

Flexible Ureteroscopy and Laser Lithotripsy Intervention for the Management of Stone Disease

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ABSTRACT

Background: The role of ureteroscopy has dramatically evolved over the past twenty years driven by profound enhancement in various factors and assisting techniques such as the ureteroscope size, deflection capabilities, video-imaging, and in lithotripsy (stone breakage) with the advent of holmium laser, however, the stone size plays a critical role in determining outcomes and operative approach. **Aim of the work:** we conducted a systematic review of the literature to look at the safety and efficacy of flexible utereroscopy and laser lithotripsy intervention in patients with stone disease; particularly those with stones larger than 2 cm.

Methods: A systematic search was performed in the scientific database particularly MEDLINE (2000–2017), EMBASE (2000– 2017), Cochran Central Register of Controlled Trials, CINAHL (2000–2017), Google Scholar, and individual urologic journals.

Results: The search yielded eight studies involving 392 patients, (390 renal units) were reportedly treated with FURSL. The mean operative time was 80.7 minutes (26–215 min). The mean stone-free rate was 91.2% (77%–96.7%), with an average of 1.6 procedures per patient. The mean stone size was 2.5 cm except for one most recent study which reported stones size less than 0.5 cm. An overall complication rate was 8.1%. Major complications developed in 21 (4.2%) patients and minor complications developed in 19 (3.9%) patients.

Conclusion: Flexible Ureteroscopy and Laser Lithotripsy intervention has proven to be not only a less invasive treatment but also a successful with a low complication and stone free rate (SFR) for renal calci larger than 2 cm. FURSL may represent an alternative therapy to standard percutaneous nephrolithotomy (PCNL) with satisfactory efficacy and low morbidity.

Keywords: Ureteroscopy, Laser Therapy, Urinary Calculi, Lithotripsy, kidney stone, ureteric stone.

INTRODUCTION

The annual incidence of stone formation in the industrialized world is generally considered to be 1500–2000 cases per million¹. The disease most commonly presents with pain, usually an episode of renal stone colic, but other types of pain, haematuria and infection might lead to the diagnosis. The stone needs to be actively removed in approx. 25% of those affected, and hence such procedures are required in ^a500 patients per million².

Countries in the Afro-Asian stone belt (stretching from Egypt and Sudan, through the Middle East, India, Pakistan, Burma, Thailand, Indonesia and the Philippines) falling within the tropical and subtropical regions have consistently reported a high incidence of urolithiasis. Generally in this region the population density is high, the gross national product is low and 30–50% of the population live below the poverty line. Poor

nutritional status and inadequate health facilities are common in the region. More than half the people live in rural areas and the climate is moderate to hot³. Against this background urolithiasis constitutes 40–50% of the urological workload in hospitals⁴. A specific problem of this region is the neglected asymptomatic large and/or staghorn calculi which present with renal failure⁵. The etiology of stone formation in a given population is reflected in the composition of calculi, metabolic studies, and dietary habits. In the region, 60–65% of the patients form calcium oxalate, 15–30% uric acid and 10–15% struvite stones. Ammonium hydrogen urate is found in \approx 30% of renal calculi in children and in 3% in adults. Bladder calculi in children are predominantly calcium oxalate, ammonium hydrogen urate and uric acid⁶. Metabolic studies from the region and data from SIUT (Table 2)

show that the major risk factors are low urinary volume (20–30%), hyperuricosuria (20–60%), hyperoxaluria (50–60%), hypomagnesuria (20–30%) and hypocitraturia (30–40%). Hypercalciuria is encountered in 7–10% of the patients⁷. Most studies in stone-formers show normal blood calcium levels and hyperuricaemia in 10–20% cases⁸. These results suggest that dietary and environmental factors are more important in this region, as oxalate-rich and calcium-poor diets prevail with the low intake of proteins. Furthermore, chronic diarrhea and malabsorption in the tropics could be a major causative factor for hyperoxaluria⁹.

The diagnostic and management facilities in the region show a wide spectrum in different countries, depending on their economic status. Most of the centers have minimal facilities for X-ray, ultrasonography, urine analysis and open surgery, the main procedure¹⁰. However, there are centers, mostly private, which are fully equipped with diagnostic methods, e.g. ultrasonography, IVU, CT, laboratories for metabolic studies and technology for minimally invasive surgery¹¹.

Open surgery for renal stone disease has decreased considerably because of the adoption of noninvasive and minimally invasive techniques. The commonest current and acceptable indications for open surgery include complex stones in kidneys with a dilated collecting system, failure of percutaneous, endourological or ESWL, and stones in a kidney with anatomical abnormalities, e.g. PUJ obstruction, infundibular stenosis, ureteric strictures and concomitant open surgery¹².

SWL has revolutionized the treatment of upper tract stones and has become the most employed option for these types of stones as well¹³. However, its success rates are far from satisfactory and may vary from 80% for those smaller than 1 cm to 54% for stones greater than 2 cm¹⁴. Percutaneous nephrostolithotomy (PCNL) has made it possible to achieve a stone free rate of more than 90%, with inherent risks of the percutaneous access¹⁵. Recognition of the limitations of SWL and PCNL has allowed the increased popularity of ureteroscopic treatment of renal stones.

PCNL has become a standard modality in the treatment of kidney stones that are larger than 2 cm in diameter and that do not respond to ESWL except for the situations including contraindications for general anesthesia, anticoagulant therapy, untreated urinary tract infection, atypical bowel interposition, potential malignant kidney tumour, and pregnancy¹⁶. An abdominopelvic ultrasound (USG), plain

abdominal films, and intravenous urography are the diagnostic imaging tools to determine stone size, location, and anatomical clues, as well as for planning treatment. Moreover, computerized tomography (CT) can be used when there is suspicion of hepatomegaly, splenomegaly, aortic aneurysm and retrorenal colon, allergies of the contrast medium, and in patients with non-opaque stone¹⁷.

Furthermore, after advances in endourology, ureteroscopic surgery has become a popular choice for the minimally invasive treatment of urolithiasis, in addition to that, it became clinically available after the development of the small diameter ureteroscope with passive and active deflection allowing access to the entire collecting system in up to 94% of the procedures¹⁸. In the general population, studies reveal stone-free rates between 77 and 93% after one procedure. Success varies depending on size, number and location of stones^{19,20}. Intra-operative complications range between 0 and 6%, and major peri-operative complications between 1 and 3%^{19,21}.

Its ability to access the upper tract collecting system, associated with the development of a safe, reliable, and flexible endoscopic lithotripsy source, combined with more efficient extraction instruments made the flexible ureteroscopic laser lithotripsy more attractive to effectively treat renal stones with high success rates and low morbidity. The present study evaluates the outcomes of Flexible Utereroscopy and Laser Lithotripsy Intervention for the Management of Stone Disease for patients with renal calculi larger than 2 cm and its competitive advantage versus PCNL.

MATERIALS AND METHODS

Data Sources

We carried out a retrospective study of patients with stone disease treated with flexible Ureteroscopy and Laser Lithotripsy operated from January 2000 to May 2017.

Data Sources

Literature searches of from MEDLINE (2000–2017), EMBASE (2000–2017), Cochrane Central Register of Controlled Trials, CINAHL (2000–2017), Google Scholar, and individual urologic journals.

The search terms were used in combinations and together with the Boolean operators OR and AND. 8 articles matched the stipulated criteria and were included in the current review.

Search terms

Keywords, phrases, and MeSH terms searched included “flexible uretero-scopy,” “urolithiasis,”

“laser”, “lasertripsy “ureteroscopy” , “Calci”, “ large stones” and “renal stones>2 cm.” Authors independently reviewed titles and abstracts and then downloaded relevant studies. References were reviewed for additional studies.

Study Selection and Criteria

Search results were screened by scanning abstracts for the following:

Inclusion Criteria

- 1- Retrospective studies involving the combined intervention of Flexible Utereroscopy and Laser Lithotripsy for treatment of stone disease.
- 2- Studies involving patients with renal calci larger than 2 cm (exception was for one most recent study which covered the same intervention technique yet for stones less than 2 cm which served as a comparison/reference point and provided update for the potential broad advantage of the technique of concern).

Exclusion Criteria

- 1- Publications conducted in languages other than English and Arabic languages.
- 2- Articles that didn’t meet the present study endpoint (different intervention technique and target study group).

Data Extraction

Two reviewers independently reviewed studies, abstracted data, and resolved disagreements by

consensus. Studies were evaluated for quality. A review protocol was followed throughout.

RESULTS

Electronic Searches identified 174 publications in addition to another 21 publications that were found through manual research. After removal of duplicates, abstracts and titles 113 publications were assessed as identified from title and abstract and 54 papers were excluded. 8 papers full text could not be retrieved and another 14 papers with the same cohort. There were also 29 papers excluded because they did not Flexible Utereroscopy and Laser Lithotripsy Intervention for the treatment of Stone Disease particularly for stones larger than 2 cm. We followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines²² in reporting the results (**Figure 1**).

Data extracted using a standard protocol concerning target population, sample size, intervention components, processes, and outcomes. Comparison among provider type was computation of differences between percent of successful program to number attempted. No further statistical analyses were employed. Finally 8 studies²³⁻³⁰ were included and detailed as the focus for the present study.

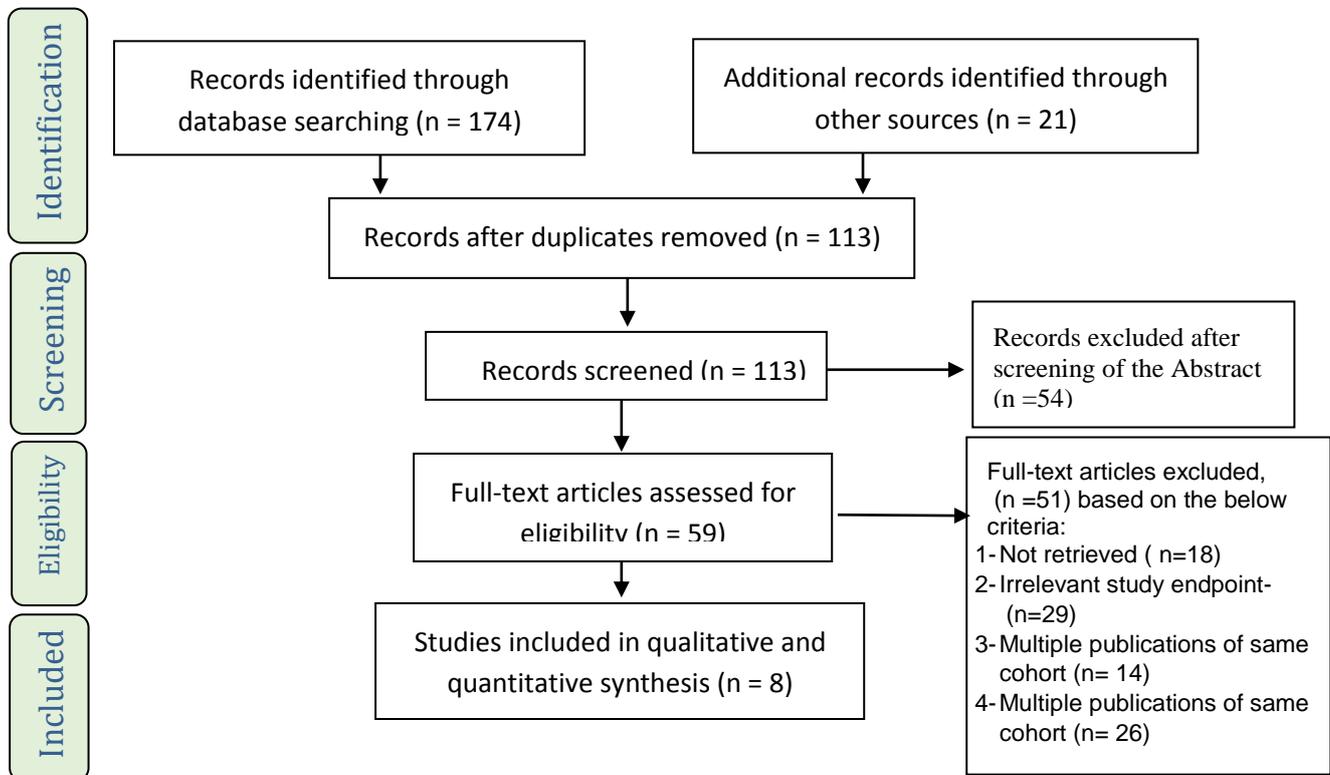


Figure 1: PRISMA flow diagram showing the selection criteria of assessed studies²².

1. Characteristics of the included studies and patients demographics

The studies were published between 2001 and 2015; three of which were conducted in Europe, three of which were conducted in the United States, one in Turkey and one in Africa. There were 460 renal units in 392 patients with an age range between 23 and 78 years. Male to female ratio was 55% (Table 1). As previously mentioned in the inclusion criteria, the majority of the included studies²⁴⁻³⁰ – seven studies - reported on FURSL of stones >2cm whilst the most recent of all²³ by Ugurlu *et al.* covered the same procedure with stone size less than 0.5 cm.

Six studies reported on the average number of procedures performed, with seven studies reporting on the average operative time. A further five studies reported their use of ureteral access sheath. All studies reported on stone size.

Predominantly, all eight studies reported on SFRs, and seven studies reported on complications;

however, Breda *et al.*²⁹ was not clear on whether complications occurred in patients with stones larger or smaller than 2 cm (Table 2).

Overall complication rate of 10.1%, with minor complications developing in 19 (4.8%) patients, major complications developing in 21 (5.3%) patients, and a 0% mortality rate. Of the 19 minor complications, self-limiting hematuria occurred in six patients, postoperative pyrexia or pain in three patients, urinary tract infection treated with simple oral antibiotics in five patients, and minor intraoperative bleeding and postoperative urinary retention in one patient each. Of the 21 major complications, Steinstrasse occurred in five patients, subcapsular hematoma in four patients, and obstructive pyelonephritis in four patients of which one went to the intensive care unit. The remaining three major complications were cerebrovascular accident, acute prostatitis, and hematuria causing clot retention in one patient each

TABLE 1: characteristics of the included studies

#	Authors	Country	Publication year	No of Patients	Age(mean)	Male to Female ratio (%)	Operative time
1	Ugurlu <i>et al.</i> ²³ ,2015 ,Turkey	Turkey	2015	25	39.4 ± 15.75	17:8(68)	48.08 ± 22.43
2	Hussain <i>et al.</i> ²⁴ ,2011 ,UK	UK	2011	36	Not clear	Not clear	Not clear
3	Al-Qahtani <i>et al.</i> ²⁵ ,2011 ,France	France	2011	120	48 ±15.3	59:64(48)	89.1 (60–140)
4	Hyams <i>et al.</i> ²⁶ ,2010 ,USA	USA	2010	120	55.7 – 12.8	72:48(60)	74.3 ± 20
5	Bader <i>et al.</i> ²⁷ ,2010 ,Germany	Germany	2010	24	55.8 (20–78)	11:13(46)	114.1 (50–215)
6	Riley <i>et al.</i> ²⁸ ,2009 ,USA	USA	2009	22	52.1 (25–78)	16:06(40)	72 (28–138)
7	Breda <i>et al.</i> ²⁹ ,2008 ,USA	USA	2008	15	56.4 (39–70)	10:05(67)	83.3 (45–140)
8	El-Anany <i>et al.</i> ³⁰ ,2001 ,Egypt	Egypt	2001	30	43 (18–62)	22:08(56)	85 (55–160)
	Total			392	50	183:152(54.6)	80.7

TABLE 2 : data interpretation for the included studies (cases managed with flexible ureteroscopy and laser lithotripsy) in terms of key success indicators(stone free rate (SFR) success and complications)

#	Authors	Stone Free Rate (SFR)%	No of procedures (mean)	Stone Size (mean)	Minor Complications	Major Complications
1	Ugurlu <i>et al.</i> ²³	88%	not clear	<2	urosepsis, Pyelonephritis	0
2	Hussain <i>et al.</i> ²⁴	94.4	not clear	2.8	Not clear	Not clear
3	Al-Qahtani <i>et al.</i> ²⁵	96.7	1.6	2.6	Hematuria+ interperative bleeding	Perforation, obstructive pyelonephritis, Steinstrasse, subcapsular hematoma
4	Hyams <i>et al.</i> ²⁶	97.5	not clear	2.4	acute retention, fever , UTI	Perforation, obstructive pyelonephritis, Steinstrasse, subcapsular hematoma
5	Bader <i>et al.</i> ²⁷	92	1.7	3	UTI	Not clear
6	Riley <i>et al.</i> ²⁸	91	1.82	3	Postoperative pain	ITU admission with bacteremia, subcapsular hematoma
7	Breda <i>et al.</i> ²⁹	93	1.4	2.2	Fever,hematuria	0
8	El-Anany <i>et al.</i> ³⁰	77%	not clear	>2	Fever,hematuria	0

DISCUSSION

A significant evolution to Ureteroscopy and laser fragmentation of stone in the upper urinary tract has taken place recently³¹.

Technical development in instruments (semi-rigid ureteroscopy), the profound progress of the new generation flexible ureteroscopes with greater angles of maximum active tip deflection as well as enhanced durability , moreover, the introduction of laser lithotripsy with its unique and potent thermal decomposition mechanism , in addition to its exceptional safety profile with the aptitude of carrying laser energy through small, flexible fibers have paved the way for fragmentation of stones throughout the upper urinary tract³².

On the other hand, there is a strong body of evidence suggesting that Rigid ureteroscopy (URS) has demonstrated a great efficiency in stone clearance for proximal ureteral stones and superior in treating distal ureteral stones similar to SWL³¹. An undeniable advantage of the ureteroscope lies in its small size and the further decrease in the size has taken down the complication rates for URS from 6.6% to 1.5%³². Furthermore, after advancements in ureteroscopic technology, the overall complication rates have dropped

significantly with major complication rates reported to be <1% to 1.5%. Meanwhile, the overall complication rates in PCNL have been reported to be as high as 83% with a 15% to 20% major complication rate²⁶.

FURSL has grown to be the procedure of choice in patients whom happened to experience failure with other modalities as well as a feasible substitute for obese, anatomically deformed such as kyphoscoliosis, and pregnant patients²⁷.

Nevertheless, the use of a ureteral access sheath facilitates easy passing of the ureteroscope, allows the removal of stone fragments, allows additive benefit of protecting the ureter from repeated insertion and removal of the scope, in addition to decreasing the intrarenal pressures during prolonged procedures by upholding continuous drainage²⁹.

The present review shed the light on the companionship of the FURSL procedures and ureteral sheath, with reference to the studies included found that 86% of FURSL procedures were assisted with ureteral sheath, worth mentioning that the one study that did not use a ureteral access sheath was El-Anany *et al.*³⁰ was

published in 2001, while the first article³⁴ published on assessing ureteral access sheath use was earlier in the same year; 2001, thus, it is now clear that this technology was not readily available at the time the study was conducted. None of the studies predefined the meaning of minor or major complications.

LIMITATIONS OF THE REVIEW

Studies included in the present review were all retrospective, yet the methods were thoroughly explained which might contribute to lowering down the risk of bias. However and despite such limitations, all the studies had similar key comparative parameters. Another limitation is that the SFR was defined differently in studies. All the studies were from high-volume centers of excellence with procedures performed by trained experienced endourologists, and such high SFR may not be achievable in centers in which there is less experience. Further research is vital to evaluate the role of URS and laser fragmentation of large urinary stones. Furthermore, a multi-centric randomized trial comparing FURSL with PCNL for treatment of stones larger than 2 cm needs to be conducted. The parameters should ideally encompass operative times, number of procedures per patient, length of hospital stay, number of clinic or emergency department visits, SFRs, and complication.

CONCLUSION

Flexible Ureteroscopy and Laser Lithotripsy intervention has proven not only an invasive treatment but also a successful with a low complication and stone free rate (SFR) for renal calculi larger than 2 cm. FURSL may represent an alternative therapy to standard percutaneous nephrolithotomy (PCNL) with satisfactory efficacy and low morbidity.

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