Endourology and Stones

Shock Wave Lithotripsy Versus Semirigid Ureteroscopy for Proximal Ureteral Calculi (<20 mm): A Comparative Matched-pair Study


OBJECTIVES
To use a matched-pair analysis design to compare the safety and efficacy of shock wave lithotripsy (SWL) and ureteroscopy (URS). Controversy still exists regarding whether SWL or URS is the best management of upper ureteral calculi.

METHODS
We reviewed the records of patients with a single radiopaque upper ureteral stone treated by URS or SWL from January 2003 to December 2005. SWL was performed as an outpatient procedure using the electromagnetic lithotripter (Dornier Lithotripter S). URS was performed using an 8F or 8.5F semirigid ureteroscope. Intracorporeal lithotripsy with pneumatic or holmium laser energy was used when needed. A matched-pair analysis was performed using 3 parameters (sex, stone size, and degree of hydronephrosis). The success rates, retreatment rates, auxiliary procedures, and complications were compared in each group.

RESULTS
A total of 427 patients were treated for upper ureteral stones. Forty-three matched pairs were identified and compared. The success rate was 83.7% for SWL vs 88.4% for URS ($P = .8$). The retreatment rate was significantly greater in the SWL group than in the URS group (65% vs 2.3%, respectively; $P < .001$). The need for auxiliary procedures was equal in both groups (16.3%). The complication rate was 14% in the URS group and 4.7% in the SWL group ($P = .1$).

CONCLUSIONS
SWL and semirigid URS are highly effective in the treatment of proximal ureteral stones <20 mm. The results of our study showed that SWL was safer and less invasive, but that URS was more effective and resulted in a lower retreatment rate.

The technical achievements during the past 20 years have dramatically changed the methods for the removal of ureteral stones. The introduction of extracorporeal shock wave lithotripsy (SWL) and ureteroscopy (URS) has made open surgery unnecessary in most cases. The most popular management for upper ureteral stones is SWL because of its noninvasiveness, low morbidity, and acceptable efficacy. The high success rates (85%-93%) of SWL have been previously reported. However, it might be less effective (55%-79%) for large stones. The need for repeated treatment in a substantial fraction of patients remains the most important drawback of SWL. The introduction of small-caliber semirigid ureteroscopes, as well as the development of effective intracorporeal lithotripsy methods, has substantially improved the URS stone-free rates (71%-87%) and greatly decreased the complication rates. This has made ureteroscopic management of proximal ureteral stones much more attainable. The introduction of the holmium laser has resulted in marked improvements in the outcomes of URS for proximal ureteral calculi in terms of efficacy and safety. URS has superior stone-free rates compared with SWL in the management of larger stones. Although URS has a much lower retreatment rate, it requires regional or general anesthesia, access to an operating theater, and considerable skill. In addition, it might be associated with a greater risk of complications. SWL remains the primary modality of treatment of proximal ureteral calculi in many centers; however, some urologists have recommended URS as first-line treatment. Despite the introduction of guidelines for the treatment of ureteral calculi, the debate continues on whether SWL or URS should be the first-line treatment for patients with stones located in the proximal ureter.
The aim of the present study was to compare the safety and efficacy of SWL and semirigid URS in the treatment of proximal ureteral stones using a matched-pair analysis study design.

**MATERIAL AND METHODS**

From January 2003 through December 2005, 427 adult patients (age 18-75 years) with a single, radiopaque proximal ureteral stone, <20 mm, were treated by SWL (284 patients) or semirigid URS (143 patients). Morbidly obese patients, those with a high serum creatinine (>2 mg/dL), or advanced hydronephrosis were not included in the study. The proximal ureter was defined as the segment between the ureteropelvic junction and the superior margin of the sacroiliac joint. The electronic records of these patients were reviewed to compile a database that included age, sex, stone length, stone width, degree of hydronephrosis of the affected renal unit, success rate, retreatment rate, auxiliary procedures required, and complications.

All patients were evaluated before treatment with history taking, clinical examination, ultrasonography, and intravenous urography. The laboratory investigations included urinalysis and urine culture, serum creatinine, and coagulation profile. The grades of hydronephrosis on ultrasonography were categorized as none, mild, moderate, or advanced according to the appearance of the pelvis, calices, and parenchymal atrophy.10

SWL was performed using the electromagnetic Dornier Lithotripter S (Dornier Med Tech, Germering, Germany) as an outpatient procedure. All patients were treated in the supine position and received sedoanalgesia in the form of meperidine hydrochloride (1 mg/kg). No stenting of the ureter was attempted before or after SWL. The therapy was usually started at a low power of 12 kV and then increased gradually to 20 kV. A maximum of 3000 shocks were delivered for each session or until complete fragmentation of the stone had occurred as judged by fluoroscopy. The patients were evaluated 1 week after the SWL session by plain abdominal radiography to assess fragmentation. Repeated treatment was performed if inadequate fragmentation of the stone was observed. If no breakage of the stone had occurred after 2 sessions, the case was considered a SWL failure, and the patient underwent URS.

URS was performed as an inpatient procedure in the operating theater with the patient under spinal anesthesia using an 8F or 8.5F semirigid ureteroscope (Richard Wolf, Knittlingen, Germany). Intracorporeal lithotripsy was performed using pneumatic or holmium laser lithotripsy. A ureteral catheter was placed after the procedure for 1-2 days. If excessive manipulation had occurred or mucosal edema or injury had developed, a double-J stent was placed for 2-4 weeks. Plain abdominal radiography was performed the morning after URS to exclude the presence of residual stones.

All patients were finally evaluated at 3 months after treatment by plain abdominal radiography to assess the stone-free status and by renal ultrasonography to evaluate the hydronephrosis. The success of treatment was defined as no residual stones.

Exact matching criteria were used to compare SWL and semirigid URS in the management of proximal ureteral stones. The patients were exactly matched for sex, stone size (length and width), and the degree of hydronephrosis. Each of the matched pairs was classified into 4 possible combinations according to the treatment modality and treatment outcome, similar to the method used by Portis et al.11 Concordant pairs included SWL and URS success or SWL and URS failure.

**Table 1. Pretreatment patient and stone characteristics**

<table>
<thead>
<tr>
<th>Variable</th>
<th>SWL (n = 43)</th>
<th>URS (n = 43)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age ± SD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex (n)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>13 (72)</td>
<td>13 (72)</td>
<td>1†</td>
</tr>
<tr>
<td>Women</td>
<td>12 (28)</td>
<td>12 (28)</td>
<td></td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>29.4</td>
<td>31.3</td>
<td>.06*</td>
</tr>
<tr>
<td>Range</td>
<td>23-37</td>
<td>26-36</td>
<td></td>
</tr>
<tr>
<td>Side (n)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>19 (44)</td>
<td>21 (49)</td>
<td>.66†</td>
</tr>
<tr>
<td>Left</td>
<td>24 (56)</td>
<td>22 (51)</td>
<td></td>
</tr>
<tr>
<td>Stone length (mm)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>10.7</td>
<td>10.7</td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>5-17</td>
<td>5-17</td>
<td></td>
</tr>
<tr>
<td>Stone width (mm)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>6.9</td>
<td>6.9</td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>4-12</td>
<td>4-12</td>
<td></td>
</tr>
</tbody>
</table>

SWL, shock wave lithotripsy; URS, ureteroscopy; BMI, body mass index.

* Data in parentheses are percentages.
† t Test.
‡ χ² test.

Discordant pairs included SWL success and URS failure or SWL failure and URS success.

**Statistical Analysis**

The data were analyzed using Statistical Package for Social Sciences, version 11 (SPSS, Chicago, IL). The success rates, retreatment rates, need for auxiliary procedures, and complications were compared for both groups using the χ² or t test. P < .05 was considered statistically significant.

**RESULTS**

Of the 427 patients, we could identify 43 matched pairs of patients, with 1 patient in SWL group and 1 in the URS group, with similar characteristics. Of the 43 matched pairs, 29 were concordant pairs (with only 1 pair in which both SWL and URS failed) and 14 discordant pairs. SWL failed in 10 cases and URS succeeded for their matches. No multiple acceptable matched pairs were found.

The pretreatment patient and stone characteristics are listed in Table 1. The treatment outcomes were compared in both groups (Table 2). The overall success rate for URS was greater than for SWL, but the difference was not significant (P = .8). When we categorized the cases according to stone length, the success rate was equal for stones <10 mm, and URS achieved a success rate greater than that for SWL (90% vs 80%) for stones >10 mm; however, the difference was also not significant.

The retreatment rate was significantly greater for the SWL group (P < .001). However, the need for auxiliary procedures was equal in both groups. In the SWL group, the auxiliary procedures included URS for failed or complicated cases. In the URS group, the auxiliary procedures included double-J stenting in complicated cases or SWL in patients with residual stones.
**Table 2. Comparison of treatment outcomes for both groups**

<table>
<thead>
<tr>
<th>Variable</th>
<th>SWL (n = 43)</th>
<th>URS (n = 43)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall success rate</td>
<td>36/43 (83.7)</td>
<td>38/43 (88.4)</td>
<td>.8</td>
</tr>
<tr>
<td>Stone size (mm) ≤10</td>
<td>20/23 (87)</td>
<td>20/23 (87)</td>
<td>1</td>
</tr>
<tr>
<td>&gt;10</td>
<td>16/20 (80)</td>
<td>18/20 (90)</td>
<td>.37</td>
</tr>
<tr>
<td>Hydroureteroscopy None or mild</td>
<td>26/29 (89.7)</td>
<td>26/29 (89.7)</td>
<td>1</td>
</tr>
<tr>
<td>Moderate</td>
<td>10/14 (71.4)</td>
<td>12/14 (85.7)</td>
<td>.36</td>
</tr>
<tr>
<td>Retreatment</td>
<td>28 (65)</td>
<td>1 (2.3)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Auxiliary procedures</td>
<td>7 (16.3)</td>
<td>7 (16.3)</td>
<td>1</td>
</tr>
<tr>
<td>Complications</td>
<td>2 (4.7)</td>
<td>5 (14)</td>
<td>.1</td>
</tr>
</tbody>
</table>

Data presented as number of patients, with percentages in parentheses.

The mean hospital stay for patients who underwent URS was 2 days (range 1-7). The complications were insignificantly greater in the URS group (P = .1). In 2 cases, perforation of the ureter occurred, and in 3 cases, minimal extravasation developed. These 5 patients were treated with fixation of a double-J stent for 4 weeks. Only 1 patient developed significant renal colic and obstruction after removal of the stent. In that patient, laser lithotripsy was performed without mechanical removal of the fragments, and the patient was treated conservatively until the spontaneous passage of the gravel had occurred.

Only 2 complicated cases occurred after SWL. One patient developed steinstrasse after SWL for a 15-mm stone and 1 patient developed fever and obstruction. The first patient underwent URS, and the second was treated with antibiotics and antipyretics, followed by URS to retrieve an obstructing stone fragment.

**COMMENT**

With the development of advanced instruments and techniques, minimally invasive surgical procedures have gradually replaced open surgery for treating proximal ureteral stones.1 SWL and URS are the most common modalities used for the treatment of ureteral stones, but the debate continues on which is the best treatment modality. The number of previous prospective randomized trials of URS vs SWL for proximal ureteral stones is very limited.9 Most of the previous studies addressing this issue were retrospective in design.6,7 These retrospective reviews have been the only evidence base for advocating the merits of 1 treatment over the other. However, such studies have been hampered by discrepancies in cohort size, selection bias, and inadequate follow-up.

Matched-pair analysis enables comparison of 2 treatment modalities with a relatively small clinical study group by comparing “like-for-like” cases. It enabled SWL and URS to be assessed head-to-head, comparing the outcome of similar patients with almost identical stones. It was used by Stewart et al.5 to compare 27 pairs treated by SWL vs URS. They found that the 3-month stone-free rate was 82% for URS and 89% for SWL (P = .625). Retreatment was required in 11% and 26% after URS and SWL, respectively (P = .219). However, 41% of URS patients required ancillary treatment compared with only 22% of SWL patients (P = .227). They concluded that the choice of treatment should therefore be based on parameters such as the availability of equipment, waiting times, and patient preference.5 The results of that study were different from those of our study in terms of the greater efficacy and lower ancillary procedures for URS in our study for many reasons. Their mean stone length was 8 mm compared with 11 mm in our study. They considered removal of a double-J stent an ancillary procedure. We also frequently used laser lithotripsy for stone disintegration.

On reviewing the records of the 427 patients with a proximal ureteral stone, we found a tendency to treat larger stones using URS. We included only patients with a stone length of 5-20 mm because stones any larger would be not suitable for treatment by SWL. Moreover, we compared only stones of the same length and width to abolish the effect of any selection bias regarding stone size on the outcome of the 2 treatment modalities.

In our study, we excluded children because they appear to pass stone fragments after SWL more readily than do adults.3,12 We also excluded patients with advanced hydronephrosis because impacted ureteral stones or associated ureteric stricture can lead to advanced hydroureteronephrosis with a tortuous, kinked, or angulated ureter making the ureteroscopic procedure more difficult, less successful, and associated with the greater possibility of complications. We included the degree of hydronephrosis (none or mild vs moderate) in our matching parameters, because it can affect the outcome of both treatment modalities. The effect of the degree of hydronephrosis on SWL for proximal ureteral stones is debatable. In a previous study, we found that the degree of hydronephrosis did not significantly affect the success of SWL in the management of solitary proximal ureteral stones <20 mm in length. However, the presence of hydronephrosis significantly increases the retreatment rate and prolongs the time to stone clearance.13

We excluded morbidly obese patients from the study because they cannot be treated with SWL, and we included in the matched-pair analysis only patients who could be treated with either SWL or URS. However, the body mass index was comparable in both groups (Table 1). A potential future improvement would be the addition of patient age, body mass index, and, perhaps, the skin-to-stone distance in the matching criteria. The small patient numbers limited our ability to include many variables in the present matched-pair analysis.

The success rates in our study did not differ much from those documented in the last guideline for the management of ureteral calculi.3 We found both treatment modalities highly effective, with no significant difference.
even when we separated the stones according to their length into stones \(<10\) mm or \(>10\) mm (Table 2). However, the trend for a greater success rate of URS in the treatment of larger stones (\(>10\) mm) might have statistically insignificant owing to the relatively small sample size. The same was applicable to the grade of hydronephrosis, for which URS showed a trend toward more success compared with SWL for patients with moderate hydronephrosis (Table 2). Therefore, a prospective randomized study with a larger number of patients is encouraged to prove or disprove these trends.

SWL was less invasive and was performed as an outpatient procedure with the patient under sedation. It did not need hospital admission or an operating theater. The retreatment rate after SWL was very high (65%) because large stones (\(>10\) mm) and those giving a greater degree of hydronephrosis usually required more treatment sessions. URS was more invasive, requires hospitalization and a skillful surgeon, was performed with the patient under anesthesia in the operating theater, and was associated with a greater complication rate. However, the complication rate was not significantly greater in the URS group (14% vs 4.7% in SWL group; \(P = .1\)). The practice of keeping the patient hospitalized for 1 or 2 days after URS is not universal, and URS can be done as an outpatient procedure in many centers, especially in the United States. Another difference was the use of semirigid ureteroscopy for the treatment of proximal ureteral stones in the present study. Flexible ureteroscopy was performed in some cases. However, they were not included because our experience with flexible ureteroscopy was not sufficient during the study period and the learning curve can affect the results of URS. Proximal ureteral stones are better treated by flexible ureteroscopy. However, it is not used in many hospitals worldwide, because of financial or experience defects in these hospitals. Therefore, semirigid URS is still used in many places, because it is less expensive and more durable with better vision, and its small diameter allows its passage into the proximal ureter. Nevertheless, studies comparing flexible URS and SWL in the treatment of proximal ureteral stones are encouraged.

Finally, each treatment modality has its own advantages and disadvantages, and several factors will influence the choice of treatment. Those urologists who prefer SWL have based their decision on its noninvasiveness, minimal anesthetic requirements, low morbidity, and acceptable efficacy. Urologists who favor URS claim that although it is an invasive procedure, it has, in contrast to SWL, a greater success rate at the first treatment session. The lack of access to a nearby lithotripter and surgeon preference for an endourologic procedure are also important factors. Patient preference should always be a great concern. Some patients might have some fears regarding the anesthesia required and invasiveness of URS. Others might prefer to have the stone removed and the pain alleviated more rapidly without the possibility of multiple treatment sessions and prolonged stone clearance period such as can occur with SWL. The availability of the equipment, experience of the surgeon with both modalities, and patient preference will determine the choice.

**CONCLUSIONS**

The results of our study have shown that both SWL and URS are highly effective in the treatment of proximal ureteral stones \(<20\) mm. However, SWL was safer and less invasive, and URS was more effective with a lower retreatment rate.

**References**