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Comparison of Efficacy of Extracorporeal Shock Wave Lithotripsy (ESWL) and Ureteroscopy for the Treatment of Proximal Ureteric Stone

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ABSTRACT

Background: Proximal ureteric stones are a common urological problem requiring timely and effective management. Among the available interventions, Extracorporeal Shock Wave Lithotripsy (ESWL) and Ureteroscopy (URS) are two widely used techniques, each with its own advantages and limitations. **Objective:** To compare the efficacy of ESWL and URS in the treatment of proximal ureteric stones, defined by complete stone clearance on ultrasound three weeks post-procedure. **Methods:** This observational cross-sectional study was conducted at the Department of Urology, Balochistan Institute of Nephro-Urology, Quetta, over a six-month period. A total of 60 patients aged 17–60 years with single proximal ureteric stones (9–15 mm on CT KUB) were randomized into two groups: Group A (URS) and Group B (ESWL). All procedures were performed by a single experienced urologist. Stone-free status was assessed via ultrasound at three weeks post-intervention. **Results:** The stone clearance rate in the URS group was significantly higher (93.3%) compared to the ESWL group (60%) with a p-value of 0.003, indicating statistical significance. Complication rates were higher in the URS group, but generally mild and manageable. **Conclusion:** Ureteroscopy is significantly more effective than ESWL for the treatment of proximal ureteric stones, especially in cases with larger or harder stones. While ESWL remains a valuable non-invasive option, URS provides a higher stone-free rate and should be considered the preferred first-line treatment when appropriate.

INTRODUCTION

Urolithiasis, or urinary stone disease, is a prevalent urological condition affecting a significant portion of the global population. It is estimated that the lifetime risk of developing urolithiasis ranges from 1% to 20%, depending on geographic, dietary, and genetic factors. In the Western world, the prevalence ranges between 5% and 15%, with the United States reporting some of the highest rates. In contrast, developing countries, including Pakistan, report an alarmingly high burden, with nearly 50% of urological hospital admissions attributed to stone disease. The disease poses a considerable socioeconomic burden due to its recurrent nature, impact on renal function, and the necessity of surgical intervention in many cases.

The ureter, a narrow muscular tube that transports urine from the kidney to the bladder, is anatomically divided into proximal, mid, and distal segments. Proximal ureteric stones, which are located from the ureteropelvic junction to the point where the ureter crosses the sacroiliac joint, are especially problematic due to their likelihood of causing obstruction and acute renal colic. Stones ranging in size from 9 mm to 15 mm are less likely to pass spontaneously and often require active intervention.

The management of proximal ureteric stones has evolved significantly over recent decades. Traditionally, open surgical procedures were the mainstay of treatment, but the advent of minimally invasive techniques such as Extracorporeal Shock Wave Lithotripsy (ESWL) and Ureteroscopy (URS) has transformed the therapeutic landscape. ESWL utilizes high-energy acoustic pulses to fragment stones from outside the body, enabling the patient to pass the fragments naturally. It is non-invasive, widely available, and associated with a low complication rate. However, its effectiveness diminishes with increased stone size, higher stone density (measured in Hounsfield units), and unfavorable anatomical positioning.

Ureteroscopy, on the other hand, involves direct visualization of the ureter using a semirigid or flexible ureteroscope. Stones are either removed intact or fragmented in situ using pneumatic or laser lithotripsy. URS typically offers higher stone-free rates in a single session, especially for stones larger than 10 mm or those

that are impacted. However, the procedure is more invasive than ESWL, requires regional or general anesthesia, and may involve post-operative complications such as ureteral injury, infection, or hematuria.

Despite continuous improvements in endourological techniques, the choice between ESWL and URS for proximal ureteric stones remains a subject of ongoing debate. Treatment selection is often influenced by stone characteristics (size, location, composition), patient factors (age, comorbidities, anatomical variations), physician expertise, and available institutional resources. While several international studies have compared these modalities, there remains a paucity of local data, particularly within the Pakistani context, where access to advanced urological care is often limited and patient follow-up is variable.

The present study was designed to address this gap by comparing the efficacy of ESWL and URS in terms of stone-free rate at three weeks post-procedure among patients presenting with proximal ureteric stones. By adopting strict inclusion and exclusion criteria, standardizing procedural techniques, and conducting follow-up imaging uniformly, this study aims to provide reliable and locally relevant evidence that may inform clinical decision-making and contribute to the optimization of urolithiasis management in resource-limited settings.

Ultimately, the findings of this study have the potential to influence treatment protocols at the institutional and possibly national level by identifying the modality that offers superior outcomes with minimal complications. Such evidence is vital for improving patient satisfaction, reducing procedural costs, minimizing hospital stays, and alleviating the burden on healthcare systems in regions with high urolithiasis prevalence.

LITERATURE REVIEW

Management of ureteric stones, particularly those located in the proximal ureter, has undergone a major shift with the advancement of minimally invasive techniques. Two of the most widely adopted procedures are Extracorporeal Shock Wave Lithotripsy (ESWL) and Ureteroscopy (URS). Although both methods are clinically effective, their outcomes vary based on stone characteristics, patient profiles, and institutional capabilities.

1. Extracorporeal Shock Wave Lithotripsy (ESWL)

ESWL was first introduced in the 1980s and quickly gained popularity due to its non-invasive nature. It utilizes focused acoustic waves to fragment stones, which are subsequently passed through the urinary tract. The success of ESWL is closely linked to stone size, location, and composition. According to Nguyen et al. (2015), ESWL achieves optimal results when the stone is <10 mm in size, of low density (<1000 HU), and located in the renal pelvis or upper ureter. Their prospective randomized trial demonstrated that optimizing delivery rates during ESWL significantly improves outcomes.

However, ESWL also has limitations. Yilmaz and Cinislioğlu (2022) found that stone-free rates drop significantly when ESWL is used for proximal ureteric stones >10 mm. Furthermore, multiple treatment sessions may be required, leading to delayed clearance and increased patient discomfort. Residual fragments, also known as "clinically insignificant stone fragments" (CISFs), may persist and potentially become symptomatic or require further intervention.

2. Ureteroscopy (URS)

URS, particularly semirigid ureterorenoscopy, allows for direct visualization and active extraction or fragmentation of stones. With the advent of laser and pneumatic lithotripsy and improved optics, URS has become a first-line treatment for ureteric stones in many settings. It is particularly effective for stones that are impacted, of high density, or not amenable to fragmentation by ESWL.

In a study by Mustafa et al. (2024), URS achieved a stone-free rate of 83.3% compared to 64.2% for ESWL in patients with proximal ureteric stones. The authors concluded that URS offers superior clearance and requires fewer repeat procedures. Similar findings were reported by Farhan Khan et al. (2023), who observed a 93.3% efficacy rate in the URS group versus 60% in the ESWL group. This significant difference underscores the clinical reliability of URS, especially in difficult-to-treat stones.

3. Comparative Studies and Meta-Analyses

Several meta-analyses and systematic reviews have aimed to determine the most effective modality. A review by Elmekresh et al. (2022) highlighted that URS has a higher initial success rate, lower retreatment rate, and shorter time to stone clearance, albeit with a slightly higher risk of complications, such as mucosal injury and postoperative ureteral strictures. Conversely, ESWL was favored in terms of patient comfort, anesthesia avoidance, and minimal invasiveness.

According to Bagtug et al. (2022), ureteroscopy techniques also benefit from the use of ureteral access sheaths, which improve procedural efficiency and reduce intraoperative complications. However, the increased need for anesthesia and specialized training in URS procedures may limit its availability in low-resource settings, making ESWL a more practical choice despite its slightly lower efficacy.

4. Gaps in Local Evidence

In Pakistan, most urological centers lack robust data comparing these two modalities in a controlled environment. The few published local studies have shown trends similar to international findings but are limited by small sample sizes and inconsistent methodologies. There is a critical need for context-specific evidence to guide treatment protocols, especially considering patient population characteristics, cost constraints, and healthcare infrastructure.

Summary

The literature overwhelmingly supports the superior stone-free rates associated with URS, especially for larger or impacted proximal ureteric stones. ESWL remains a valuable option due to its non-invasiveness and patient acceptability, but its efficacy diminishes under specific clinical conditions. The decision between these modalities should ideally be based on individualized patient assessment, stone parameters, and institutional resources.

MATERIALS AND METHODS

Study Design: This was an observational cross-sectional

study designed to compare the effectiveness of Extracorporeal Shock Wave Lithotripsy (ESWL) and Ureteroscopy (URS) in the treatment of proximal ureteric stones.

Study Duration: The study was conducted over a period of six months following approval of the research synopsis by the College of Physicians and Surgeons Pakistan.

Study Setting: All procedures and assessments were carried out at the Department of Urology, Balochistan Institute of Nephro-Urology, Quetta, a tertiary care hospital equipped for both ESWL and URS interventions.

Sample Size Calculation

Using the WHO sample size calculator and data from previous studies—assuming an efficacy of 93.3% for URS and 60% for ESWL—a sample size of 26 patients per group was calculated to detect a significant difference, with 95% confidence level and 80% power. To account for potential loss to follow-up or dropout, a minimum of 30 patients per group (total n = 60) were enrolled.

Sampling Technique

A non-probability consecutive sampling technique was employed. Eligible patients were enrolled as they presented to the outpatient department until the required sample size was achieved.

Inclusion Criteria

- Patients aged 17 to 60 years.
- Both males and females.
- Diagnosed with a single proximal ureteric stone (between 9 mm and 15 mm), located from the ureteropelvic junction to the level where the ureter crosses the sacroiliac joint, confirmed on CT KUB.

Exclusion Criteria

Patients were excluded if they met any of the following:

- Chronic kidney disease (CKD).
- Stone density >1000 Hounsfield Units (HU).
- Impacted stone in ESWL group.
- History of prior renal or ureteric surgery.
- Pregnant females.
- Stone located on the transverse process.
- Active urinary tract infection (fever >38.5°C and positive urine culture).

Strict adherence to exclusion criteria was maintained to eliminate potential confounders and minimize bias in the study results.

Procedure

All patients underwent detailed clinical evaluation, including medical history, physical examination, and routine investigations. Eligible participants were randomly assigned to Group A (URS) or Group B (ESWL) using the sealed envelope method to ensure allocation concealment.

Group A – URS

- Semirigid ureteroscopy performed under general or regional anesthesia.
- Stones were either extracted intact or fragmented using intracorporeal lithotripsy.
- Procedure conducted by a single experienced urologist.

Group B – ESWL

Conducted with standard ESWL machine settings:

- Frequency: 1 shock/second
- Energy level: 7 to 8
- Shocks: 3000 to 3500
- Total duration: 50 to 60 minutes

Patients were monitored and discharged on the same or next day based on clinical status.

Outcome Assessment

Effectiveness was defined as complete stone clearance, confirmed on ultrasound (KUB) performed three weeks post-procedure. All ultrasonographic evaluations were performed by a single experienced radiologist to eliminate inter-observer variability.

Data Collection Tools

Demographic and clinical data were recorded on a pre-designed proforma, including:

- Patient demographics (age, gender)
- Clinical history (diabetes, hypertension, smoking)
- Stone characteristics (size, duration)
- Body Mass Index (BMI)
- Procedural details and outcomes (stone clearance, complications)

Data Analysis

Data were analyzed using SPSS version 25.

- Continuous variables (age, stone size, BMI) were expressed as mean ± standard deviation (SD).
- Categorical variables (gender, diabetes, hypertension, smoking status, stone clearance) were presented as frequencies and percentages.
- Shapiro-Wilk test was applied to test for normality of continuous data.
- Chi-square or Fisher's exact test was used to compare stone-free rates between the two groups.

Stratification was done for potential effect modifiers such as age, gender, BMI, and comorbidities. A p-value of <0.05 was considered statistically significant.

RESULTS

A total of 60 patients were enrolled and evenly divided into two groups: Group A (URS) and Group B (ESWL), with 30 patients in each group. The results were analyzed in terms of demographics, stone size, comorbid conditions, and treatment effectiveness.

Table 1

Demographic and Clinical Characteristics of Study Population

Variable	URS Group (n=30)	ESWL Group (n=30)	p-value
Mean Age (years)	36.9 ± 9.8	38.3 ± 10.2	0.56
Male: Female Ratio	18:12	17:13	0.79
Mean BMI (kg/m^2)	25.4 ± 2.8	25.8 ± 3.0	0.58
Duration of Disease (months)	4.5 ± 1.7	4.8 ± 1.6	0.47

No statistically significant differences were observed between the two groups in terms of baseline demographic variables.

Table 2
Stone Characteristics

Variable	URS Group (n=30)	ESWL Group (n=30)	p-value
Mean Stone Size (cm)	1.50 ± 0.05	1.28 ± 0.04	0.96
Stone Location (Proximal Ureter)	100%	100%	—
High-Density Stone (>1000 HU)	0 (excluded)	0 (excluded)	—

Both groups had comparable stone sizes and consistent anatomical distribution within the proximal ureter.

Table 3
Comorbidities and Risk Factors

Comorbidity / Risk Factor	URS Group (n=30)	ESWL Group (n=30)	p-value
Diabetes Mellitus	5 (16.7%)	6 (20.0%)	0.73
Hypertension	8 (26.7%)	9 (30.0%)	0.78
Smokers	10 (33.3%)	12 (40.0%)	0.59

No statistically significant differences were noted in comorbidities or lifestyle-related risk factors across both groups.

Table 4
Treatment Effectiveness and Stone Clearance

Outcome	URS Group (n=30)	ESWL Group (n=30)	p-value
Stone-Free at 3 Weeks	28 (93.3%)	18 (60.0%)	0.003
Not Stone-Free	2 (6.7%)	12 (40.0%)	
Complications (Minor)	4 (13.3%)	2 (6.7%)	0.38

The stone-free rate was significantly higher in the URS group compared to the ESWL group (p = 0.003), indicating superior efficacy. Minor complications (such as transient hematuria or mild pain) were more frequent in the URS group but were not statistically significant.

Summary of Findings:

- Both treatment groups were comparable in terms of demographics and stone characteristics.
- URS showed a significantly higher success rate in achieving stone clearance.
- ESWL, while non-invasive, had a lower clearance rate and a higher retreatment potential.

No major complications were reported in either group.

DISCUSSION

This study was conducted to compare the efficacy of Extracorporeal Shock Wave Lithotripsy (ESWL) and Ureteroscopy (URS) in the treatment of proximal ureteric stones. The findings demonstrated that URS had a significantly higher stone clearance rate (93.3%) compared to ESWL (60%), with a p-value of 0.003, confirming the statistical significance of this difference. The study population was carefully selected, using strict inclusion and exclusion criteria to minimize confounding factors. Both groups were well-matched in terms of age, gender, BMI, comorbidities, and baseline stone characteristics, thereby strengthening the internal validity of the results. Additionally, all procedures were conducted by a single experienced urologist, and all imaging assessments were performed by one radiologist, which helped eliminate inter-operator variability. The superior outcomes in the URS group can be attributed to the procedure's ability to directly visualize, fragment, and extract the stone in a single session. This is particularly advantageous for larger stones (>10 mm) and those of higher density, which are often resistant to ESWL. These findings are consistent with existing literature. For instance, Mustafa et al. (2024) reported a stone-free rate of 83.3% for URS versus 64.2% for ESWL, while Farhan Khan et al. (2023) observed 93.3% success with URS compared to 60% with ESWL — results almost identical to the present study.

Although ESWL remains a non-invasive and commonly used option, its effectiveness is diminished by several factors, including stone size, density, anatomical positioning, and patient body habitus. In the current study, 40% of patients treated with ESWL had residual fragments after three weeks, potentially necessitating repeat sessions or alternative interventions. This has been echoed in global research, with Nguyen et al. (2015) emphasizing that ESWL is best suited for stones <10 mm in size and of low density (<1000 HU). In addition, Yilmaz and Cinislioğlu (2022) highlighted the limitations of ESWL in clearing upper ureteric stones larger than 10 mm, with nearly 35% to 55% of patients retaining fragments post-treatment.

On the other hand, the invasiveness of URS and its associated risks — such as transient hematuria, mucosal injury, and the need for general or regional anesthesia — must be weighed against its higher efficacy. In the current study, minor complications were noted in 13.3% of URS cases, compared to 6.7% in the ESWL group, though this difference was not statistically significant (p = 0.38). Importantly, no major complications were observed in either group.

The local context is critical in interpreting these findings. In Pakistan, urolithiasis is a major public health concern, particularly in hot and arid regions like Balochistan, where dehydration and dietary factors increase the risk of stone formation. Despite this high burden, there remains a scarcity of well-designed local studies addressing the comparative effectiveness of treatment modalities. This study contributes valuable data, especially for tertiary care settings where resource optimization and patient outcomes are critical concerns. Another strength of this study was the use of uniform imaging criteria and follow-up timelines. All patients were evaluated using ultrasound three weeks post-procedure, providing a reliable and standardized measure of treatment efficacy.

Limitations

Despite its strengths, the study had some limitations. Being a single-center observational study, the generalizability of the findings may be limited. Furthermore, long-term follow-up data on recurrence and delayed complications were not captured. Future randomized controlled trials with larger sample sizes and extended follow-up periods are needed to validate these findings and assess recurrence rates and cost-effectiveness.

CONCLUSION

The findings of this study strongly support the use of

Ureteroscopy as the preferred treatment for proximal ureteric stones, particularly when stone size exceeds 10 mm or when higher stone density is noted. ESWL, while less invasive, may be more appropriate for smaller, less dense stones or in patients unfit for anesthesia. These insights can help optimize treatment selection, reduce retreatment rates, and improve clinical outcomes. This study demonstrates that Ureteroscopy (URS) is significantly more effective than Extracorporeal Shock Wave Lithotripsy (ESWL) in achieving complete stone clearance for proximal ureteric stones. With a stone-free rate of 93.3% in the URS group compared to 60% in the ESWL group, URS proved to be the more reliable modality, particularly for larger stones (9–15 mm) and those with greater density. While ESWL remains a non-invasive and generally safe option, its comparatively lower efficacy and need for potential retreatment limit its role in certain clinical scenarios. URS, despite being more invasive, offers definitive management in a single session and should be considered the first-line treatment in appropriately selected patients. These findings support a more individualized approach to treatment selection, emphasizing stone size, composition, and patient factors, while also considering local healthcare resources and surgical expertise. Further multi-center studies with larger sample sizes and long-term follow-up are recommended to confirm these results and guide national urological practice.

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