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UROLITHIASIS

# Does ureteral stenting matter for stone size? A retrospective analyses of 1361 extracorporeal shock wave lithotripsy patients

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**Introduction** The aim of our study was to determine the efficacy of ureteral stents for extracorporeal shock wave lithotripsy (SWL) treatment of pelvis renalis stones and to compare the results and complications in stented and non-stented patients.

**Material and methods** Between 1995 and 2011, 1361 patients with pelvis renalis stones were treated with SWL. Patients were subdivided into three groups according to stone burden: ≤1 cm² (group 1; n = 514), 1.1 to 2 cm² (group 2; n = 530) and >2 cm² (group 3; n = 317). Each group was divided into subgroups of patients who did and did not undergo ureteral stent implantation before SWL treatment. The efficacy of treatment was evaluated by determining the effectiveness quotient (EQ). Statistical analysis was performed by chi-square, Fisher's exact and Mann-Whitney U tests.

**Results** Of the 514, 530 and 317 patients in groups 1, 2 and 3 respectively, 30 (6%), 44 (8%) and 104 (33%) patients underwent auxiliary stent implantation. Steinstrasse rates did not differ significantly between stented and non-stented patients in each group. The EQ was calculated as 62%, 33% and 70% respectively in non-stented, stented and totally for group 1. This ratio calculated as 58%, 25% and 63% for group 2 and 62%, 26% and 47% for group 3. Stone-free rates were significantly higher for non-stented than for stented patients in groups 2 and 3.

**Conclusions** Stone free rates are significantly higher in non-stented than in stented patients with pelvis renalis stones >1 cm², whereas steinstrasse rates are not affected.

Key Words: pelvis renalis stone ‹› stent ‹› SWL ‹› stone size

## INTRODUCTION

Since its first application in 1980, extracorporeal shock wave lithotripsy (SWL) has become the preferred treatment method in many ureteric and kidney stone diseases [1]. Advances in stone treatment in the endoscopic age, such as the ability to perform retrograde intrarenal surgery more frequently and almost independently of the size of the stone and percutaneous nephrolithotripsy (PNL) gaining less invasive features defined as mini and micro, can be listed as developments that have hindered the preference of SWL [2]. The wide use of SWL is due to its higher efficacy in selected cases while its low morbidity rates is one of the most important advantages of this method, making it the first treatment choice in many cases today, despite the other treatment alternatives that are available. However, there are conditions that limit the use of the method and affect its success [2].

Among the factors that affect the success and results of SWL are; the type of lithotripter; stone-related factors such as the size, structure, number, and localization; the anatomy and the functioning of the kidney; and patient–specific structural features [3, 4, 5].

Al–Ansari et al. investigated the prognostic factors affecting the success of SWL in 427 patients and they demonstrated that in cases with renal stones larger than 30 mm, the stone's size, localization, number, radiologic renal features and congenital renal anomalies were significant factors, while ureteral stent use, age, gender, and the nature of the stone (*de novo* or recurrent) had no effect [6]. Abdel-Khalek et al. reached the same conclusions in their study of 2954 cases with renal stones that were smaller than 30 mm [7]. In addition, factors such as the presence of additional interventions pre- and post-SWL, complications, and costs can also affect the efficacy of the treatment [2, 3, 4, 7]. The routine use of ureteral stent prior to SWL is not recommended in renal stone cases despite the lack of any defined criteria in the guidelines [2, 8]. While the use of ureteral stents can reduce post-SWL complications such as obstruction and renal colic, it does not prevent steinstrasse formation and infectious complications, and does not increase stone-free rates [8, 9, 10]. Patient discomfort, pain in bladder, and issues related to urination that are associated with ureteral stent use can often be experienced [11]. According to Kirkali et al., pre-SWL ureteral stent use should be preferred only in solitary kidney patients [12]. The goal of our retrospective study of over 1361 patients was to compare the stone-free rates, steinstrasse formation, treatment efficacy and complications between patients with renal pelvic stones with and without pre-SWL stent and to contribute to medical literature based on real life experiences.

## MATERIAL AND METHODS

This is a retrospective study conducted by scanning the medical data of 1378 patients treated with SWL for renal pelvic stones at our clinic between 1995 and 2011. Seventeen patients who had percutaneous nephrostomy tube placement prior to SWL were excluded from the study. The median age of the 1361 patients included in the study was 40 (1-85) years.
All patients had routine renal function tests, urinalysis and urine culture, coagulation tests, kidney-ureter-bladder X-ray (KUB), intravenous pyelography (IVP), and ultrasonography (USG) before SWL. An abdominal contrast-free computerized tomography (CT) was performed when required. Patients with urinary system infections were treated with antibiotics according to their culture results prior to SWL. Uncontrolled infections, coagulation dysfunctions, ureteropelvic junction obstruction, and pregnancy were considered contraindications for SWL. The SWL procedure was carried out *via* Siemens Lithostar Lithotripter (Siemens Medizinische Technik, Erlangen, Germany). The size of the stone was calculated in squared centimeters, by multiplying the widest width and length observed in KUB. When multiple stones were observed, the sum of their sizes was calculated.
In order to avoid statistical bias in this study, the patients were separated into 3 groups based on the size of the stone: ≤1 cm (group 1), 1.1–2 cm$^2$ (group 2), and >2 cm$^2$ (group 3). Table 1 displays the patient characteristics, prior interventions for stones on the same side, stone characteristics, and treatment features of the 1361 patients. All procedures were performed by a single urologist (N.T.) specialized in SWL and the energy and shock wave count for each patient were

**Table 1.** *Characteristics of patients, stones and treatments*

| | |
|---|---|
| **Patient characteristics** | |
| No. of patients/RUS | 1361 |
| Age; median (range) | 41 (1-85) |
| Sex | |
| female | 562/1361(41%) |
| male | 799/1361 (59%) |
| No. of solitary kidney | 21/1361 (2%) |
| Previous history of ipsilateral stone treatment | 223/1361(16.6%) |
| Open surgery | 79/1361 (6%) |
| SWL | 99/1361 (7%) |
| URS | 5/1361 (<1%) |
| Combine | 29/1361 (2%) |
| PNL | 11/1361 (<1%) |
| **Stone characteristics** | |
| Stone(s) in: | |
| left kidney | 653/1361 (48%) |
| right kidney | 708/1361 (52%) |
| Stone burden: | |
| median (cm$^2$) (range) | 1.3 (0.16-10) |
| Pts. based stone burden (cm$^2$) | |
| 1.0 or less | 514 (38%) |
| 1.1–2 | 530 (39%) |
| Greater than 2 | 317 (23%) |
| **Treatment characteristics** | |
| No. of shock waves: | |
| Median (range) | 2000 (500-3500) |
| Generator energy (kV): | |
| Median (range) | 17.2 (14.2-18.4) |
| No. of session(s): | |
| Median (range) | 2 (1-14) |
| 1 session | 657/1361(48%) |
| 2 sessions | 348/1361 (26%) |
| 3 sessions | 171/1361 (13%) |
| 4 and more sessions | 185/1361 (14%) |
| Ancillary procedures | |
| Double J stent (JJ) | 178/1361(13%) |
| Steinstrasse: | 187/1361 (14%) |
| with stent | 34 /178 (19%) |
| no stent | 153 /1183 (13%) |
| Result: | |
| stone free | 1082/1361 (80%) |
| unsuccessful | 279/1361 (20%) |

determined by the same physician. Prior to the procedure, an ureteral stent (Percuflex Plus 4.8 F X 26 cm, Boston Scientific, Quincy, MA, USA) was placed in solitary kidney patients, patients with renal ectasia of grade ≥2, and patients with obstruction symptoms lasting a long period of time (>1 month). SWL was performed on all patients in the supine position, under fluoroscopic control and as an outpatient procedure. Fourteen patients had the procedure under anesthesia where 0.1–0.2 mg/kg midazolam and 0.5 mg alfentanil were used for analgesic sedation. The treatment was initiated with 13 kilovolt (kV) and was increased with 0.3 kV increments up to the highest level that the patient could tolerate. The procedure was ended when full fragmentation of the stones was observed in the fluoroscopic control. The procedure was considered unsuccessful in cases where fragmentation was not achieved at the end of the 3rd session and/or in patients who wanted to try another treatment. Patients were given hydration, analgesic and antispasmolytic treatments during the sessions and the first post-treatment week. Patients were evaluated with KUB and USG at the end of the first week after the procedure and at 3-month follow-ups. CT was not performed on any patients who did not display significant symptoms or if hydronephrosis was not detected in their USG. Size of the stone(s), auxiliary procedures (with or without stent use), radiologic evaluations at 3-month follow-up, and complications were evaluated retrospectively. Statistical analyses were performed using Chi-square, Fisher's exact and Mann-Whitney U tests. Treatment efficacy in each group was calculated as described by Clayman et al. using the efficacy coefficient equation (EQ): stone free % / (100% + re-treatment + auxiliary procedures %) X 100 [13].

## RESULTS

The grouping of 1361 patients according to the renal pelvis stone size was as follows: 514 patients in group 1, 530 in group 2, and 317 in group 3. There were 178 patients (13%) who had stent placement prior to the procedure according to the aforementioned criteria. The number of patients in groups 1, 2 and 3 who had pre-SWL stent placement was 30 (6%), 44 (8%), and 104 (33%), respectively. Patient and stone characteristics by groups and stent placement are presented in Table 2, while treatment features by groups are shown in Table 3. The average number of sessions was found to be significantly higher among the patients with stent placement in all groups (group 1: p = 0.022; group 2 and 3: p = 0.000), while the proportion of stone-free patients was similar across patients with and without stent placement in group 1 (86.4% and 73.3%; p = 0.06), a significant difference was observed in group 2 (without stent 80.2% *vs.* with stent 56.8%; p= 0.000) and group 3 (without stent 75.1% *vs.* with stent 64.4%; p= 0.047). Treatment EQ for patients without and with stent placement, and for all patients within the groups were 64%, 46%, and 63.7%, respectively, for group 1; 52%, 30%,

**Table 2.** *Comparison of characteristics of patients and stones according to the groups*

| | Group 1 | | P | Group 2 | | P | Group 3 | | P |
|---|---|---|---|---|---|---|---|---|---|
| | Stent | No stent | | Stent | No stent | | Stent | No stent | |
| **Patient characteristics** | | | | | | | | | |
| No. of patients | 30 | 484 | | 44 | 486 | | 104 | 213 | |
| Age<br>Median (range) | 43 (2-85) | 37.5 (1-79) | 0.139 | 40.5 (4-80) | 41 (1.5-84) | 0.991 | 45 (12-80) | 42 (4-74) | 0.113 |
| Sex<br>Female<br>Male | <br>10/30 (33%)<br>20/30 (66%) | <br>203/484 (42%)<br>281/484 (58%) | <br>0.353 | <br>24/44 (55%)<br>20/44 (45%) | <br>197/486 (41%)<br>289/486 (59%) | <br>0.071 | <br>44/104 (42 %)<br>60/104 (58 %) | <br>84/213 (39 %)<br>129/213 (61 %) | <br>0.625 |
| No. of solitary kidney | 5/15 (33%) | 4/6 (67%) | 0.000 | 8/15 (53%) | 1/6 (17%) | 0.000 | 2/15 (13 %) | 1/6 (17 %) | 0.209 |
| Previous history of ipsilateral stone treatment | 8/38 (21%) | 73/185 (39%) | 0.116 | 12/38 (32%) | 73/185 (39%) | 0.034 | 18/38 (47 %) | 39/185 (21 %) | 0.827 |
| **Stone characteristics** | | | | | | | | | |
| Stone(s) in:<br>left kidney<br>right kidney | <br>17/30 (57%)<br>13/30 (43%) | <br>221/484 (46%)<br>263/484 (54%) | <br>0.241 | <br>23/44 (52%)<br>21/44 (48%) | <br>244/486 (50%)<br>242/486 (50%) | <br>0.793 | <br>53/104 (51 %)<br>51/104 (49 %) | <br>118/213 (55 %)<br>95/213 (45 %) | <br>0.287 |
| Median of<br>Stone burden (cm$^2$)<br>(range) | <br>0.6<br>(0.2-1) | <br>0.6<br>(0.2-1) | <br>0.620 | <br>1.7<br>(1.2-2) | <br>1.5<br>(1.04-2) | <br>0.482 | <br>3.2<br>(2.1-6.3) | <br>2.7<br>(2.1-10) | <br>0.512 |

**Table 3.** *Treatment characteristics according to groups*

| Treatment characteristics | Group 1 | | P | Group 2 | | P | Group 3 | | P |
|---|---|---|---|---|---|---|---|---|---|
| | Stent | No stent | | Stent | No stent | | Stent | No stent | |
| No. of shock waves:<br>Median<br>(range) | 2000<br>(1000-3500) | 1800<br>(500-3500) | 0.078 | 2000<br>(1000-3500) | 1952<br>(500-3500) | 0.219 | 2000<br>(1000-3500) | 2000<br>(500-3500) | 0.138 |
| Generator energy(kV):<br>Median<br>(range) | 17.2<br>(16-18.4) | 17.2<br>(14.2-18.4) | 0.631 | 17.2<br>(15.4-17.8) | 17.2<br>(14.5-18.4) | 0.627 | 17.2<br>(14.5-18.2) | 17.2<br>(14.5-18.4) | 0.988 |
| No. of session(s):<br>1 session<br>2 sessions<br>3 sessions<br>>4 sessions | 14/30 (47%)<br>3/30 (10%)<br>11/30 (37%)<br>2/30 (6%) | 325/484 (67%)<br>100/484 (21%)<br>39/484 (8%)<br>20/484 (4%) | 0.022 | 8/44 (18%)<br>12/44 (27%)<br>10/44 (23%)<br>14/44 (32%) | 233/486 (48%)<br>152/486 (31%)<br>54/486 (11%)<br>47/486 (10%) | 0.000 | 12/104 (12 %)<br>24/104 (23 %)<br>24/104 (23 %)<br>44/104 (42 %) | 65/213 (31 %)<br>57/213 (27 %)<br>33/213 (15 %)<br>58/213 (27 %) | 0.000 |
| No. of additional SWL sessions in different location | 2/30<br>(6.7%) | 32/484<br>(6.6 %) | 1 | 6/44<br>(13.6 %) | 90/486<br>(18.5 %) | 0.421 | 29/104<br>(27.9%) | 77/213<br>(36.2%) | 0.143 |
| Steinstrasse | 2/30<br>(6.7%) | 28/484<br>(5.8%) | 0.692 | 5/44<br>(11.4%) | 77/486<br>(15.8%) | 0.431 | 27/104<br>(26 %) | 48/213<br>(22.5 %) | 0.500 |
| Result:<br>stone free<br>unsuccessful | 22/30 (73%)<br>8/30 (27%) | 418/484 (86%)<br>66/484 (14%) | 0.060 | 25/44 (57%)<br>19/44 (43%) | 390/486 (80%)<br>96/486 (20%) | 0.000 | 67/104 (64 %)<br>37/104 (36 %) | 160/213 (75 %)<br>53/213 (25 %) | 0.047 |

and 49%, respectively, for group 2; and 43%, 33%, and 40%, respectively, for group 3. The distribution of patients with and without stent placement according to steinstrasse formation was 6.7% and 5.8% (p = 0.692) in group 1, 11.4 % and 15.8% (p = 0.431) in group 2, and 26% and 22.5% (p = 0.500) in group 3, respectively. According to these findings, no significant difference was observed between the patients with and without stent placement within the groups in terms of steinstrasse formation. Gender distribution and side of the stone localization yielded similar results across groups, as well. While the rates of solitary kidney patients were significantly different across patients with and without stent placement in groups 1 and 2 (p = 0.000), no such significant difference was observed in group 3 (p = 0.209). None of the major complications such as stent migration, infection, pyelonephritis or stent breakages were observed in any of the patients with stent placement in this study. Of the 178 patients with stent placement, 68 (38%) complained of frequent urination and pain in the bladder and kidney area that was associated with the stent but these issues were resolved *via* symptomatic therapies.

## DISCUSSION

Ureteral stents are mostly used to enable continuation of drainage in the presence of complications such as stone, tumor or obstruction between the kidney and the bladder. The pieces of the stones broken down still have a risk of causing obstruction in the ureter following SWL and this condition is associated with the size of the stone [4].

Use of ureteral stent in SWL is generally not recommended and there are various studies on the matter. Although ureteral stent is useful to prevent complications such as obstruction and renal colic following SWL, it does not protect from steinstrasse formation or infectious complications and does not increase the proportion of stone-free patients [8, 9, 10]. In our study, the stone-free rate following SWL was found to be higher for renal pelvis stones >1 $cm^2$ in patients without stent placement, although no difference was observed regarding steinstrasse formation. As for the demographic characteristic of our patient series, the female/male ratio, side ratio, stone load, and the number of SWL sessions were in line with the literature findings. Libby et al. demonstrated that ureteral stents reduced morbidity in case of stones of sizes >2.5 $cm^2$ [14]. Lingeman et al., on the other hand, reported that the SWL morbidity with or without stent placement is similar to that of PNL in patients with stones of >2 $cm^2$ [15]. Groeneveld recommended ureteral stent placement in case of stones that are greater than 3 $cm^2$, if SWL with prior debulking or SWL alone will be performed [16]. However, the benefits of ureteral stent use prior to SWL are still disputable [17, 18]. Low et al., with their 179-patient retrospective series, determined that there was no difference between the stone-free rates of patients with or without stent placement in their 1-month and 3-month evaluations [17]. Sulaiman et al. reported that ureteral stents did not make a difference in steinstrasse formation in cases of stones that greater than 2 $cm^2$ [18]. Preminger et al. also failed to detect a difference between patients with and without stent placement in terms of their stone-free rates, independent of the stone load and shock strength [19]. Bierkens et al. reported that stent use did not cause a significant difference in the stone-free rates of large kidney stones or reduce post-SWL morbidity and that their use in routine care is not necessary [20]. However, in Hollowel's inquiry of urologic specialists in the United States, it was determined that most of the urologists declared that they use stents in case of stones that are greater than 2 $cm^2$ in size although there was no objective data about their usage [21]. We believe that the urologists' desire to stay on the safe side in terms of colic-type pain or obstructions following SWL for relatively larger stones play a role in the decision. In Sfoungaristas et al.'s study investigating stent use in ureter stones that are 4-10 mm in size, stent use was reported to reduce stone-free rates and that it negatively affected the post-SWL quality of life [22]. Again, in Pettenali et al.'s retrospective study, stent use was reported to reduce SWL success in cases of proximal ureteral stones that are larger than 8 mm [23]. Kato et al.'s retrospective analysis showed that, in cases of kidney stones larger than 30 mm, steinstrasse formation was more common among patients with stent placement, and that the sole removal of the stent would be sufficient for these patients; and in cases of stones that are between 20–30 mm, they reported no difference between patients with and without stent placement in terms of steinstrasse formation. They do not recommend stent use in the case of stones smaller than 20 mm in size [24]. Mustafa et al. also reported that the placement of a ureteral stent for the purpose of improving stone free rates or enhancing the passage of fragments during SWL is unnecessary in renal stones with diameters less than 2.5 cm [25].

Though medical literature specifies that stents generally do not affect SWL results or at least do not have a negative effect on stone-free rates, we state in our series that ureteral stents were observed to have a negative effect on the stone-free rates among stones greater than 1 $cm^2$ in size. According to this finding, while stone-free rates do not vary across groups with or without stent placement in case of stones up to 1 $cm^2$, stent use was observed to have a negative impact on the stone-free rates in groups 2 and 3. Again, the EQ values were higher among patients without stent placement in all groups. This is contradictory with the predisposition of stent use with increase in stone size and in fact shows that ureteral stents may reduce the efficacy of SWL as stone size increases. In all 3 groups of our series, SWL session count was higher among patients with stent placement. We believe that the difficulty the stent creates in focusing on the stone and the additional sessions performed for the stones traveling down the ureter plays a significant role in these findings. Furthermore, in such cases stents can also block the particles that could migrate downwards under normal conditions. In terms of steinstrasse formation, no significant difference was observed between the patients with and without stent placement in any of the 3 groups and ureteral stents were observed to be unable to prevent steinstrasse formation.

Literature reports migration, stent breakage, encrustation, infection, pyelonephritis, and stone formation as stent-related complications [26, 27]. El-Faqih et al.'s evaluation of 290 cases with stent placement that had uretero-renoscopy and SWL, the 12-week rates for encrustation was 76.3%, migration was 3.7%, and breaking of stent was 0.3% [26]. Joshi et al. also reported that 60% of the patients had stent-related symptoms of overactive bladder such as increased urination frequency and urge incontinence [28]. While we did not observe complications such as migration, encrustation, breaking or pyelonephritis in our series, about 38% of the patients had symptomatic (frequency, urgency, hematuria, dysuria, and in some patients a colic-like pain) complaints. We believe that urinary reflux related to stent may play a role especially if the patient with a full bladder experiences colicky pain after urination. These complaints were generally controlled *via* symptomatic treatments and none of the patients required stent removal due to these symptoms. We believe that informing the patients about the possible symptoms that can be experienced following stent placement will allow them to tolerate the ureteral stents better.

The retrospective nature, lack of randomization in terms of ureteral stent use prior to SWL and that only 13% of patients had stent placement may be considered the limitations of this study. On the other hand, these limitations are avoided by the sole use of specialists with 25 years of SWL experience (N.T.) in the performance of all procedures, which contributed significantly to our study with respect to the standardization provided in ureteral stent preference and adjustment of the number and strength of shock waves. We believe that our patient series with cases of various stone loads has a lot to contribute to the medical literature on this matter. The usage of KUB and USG for monitoring the treatment results, but not CT could also be argued. KUB and USG are preferred in the aim to avoid the risk of high radiation levels and financial burden on the health system especially in symptom-free patients.

Bindman et al.'s study on this topic with 2759 patients between the ages of 18–76 years reported that USG, compared to CT, does not increase complications, pain score, admission rates to the emergency department, or hospitalization but does reduce exposure to radiation [29].

## CONCLUSIONS

In our study, the stone-free rate following SWL was found to be higher for renal pelvis stones >1 $cm^2$ in patients without stent placement, although no difference was observed regarding steinstrasse formation. The EQ values were higher among patients without stent placement in all groups. Our results showed that ureteral stents were observed to have a negative effect on the stone-free rates among stones greater than 1 $cm^2$ in size. The results of this study support the idea of limiting the application of stents during SWL and prevent possible complications as well as reduce the financial cost of treatment. Considering that ureteral stents reduce stone-free rates, we believe that they should be preferred in special cases such as solitary kidney patients or those with long-term obstruction.

### CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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