urography and NCCT, preoperatively. We evaluated all patients with NCCT preoperatively. We calculated stone sizes from the greatest diameter on the NCCT obtained from picture archiving and communication system. We also measured the Hounsfield unit (HU) on NCCT. We calculated stone clearance time from the day of complete stone fragmentation after SWL in SWL group and the operation day in RIRS group until the complete clearing of stones from the urinary system after treatment. We performed another calculation following the first SWL session to achieve complete fragmentation time for informing patients. The primary aim of the present study was to compare the stone clearance times after RIRS and SWL. We also compared group differences in stone diameter, age, sex, body mass index, fluoroscopy time (second) and HU.

Procedures

We treated all patients according to the outpatient treatment protocol for SWL. Before the procedure, we evaluated urine tests, urine culture, blood and clotting parameters. We used an electrohydraulic extracorporeal lithotripter (Argemet A1000, Ankara, Turkey) for the SWL. We performed the SWL with a team comprised of an experienced urologist and a technician. We performed the SWL treatment with 60-shocks/per minute and lasted to visible stone fragmentation. If stone fragmentation was not visible, we did not exceed 3000 shock waves per session. We applied the SWL sessions at intervals of two weeks. We administered nonsteroi-

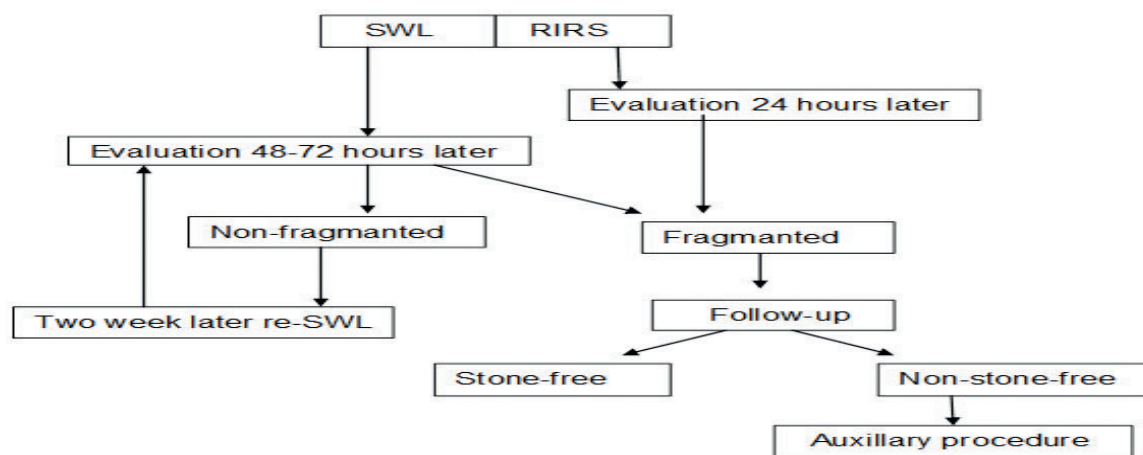


Figure 2. The algorithm of the follow-up.

Abbreviations: SWL, extracorporeal shock wave lithotripsy; RIRS, retrograde intrarenal surgery.

dal anti-inflammatory drugs (NSAIDs) to the patients for pain relief after the SWL session.

For RIRS, we admitted patients to the hospital and conducted routine tests for general anesthesia. We applied the RIRS to patients under general anesthesia in the lithotomy position. Firstly, under semi-rigid ureteroscopy, we placed a hydrophilic guidewire in the renal pelvis. Then, accompanying the guidewire, we advanced a ureteral access sheath (11/13 French [F]) as far as the proximal ureter. We reached the renal pelvis using the RIRS flexible ureteroscope (Flex-X2, Karl Storz, Tuttlingen, Germany) contained in the ureteral access sheath. For fragmentation of the stones, we used the Holmium: YAG laser (Sphinx, LISA, Katlenburg, Germany) with 272-micron fiber, set at energy 0.5-1 J and frequency 5-20/sec. The stones were fragmented as small as possible to pass through the ureter spontaneously. We did not actively remove the stones. None of the patients had inserted DJ stents after the procedure. We administered NSAIDs in the postoperative period and discharged patients with non-complicated opera-

tions on postoperative day 1.

Evaluations

We followed-up with our patients as described below. In the SWL intervention, we assessed stone clearance with KUB radiography after 48-72 hours of the SWL session. We repeated SWL sessions if stones were un-fragmented or semi-fragmented. The intervals between SWL sessions were two weeks. For the RIRS procedure, we assessed stone clearance with postoperative 1st day KUB radiography. In both procedures, we evaluated patients with complete disintegration of the stone, weekly with KUB radiography and USG for stone clearance time. We evaluated stone-free status with KUB radiography and USG. We followed-up with KUB and USG. We utilized NCCTs if there was doubt regarding the stone-free status or in symptomatic patients with a normal KUB radiography. This algorithm is in **Figure 2**.

Statistical Analysis

We performed statistical analysis using Statistical

Table. Comparison of patient demographic and clinical characteristics.

Variables	SWL Group (n = 58)	RIRS Group (n = 46)	P Value
Age, year	38.93 ± 10.05	40.54 ± 13.02	.491
Stone size, mm	14.62 ± 2.58	14.91 ± 2.92	.592
BMI, kg/m ²	23.61 ± 3.05	23.55 ± 3.25	.924
Fluoroscopy time, s	32.95 ± 13.99	11.48 ± 3.97	< .001
Hounsfield units	585.40 ± 158.39	567.74 ± 186.85	.610
Stone clearance time of SWL starting first day of treatment, days	37.74 ± 12.35	11.59 ± 7.01	< .001
Stone clearance time following the completion of SWL treatment, days	26.55 ± 9.71	11.59 ± 7.01	< .001

Abbreviations: BMI, Body Mass Index; SWL, extracorporeal shock wave lithotripsy; RIRS, retrograde intrarenal surgery.

Package for the Social Science (SPSS Inc, Chicago, Illinois, USA) version 20. We used the Shapiro-Wilk test to assess normality; all normally distributed data are presented as mean \pm the standard deviation. We used the Student's *t*-test for parametric variables and the Mann-Whitney *U* test for nonparametric variables. For multivariate analysis, we used the linear regression analysis test. We performed a retrospective power analysis and considered $P < .05$ statistically significant.

Results

We evaluated 161 patients in the RIRS group. A total of 19 patients experienced treatment failure due to residual stone, technical problems, or steinstrasse. The success rate in the RIRS group was 88.2%. However, only 46 of these patients met the inclusion criteria. We evaluated 172 patients in the SWL group. A total of 35 patients experienced treatment failure due to a residual stone, an unfragmented stone, or steinstrasse, and etc. The success rate in the SWL group was 79.7%. However, only 58 of these patients met the inclusion criteria.

The mean age of the patients was 38.93 ± 10.05 years and 40.54 ± 13.02 years for the SWL and RIRS groups, respectively. The average stone size for the SWL group was 14.62 ± 2.58 mm and 14.91 ± 2.92 mm in the RIRS group. The mean HU of the patients was 585.40 ± 158.39 HU in the SWL group and 567.74 ± 186.85 HU in the RIRS group. As delineated in **Table**, there was no significant difference between the groups on demographic characteristics.

The mean number of sessions for the SWL group was 1.86 (range 1-3). We treated 19 patients in one session, 28 patients in two sessions, and 11 patients in three sessions. The mean fluoroscopy screening time was 32.95 ± 13.99 seconds in the SWL group and 11.48 ± 3.97 seconds in the RIRS group ($P < .001$). Following full fragmentation, the mean stone clearance time was 26.55 ± 9.71 days in the SWL group and 11.59 ± 7.01 days in the RIRS group ($P < .001$). When calculated from the beginning of SWL treatment, 37.74 ± 12.35 days was found necessary for complete stone clearance.

We performed multivariate linear regression analysis to evaluate risk factors of stone clearance time. The type of treatment ($P < .001$) and stone size ($P = .04$) were significant factors in stone clearance time. However, HU ($P = .552$), age ($P = .173$), and BMI ($P = .858$) did not have an effect on stone clearance time. The retrospective power analysis yielded 91% power.

DISCUSSION

The treatment modality selection of renal stones usually depends on stone-related factors (location, size, and

composition), clinical factors (patient's comorbidities, patient's compliance, solitary kidney, and abnormal anatomy), and technical factors (equipment available for treatment, success rates, possible complications, invasiveness, the need for anesthetics, hospitalization times, and costs).⁽¹¹⁾ All of these factors may shift the balance towards a certain modality or away from other treatments. Patients may desire immediate or nearly immediate stone-free status with a single procedure or a less invasive procedure. Conversely, a patient may be reluctant to anesthetics, hospitalization or the possibility of a temporary ureteral stent.⁽¹²⁾ Therefore, patients must be informed of the available treatment options, and patient's expectations should be considered, including the relative benefits and risks associated with each treatment. In the decision-making process, patients are informed about factors predicting poor treatment outcomes and can be advised about alternative therapeutic modalities. However, there is no clear information to the patients about the time taken for clearing stones from the urinary system after treatment.

The exact time taken for all stone fragments to clear from the urinary system after treatment is difficult to predict precisely; it is estimated from weekly imaging techniques (mainly plain radiographs or ultrasonography). In a study conducted by Goren and colleagues⁽⁶⁾ 117 patients with ureteral stones, treated with SWL were followed. In 20 days, 93.1% of patients remained stone-free after the first session. The authors claim a mean of 13.1 (range 7-42) days for the clearance of proximal ureteral stones in 27 patients with a mean stone size of 20.7 mm.

Currently, the SWL technique has been applied successfully in an outpatient setting (without anesthesia), with a low morbidity rate, and high patient compliance for the treatment of kidney and ureter stones. Although patients with renal pelvic stones between 10 and 20 mm have several treatment options (SWL, RIRS or PCNL), it is still challenging deciding which treatment is the first choice. PCNL can achieve better results but is more invasive, is associated with greater morbidity and complications, and may be reserved for selected circumstances.⁽¹³⁾ With similar success rates and complication rates, it is very challenging to prefer one modality over another.

There are a limited number of studies that have evaluated stone clearance times in renal stones after SWL. In 2008, Naja and colleagues⁽⁹⁾ evaluated the role of tamsulosin in the clearance of stone fragments after SWL for the treatment of single radiopaque renal stones (5-20 mm). The stone positions were mostly in the renal pel-

vis (renal pelvis in 90 patients, superior calyx in 16 patients, and middle calyx in 10 patients). The total days required for a successful treatment were 35.53 ± 9.47 in the tamsulosin group and 47.22 ± 23.64 in the control group ($P = .006$). The authors reported that tamsulosin facilitates earlier clearance of fragments after SWL and reduces the pain intensity associated with the tendency of the spontaneous clearance of steinstrasse. In the control group, the mean values of the stone size, the number of SWL sessions, success rate and stone clearance time were determined as 13.06 ± 3.49 mm, 2.16, 84.6% and 47.22 ± 23.64 days respectively. Similar to the previously study, Zaytoun and colleagues⁽¹⁰⁾ compared stone clearance times of renal stones with and without alpha receptor blockers after SWL. The study included patients with single radiopaque renal stones up to 20 mm in diameter located in the renal pelvis, middle or upper calices. The mean expulsion time was 7.3 ± 2.7 weeks in the control group, 5.3 ± 2.6 weeks in tamsulosin group and 6.8 ± 2.8 weeks in the doxazosin group. The tamsulosin group was significantly shorter than both the control group ($P = .002$) and the doxazosin group ($P = .026$). On the other hand, there were no significant differences between the groups regarding the overall stone expulsion rates. In our study, the mean values of stone size, the number of SWL sessions and stone clearance time were 14.62 ± 2.58 mm, 1.86 ± 0.71 sessions, and 26.55 ± 9.71 days. The shorter stone clearance time in our study group is thought to be due to the patient's selection criteria and strict follow-up.

Stone clearance following kidney stone treatment is not well defined. For lower pole stones, Sener and colleagues compared RIRS with SWL and reported a stone-free rate of 52.3% with patients treated using RIRS one week after treatment. However after three months, the stone-free rate improved to 100%.⁽¹⁴⁾ However, this study did not calculate stone-free clearance time. There is no clear information in the literature related to stone clearance time following RIRS treatment. In the current study, stone size and stone clearance time were found to be 14.91 ± 2.92 mm and 11.59 ± 7.01 days respectively.

To our knowledge, this is the first study to address stone clearance following SWL and RIRS. Even though the study may be a great influence, there are several limitations. The study is retrospective, with a relatively low number of patients and lacked randomization. Also, the comparison of RIRS and SWL seems to cause bias, but a comparison is necessary for informing patients.

CONCLUSIONS

With advancements in endourology, many treatment options are available for both patients and physicians. Having similar morbidities and success rates, RIRS has a shorter clearance time, thus, may be one step ahead of the 'gold standard' race. Therefore, prospective randomized studies on larger cohorts are needed.

CONFLICT OF INTEREST

None declared.

REFERENCES

1. Matlaga BR, Assimos DG. Changing indications of open stone surgery. *Urology*. 2002;59:490-4.
2. Sener NC, Bas O, Sener E, et al. Asymptomatic lower pole small renal stones: shock wave lithotripsy, flexible ureteroscopy, or observation? A prospective randomized trial. *Urology*. 2015;85:33-7.
3. Inci K, Sahin A, Islamoglu E, Eren MT, Bakkaloglu M, Ozen H. Prospective long-term followup of patients with asymptomatic lower pole caliceal stones. *J Urol*. 2007;177:2189-92.
4. Dellabella M, Milanese G, Muzzonigro G. Efficacy of tamsulosin in the medical management of juxtavesical ureteral stones. *J Urol*. 2003;170:2202-5.
5. Turk C, Knoll T, Petrik A, Sarica K. Guidelines on urolithiasis. European Association of Urology 2015 <http://www.uroweb.org/publications/eau-guidelines/>
6. Resit-Goren M, Dirim A, Ilteris-Tekin M, Ozkardes H. Time to stone clearance for ureteral stones treated with extracorporeal shock wave lithotripsy. *Urology*. 2011;78:26-30.
7. Seitz C, Liatsikos E, Porpiglia F, Tiselius H-G, Zwergel U. Medical therapy to facilitate the passage of stones: what is the evidence? *Eur Urol*. 2009;56:455-71.
8. Zhu Y, Duijvesz D, Rovers MM, Lock TM. alpha-Blockers to assist stone clearance after extracorporeal shock wave lithotripsy: a meta-analysis. *BJU Int*. 2010;106:256-61.
9. Naja V, Agarwal MM, Mandal AK, et al. Tamsulosin facilitates earlier clearance of stone fragments and reduces pain after shockwave lithotripsy for renal calculi: results from an open-label randomized study. *Urology*. 2008;72:1006-11.
10. Zaytoun OM, Yakoubi R, Zahran ARM, et al. Tamsulosin and doxazosin as adjunctive therapy following shock-wave lithotripsy of renal calculi: randomized controlled trial. *Urol Res*. 2012;40:327-32.
11. Lehtoranta K. Cost and effectiveness of different treatment alternatives in urinary stone practice. *Scand J Urol Nephrol*. 1995;29:437-

47.

12. Resorlu B, Oguz U, Resorlu EB, Oztuna D, Unsal A. The impact of pelvicaliceal anatomy on the success of retrograde intrarenal surgery in patients with lower pole renal stones. *Urology*. 2012;79:61-6.
13. Bas O, Bakirtas H, Sener NC, et al. Comparison of shock wave lithotripsy, flexible ureterorenoscopy and percutaneous nephrolithotripsy on moderate size renal pelvis stones. *Urolithiasis*. 2014;42:115-20.
14. Sener NC, Imamoglu MA, Bas O, et al. Prospective randomized trial comparing shock wave lithotripsy and flexible ureterorenoscopy for lower pole stones smaller than 1 cm. *Urolithiasis*. 2014;42:127-31.