Comparative study of extracorporeal shock wave lithotripsy and ureteroscopy in the management of upper third ureteral calculi

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Purpose
To do a matched pair analysis of extracorporeal shock wave lithotripsy (ESWL) versus ureteroscopy (URS) for the management of upper third ureteral calculi.

Patients and methods
Totally 60 cases, between 25 and 52 years referred to our endourology clinic with large upper third ureteral calculi (≥1 cm in size and ≥900 HU in density). The cases were classified into two groups. Group A (30 cases) underwent ESWL, while group B (30 cases) underwent URS. All cases were evaluated by plain KUB (Plain X-ray on Kidney, Ureter and Urinary Bladder), abdominal ultrasound, and MSCT KUB (MultiSlice Computed Tomography on Kidney, Ureter and urinary Bladder) without contrast. Stone clearance has been assessed both after the procedure and at 3-month follow-up for URS cases and 3-week follow-up for ESWL cases.

Results
Complete stone clearance occurred in 20 (66.7%) of the 30 patients undergoing ESWL and in 24 (80%) of the 30 patients undergoing URS, indicating no significant difference in overall stone clearance between both groups. However, the ESWL cases needed longer time, greater number of sessions, and sometimes auxillary procedures and acorrdingly ESWL was less cost-effective than URS. We also identified in our study three cutoff points for ESWL cases above which the case will mostly need more than one session (skin to stone distance >8.8 cm, stone size >1.1 cm, and stone density >1100 HU).

Conclusion
Both ESWL and URS are efficient modalities for the management of upper third ureteral stones. However, in large upper third ureteral stones (>1.1 cm), with high density (>1100 HU) especially in obese patients (skin to stone distance more than 8.8 cm), URS has proved to be a more practical option.

Keywords:
extracorporeal shock wave lithotripsy, upper third ureteral calculi, ureteroscopy

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Introduction

Urinary stones, one of the most common urological diseases, require active treatment due to its high prevalence, high recurrence rates, and various complications [1,2]. There are many therapeutic approaches for the treatment, that is, complete stone clearance with minimal patient morbidity, of ureteral stones. The most commonly used approaches include extracorporeal shock wave lithotripsy (ESWL), ureteroscopy (URS), percutaneous nephrolithotripsy, laparoscopic ureterolithotomy and open ureterolithotomy [3]. However, there is a lack of definite evidence-based options for managing large proximal ureteral stones [3].

Moreover, the optimal choice of treatment depends on various factors, including stone size, composition and location, clinical factors, equipment availability, and surgeon capability [1]. The European Association of Urology guidelines recommend ESWL or URS as the first-line treatment for proximal ureteral stones [1].

Both these procedures are preferred because they are less invasive than other approaches, have low complication rates, and are well tolerated by patients. In general, ESWL is preferred by both patients and physicians [1,4,5].

However, in the past two decades, the technological advancements achieved in ureteroscope manufacturing and laser lithotripsy have considerably improved the outcomes of treatment of proximal ureteral stones exceeding 10 mm in diameter [1].

ESWL is an effective and noninvasive treatment method in urolithiasis, particularly in stones located in the upper third of the ureters. However, URS is a more invasive technique when compared with ESWL. URS became the most efficient treatment method in proximal ureteral calculi after the development of small-caliber, semirigid, and flexible endoscopes and the holmium: YAG laser [6].

Patients and methods

This is a prospective non randomized (quasi-experimental study) hospital-based study that was conducted in Assiut Urology and Nephrology Hospital in the period from May 2016 to May 2018. Our study included 60 cases who were classified into two groups:

Group A (the ESWL group) included 30 cases who underwent ESWL for management of upper third ureteral calculi.

Group B (the URS group) included 30 cases who underwent URS for management of upper third ureteral calculi.

Study participants

Inclusion criteria

The study included patients in the age group of 18–70 years with a BMI of less than or equal to 40 kg/m^2 with upper ureteral stones of more than or equal to 1 cm with a density of more than or equal to 900 HU.

Exclusion criteria

(1) Patients with distal obstruction.
(2) Impacted stones.
(3) Marked hydronephrosis.
(4) Radiolucent stones.
(5) Pregnancy.
(6) Stones in children.
(7) Spinal deformity.
(8) Morbid obesity.
(9) Patients with uncorrected bleeding diathesis.

Study workup

Preoperative workup

First, history and routine clinical examination were obtained from all cases being prepared for undergoing either ESWL or URS followed by urine analysis for cases being prepared for undergoing URS, urine culture for cases being prepared for undergoing URS in cases of pyuria (treatment of urinary tract infection was done preoperatively according to culture and sensitivity results), imaging (pelvi–abdominal ultrasound, plain KUB, and MSCT KUB without contrast) for all cases being prepared for undergoing either ESWL or URS, routine laboratory investigations (complete blood count, coagulation profile, renal function tests, blood sugar, hepatitis, and HIV serological markers for cases being prepared for undergoing URS and just coagulation profile for cases being prepared for undergoing ESWL), and finally surgical fitness for cases being prepared for undergoing URS.

Intraoperative workup

First group: URS cases:

(1) Either spinal or general anesthesia was used.
(2) Intravenous prophylactic third-generation cephalosporin was administrated for all patients.
(3) The patients were placed in dorsal lithotomy positon.
(4) At first, the ureteric orifice was identified during cystoscopy using the rigid 22 Fr cystoscope sheath.
(5) This was followed by trial of passing a guidewire beyond the stone. As a routine, a PolyTetraFlouroEthylene (PTFE)-coated straight-tipped guidewire (Accoat; SP Medical, Karise, Denmark) with 0.035-inch diameter and 150 cm length was used.
(6) In cases of failure to introduce this standard guidewire, other guidewires that allow for more negotiation were used such as the Nitinol Zebra guidewire, the Nitinol Hydrophilic Zipwire, or the Sensor guidewire (Nitinol-PTFE hybrid guidewire with a hydrophilic tip). All these guidewires are the property of Boston Scientific (Natick, Massachusetts, USA).
(7) This step was followed by trial of introduction of the 6 Fr ureteroscope into the ureter.
(8) If the latter step failed, the part of the ureter distal to the stone was then dilated either by Teflon or balloon dilators, then the ureteroscope was introduced into the ureter till reaching the stone.
(9) When the introduction of ureteroscope failed after all these measures, a ureteric stent was inserted prior to re-do URS. These failed trials of URS were not considered actual URS as they lack most of the steps of URS; therefore, they were not counted among the total procedures.
(10) After reaching the stone by a ureteroscope, the stone was disintegrated.
(11) For stone disintegration, only pneumatic lithotripters were used. Stone fragments after lithotripsy were extracted by a Dormia basket if needed.

(12) At the end of procedure, the ureter was inspected endoscopically to detect and deal with any residual stone fragments or ureteral injury.
(13) This was followed by ascending ureterography to detect any extravasation.
(14) Ureteric stenting (by either ureteric catheter or double J) was done according to the situation.
(15) Finally, fluoroscopic confirmation of correct stent position and stone clearance was done and then a urethral catheter was inserted.

Second group: extracorporeal shock wave lithotripsy cases

(1) Patient preparation before ESWL:
   (a) In most of the patients, patient bowel preparation the night before treatment was done by taking a mild laxative together with carbon tablets.
   (b) 20–30 min prior to treatment, 10–20 mg of morphine sulfate plus one ampule of one of the NSAIDs were injected intramuscularly.
   (c) Also parenteral fluids and suitable antibiotics were given for those patients.
(2) Patient positioning on the lithotripter:
   (a) The patients were treated in the supine position.
   (b) The therapy head was rotated either to the above table position when the radiography localization system was used or the below table position when the ultrasonic localization system was used.
(3) Stone localization:
   (a) The standard localization system in the upper ureteric stones is the radiography localization system.
   (b) The ultrasonic localization system was used in patients with dilated upper urinary tract or stones just below the ureteropelvic junction.
(4) Shock wave adminstration:
   (a) We began with 14 kV, then after 100–200 shocks the voltage was increased in a stepwise manner.

Postoperative workup

(1) -Postoperative complications were reported for both groups (URS and ESWL patients).
(2) -Research outcome measures:
   (a) Primary (main): plain KUB.
   (b) Secondary (subsidiary): abdominal ultrasound and MSCT KUB.

Stone clearance has been assessed both after the procedure and at 3-month follow-up for URS cases and 3-week follow-up for ESWL cases.

Data management and analysis

Statistical analysis was done using IBM SPSS (IBM, Armonk, New York, USA) SPSS Statistics, version 21. The *P* value was considered significant if it was less than 0.05.

Ethical considerations

Confidentiality

The confidentiality of all participants admitted to the study was protected to the fullest extent possible. The study participants were not identified by name in any report or publication resulting from data collected in this study

Research statement

Ethical aspects whether substantial or procedural were implicated in this study. Before participants were admitted in this study, the purpose and nature of the study as well as the risks were explained to them. The participants had to agree that he/she understands the investigational and operative nature of the study, its inherent risks and benefits, other treatment alternatives, his/her rights to terminate participation in this study

Table 1 Demographic data of the studied patients

Variables	ESWL group (*n*=30)	URS group (*n*=30)	*P*
Age (years)	37.83±11.81	40.23±12.65	0.45
Sex			0.50
Male	23 (76.7)	24 (80)	
Female	7 (23.3)	6 (20)	
Comorbidities			0.17
Nothing	21 (70)	18 (60)	
DM	7 (23.3)	10 (33.3)	
HTN	4 (13.3)	6 (20)	
Cardiac disease	1 (3.3)	1 (3.3)	
Hepatic disease	0	1 (3.3)	
BMI (kg/m^2)	30.53±6.74	28.20±4.60	0.06
Pervious operation			0.50
Nothing	15 (50)	14 (46.7)	
ESWL	3 (10)	3 (10)	
URS	9 (30)	6 (20)	
PNL	5 (16.7)	10 (33.3)	
Renal exploration	5 (16.7)	8 (26.6)	
Past history of stone formation	15 (50)	15 (50)	0.60

Data are presented as mean±SD and *n* (%). DM, diabetes mellitus; ESWL, extracorporeal shock wave lithotripsy; HTN, hypertension; URS, ureteroscopy.

Table 2 Presentation of patients in both the studied groups

	ESWL group (*n*=30)	URS group (*n*=30)	*P*
Complaint			0.07
Pain	29 (96.7)	28 (93.3)	
Hematuria	14 (46.3)	13 (43)	
Fever	1 (3.3)	2 (6.7)	

Data are presented as *n* (%). ESWL, extracorporeal shock wave lithotripsy; URS, ureteroscopy.

Table 3 Characteristics of the stone

Characteristics	ESWL group (*n*=30)	URS group (*n*=30)	*P*
Size (cm)	1.25±0.14	1.24±0.11	0.66
Range	1.1-1.60	1.10-1.50	
Density (HU)	1203.96±145.28	1204.4±123.02	0.98
Range	1020-1458	1030-1468	
Opacity			0.62
Radio-opaque	7 (23.3)	7 (23.3)	
Faint radio-opaque	23 (76.7)	23 (76.7)	
Skin to stone distance (cm)	9.47±1.12	9.59±0.62	0.11
Range	7.60-11.20	7.60-11.30	

Data are presented as mean±SD and *n* (%). ESWL, extracorporeal shock wave lithotripsy; URS, ureteroscopy.

Table 4 Diagnostic accuracy of skin to stone distance, stone size, and stone density in thee prediction of the need for retreatment in extracorporeal shock wave lithotripsy

	SSD	Size	Density
Sensitivity (%)	100	95.5	90.5
Specificity (%)	89	100	100
Positive predictive value (%)	95.5	100	100
Negative predictive value (%)	100	90	82
Cutoff point	>8.8 cm	>1.1 cm	>1100 HU
Area under the curve	0.95	0.97	0.90
P	<0.001	<0.001	<0.001

SSD, skin to stone distance

without affecting his/her rights in having proper health care in the study site, Whom to contact with questions regarding the study and that he/she is freely given an informed consent to participate in this study.

Informed consent

Written and informed consent were obtained from patients.

Results

The current study was conducted at the Assiut Urology and Nephrology Hospital ESWL Unit and operative theaters in the period between May 2016 and May 2018. It aimed to compare between ESWL and URS in the management of large upper third ureteral stones.

The study included 60 patients with large upper third ureteral stones who were subdivided into:

(1) 30 patients who underwent ESWL.
(2) 30 patients who underwent URS.

Tables 1–8.

Discussion

A review of the related medical journals indicates that there is no definite evidence-based option for managing large upper third ureteral stones. ESWL and URS have become the standards of care for ureteral stones.

Table 5 Degree of hydronephrosis in both groups

	ESWL group (*n*=30)	URS group (*n*=30)	*P*
Degree of hydronephrosis			0.09
No	3 (10)	7 (23.3)	
Mild	15 (50)	18 (60)	
Moderate	12 (40)	5 (16.7)	

Data are presented as *n* (%). ESWL, extracorporeal shock wave lithotripsy; URS, ureteroscopy.

Table 6 Medical expulsive therapy in both groups

	ESWL group (*n*=30)	URS group (*n*=30)	*P*
Medical expulsive therapy	5 (16.7)	12 (40)	0.06

Data are presented as *n* (%). ESWL, extracorporeal shock wave lithotripsy; URS, ureteroscopy.

However, the optimal choice of treatment depends on various factors, including stone size, composition and location, clinical factors, equipment availability, and surgeon capability [7].

In reviewing the literature, we found that several factors affect the outcome of both treatment modalities (ESWL and URS) in the management of large upper third ureteral stones. These factors can be divided into four categories: stone characteristics, patient factors, equipment availability, and operator skills.

Regarding stone characteristics, there was no significant difference between stone size for both groups. However, our study showed that URS was very effective regardless of the stone size which was not the case with ESWL.

In reviewing the literature, our results coincided with those of Aboutaleb *et al*. [1] who recommended URS over ESWL for large upper third ureteral stones of more than 1.5 cm.

Our results also matched those of Youssef *et al*. [8] who confirmed that both ESWL and URS are effective treatment modalities for upper third ureteral stones of more than 2 cm with ESWL being safer and less invasive and URS more effective with lower retreatment rate.

Kijvikai *et al*. provided results resembling ours. They recommended ESWL only for stones less than 1 cm confirming that ESWL is less successful for larger stones and recommending URS for such stones [7].

In their study, Lee *et al*. [9] stated that ESWL is not recommended for upper third ureteral stones larger

Table 7 Perioperative data in both groups

	ESWL group (*n*=30)	URS group (*n*=30)	*P*
Preoperative stenting	7 (23.3)	1 (3.3)	0.02
Number of sessions	2 (1-3)	-	-
Time needed for complete stone clearance (min)	77.17±28.96	46.37±7.28	0.00
Postoperative stenting	0	26 (86.7)	0.00
Stone clearance			0.37
Complete clearance	20 (66.7)	24 (80)	
Clinically significant residual fragments	9 (30)	6 (20)	
Clinically insignificant residual fragments	1 (3.3)	0	
Stone migration	0	6 (20)	0.02

Data are presented as mean±SD and *n* (%). ESWL, extracorporeal shock wave lithotripsy; URS, ureteroscopy.

Table 8 Auxiliary procedures and complications in both groups

	ESWL group (*n*=30)	URS group (*n*=30)	*P*
Auxiliary procedure			0.08
Nothing	21 (70)	24 (80)	
Ureteroscopy after ESWL	8 (26.7)	0	
ESWL after ureteroscopy	0	6 (20)	
PNL after ESWL	1 (3.3)	0	
Complications			0.09
Nothing	21 (70)	19 (63.3)	
Fever	0	5 (16.7)	
False passage	0	3 (10)	
Perirenal hematoma	1 (3.3)	0	
Skin bruise	3 (10)	0	
Steinstrasse	7 (23.3)	0	
Hematuria	6 (20)	7 (23.3)	

Data are presented as *n* (%). ESWL, extracorporeal shock wave lithotripsy; URS, ureteroscopy.

than 1.5 cm. We have similar results but at a cutoff point of 1.1 cm rather than 1.5 cm.

In addition, Lam *et al*. [10] declared that URS is a more preferable treatment option for upper third ureteral stones larger than 1 cm. We also have similar results but at a cutoff point of 1.1 cm rather than 1 cm.

For stone density, we found that stone density was a strong predictor for outcome of ESWL in the management of large upper third ureteral stones which was not the case with URS.

In reviewing the literature, our results matched those of Ouzaid *et al*. who confirmed 970 HU as a cutoff point above which we should opt for URS rather than ESWL for the management of upper third ureteral stones [11].

Our results also coincided with those of Wiesenthal *et al*. [12] who confirmed that the efficacy of ESWL in the management of upper third ureteral stones decreases after a cutoff point of 900 HU.

El-Nahas *et al*. [13] also recommended an alternative treatment option for ESWL in stones larger than 1000 HU in density.

Wang *et al*. [14] provided results similar to ours recommending URS over ESWL for the management of upper third ureteral stones but at a cutoff point of 900 HU in their study rather than 1100 HU in our study.

In addition, Gupta *et al*. [15] provided results resembling ours. They gave URS the upper hand in the management of large upper third ureteral stones with a stone density of more than 750 HU.

For stone opacity, it had been noted that it had no significance in URS cases which was not the case with ESWL cases where it was a significant predictor for the outcome of ESWL.

Our results coincided with those of Lim *et al*. [16] who stated that stone with a density greater than that of the 12th rib had a relatively higher risk of ESWL failure than did stone with a lower density.

Regarding patient factors, it had been noted that the most sensitive, specific, and powerful predictor was the skin to stone distance (SSD) measured by MSCT KUB without contrast. It had been noted that for URS cases, SSD was not a significant predictor.

In contrast, for ESWL cases, SSD played a significant role in predicting the outcome of ESWL in cases with large upper third ureteral stones at a cutoff point of 8.8 cm, meaning that all cases with an SSD of more than 8.8 cm required more than one session of ESWL to achieve complete stone clearance and some of them also required auxillary procedures in the form of URS.

Our results matched those of Patel *et al*. [17] who found that SSD was a significant predictor for the outcome of ESWL in large upper third ureteral stones at a mean SSD of 83.3 ± 21.9 mm as a predictor for success of ESWL.

Our results also coincided with those of Ng *et al*. [18] who identified SSD as a significant predictor for success of ESWL in upper third ureteral stones at a

cutoff SSD of 9.2 cm above which ESWL is expected to fail in the form of the need for more sessions or the need for auxiliary procedure.

Wiesenthal *et al.* [12] has also recognized SSD as a powerful predictor for the outcome of ESWL in upper third ureteral stones stating an SSD of 110 mm as a cutoff point above which ESWL is expected to fail.

As regards stenting, we found that preoperative stenting did not affect the outcome of neither ESWL nor URS in the management of upper third ureteral stones.

Our results were contradictory to those of Padhye *et al.* [19] who found that efficacy of ESWL in the management of upper third ureteral stones decreases in the presence of indwelling JJ stents.

Regarding the degree of hydronephrosis, we noticed that mild and moderate hydronephrosis did not affect the outcome neither in URS nor in ESWL.

Our results coincided with those of Seitz *et al.* [20] who recognized that presence or absence of hydronephrosis or even the degree of hydronephrosis does not influence the outcome of ESWL in the management of upper third ureteral stones.

Our results also matched those of Boulay *et al.* [21] who found that severity of renal obstruction does not affect the outcome of ESWL in the management of upper third ureteral stones.

Regarding medical expulsive therapy (MET), we found that MET does not significantly influence the outcome of either ESWL or URS in the management of upper third ureteral stones.

In reviewing the literature, our results differed from those of Wood *et al.* [22] who found that there is an advantage to MET in those patients being prepared to undergo either URS or ESWL.

Regarding postoperative complications, there was no significant difference between both groups (ESWL and URS).

Our results coincided with those of Iqbal *et al.* [23] who found that the complications rates between both ESWL and URS were comparable with no significant difference between both groups.

Our study had some limitations

The availability of equipment. We had no laser lithotripters for stone disintegration during URS.

Conclusion

We recommended URS over ESWL for the management of large proximal ureteral stones whenever the surgical skills, and the efficient equipment are available as a safe, cost-effective, and rapid modality for the management of large proximal ureteral calculi especially in patients with an SSD of more than 8.8 cm, stone size of more than 1.1 cm, and/or stone density of more than 1100 HU.

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Conflicts of interest

There are no conflicts of interest.

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