Efficacy of retrograde intra renal surgery (RIRS) in the treatment of renal pelvic stone by using Holmium YAG laser in Al-Muthanna province.

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Abstract:

Objective:

to evaluate the clinical utility, safety and outcomes of semi rigid ureteroscopy in the treatment of single renal pelvic stones by using Holmium: YAG laser lithotripsy.

Patients and methods:

Between October 2020 and April 2021 a fifty patients (28 females, 22 male), aged between 11 and 67 years (mean 41.5 years), with single renal pelvic stone from 13 - 27mm (mean size 21.8 mm), treated with S-URS by using Holmium: YAG laser for stones fragmentation at urological Department of Al-Hussien technical of alsamawa Medical City. Inclusion criteria; any patient with single renal pelvic stone <30 mm in size with hydronephrosis regardless its composition and previous history of any urological intervention. Cases with failed access to the stone for whatever the reason were excluded from the study. DJ-stent had been inserted to all patients following stone fragmentation. Preoperative data, as well as stone free rate, operative time and associated perioperative complications were evaluated.
Results:

The primary stone free rate (which was assessed by U/S and KUB) was 68% (34 patients) at the 1st postoperative day, which increased to 86% (43 patients) after 1 month by using ancillary procedures such as ESWL and S-URS for clinically significant residual fragments (i.e. >4 mm). The operative time was ranges from 44.3 to 97.8 min. (with a mean of 72.4 min.) There were no major perioperative complication; however minor complications were encountered in few patients and treated accordingly.
The hospitalization period was from 1 to 4 days (with a mean of 1.6 day). Regular follow up visits had been performed at 1 week, 1 month and 3 months post operatively for assessment.

CONCLUSIONS:

Retrograde S-URS with Holmium:YAG laser lithotripsy is an effective and safe alternative treatment modality for single renal pelvic stone <3cm in size. In selected cases, morbidity, hospital stay and complications are low with good stone free rate and no radiation fluoroscopy.
Introduction:

Urolithiasis is a major health care problem due to its high prevalence and incidence. The disease is very common among both men and women, and it is twice as often in men as in women with estimated prevalence among the population of 2 to 3% and an estimated lifetime risk of 12% for white males and 5 to 6% for white females. The lifetime recurrence rate is approximately 50%. The peak age in men is 30 years; women have a bimodal age of distribution, with peaks at 35 and 55 years. The prevalence of urinary tract stone disease is determined by intrinsic factors such as age, sex, and genetics and by environmental factors such as geographical location, climate, season, water intake, diet, and occupation. A combination of these factors often contributes to risk of stone formation.

The majority of renal pelvic stones are composed of calcium oxalate, often mixed with calcium phosphate, in both adults and children. The acute presentation is usually unmistakable with the classical history of loin to groin colicky pain. Evaluation with non-contrast CT is advisable for diagnosis. The immediate management usually involves analgesia and treatment of any infection present, and then determining definitive management. Stones smaller than 5 mm will generally pass, but larger stones often require urological intervention.

The recent options available for the management of renal pelvic stones include; Observation, Extra-Corporeal Shock wave Lithotripsy (ESWL), Ureteroscope (URS), Percutaneous Nephrolithotomy (PCNL), laparoscopy and rarely Open surgical removal. The appropriate modality for each individual patient will depend on the interaction.
between stone (size, location, appearance of the stone on imaging and composition), anatomical abnormalities, the presence of infection and concomitant comorbidities which may affect the decision regarding appropriate anesthetic time\(^{(4,5)}\).

There is also an increasing trend toward intervention because of technological improvements and a growing dissatisfaction with the overall success rates with extracorporeal shock wave lithotripsy\(^{(6)}\). Most stones less than 5mm in size will pass spontaneously. European Association of Urology (EAU) guidelines stated that active stone removal is recommended for renal pelvic stones >6-7mm in size, however, those of less than 6mm in size, if symptomatic, can be considered for treatment\(^{(7)}\).

**Non-invasive treatment of renal pelvic stones**

Extra Corporeal Shock Wave Lithotripsy is entirely non-invasive, and it uses shock waves to fragment stones into small pieces that can be easily passed. Shortly after its introduction in 1983, it became widely accepted as the first line treatment modality for the majority of stones and rapidly replaced invasive surgical options. ESWL is effective for most renal pelvic stones less than 2 cm in size and ureteric stones less than 1 cm in size.

It is important to highlight that certain stone composition such as cystine, calcium oxalate monohydrate and calcium phosphate stones may be resistant to fragmentation. There are also multiple other contraindications to the use of ESWL which include pregnancy, bleeding diatheses, severe obesity, anatomical obstruction distal to the stone\(^{(8)}\).
Also ESWL might associated with both anatomical and functional injury to the kidney which lead to reversible or irreversible changes result in loss of renal tissue.

In addition Retrograde endoscopic intracorporeal lithotripsy has several advantages including higher immediate stone-free rate, calculi can be located, fragmented and removed under direct vision, also concomitant ureteric obstruction by stone or stricture can be treated at the same time, with in situ fragmentation and basket removal of the fragments. ESWL therapy is limited to certain stone compositions but the holmium laser can fragment all types of stone\(^{(9)}\).

**Invasive treatment of renal pelvic stone**

Larger stones, particularly those composed of cystine or struvite, can be approached via establishing percutaneous access to the collecting system through a small flank puncture. This would allow direct visualization and intracorporeal lithotripsy for stone fragmentation, and removal of fragments known collectively as Percutaneous nephrolithotomy (PCNL).

PCNL has high success rates of around 90% however intraoperative or postoperative major complication rates are often reported as 0.03% to 10%.\(^{(10)}\)

However, ureterorenoscope is fast becoming the main form of treatment for renal pelvic stone. Different stone sizes respond better to different therapies and success rates are variable for the size of stone\(^{(7)}\). The European Association Urological (EAU) recommends the following management plan for kidney stones in the renal pelvis or upper/middle calyx, categorized according to size:
Intrarenal stones smaller than 10 mm, independent of location, can be treated with SWL or ureteroscopy, with PNL as second line therapy. For stones larger than 20 mm, PNL is recommended as first line therapy, with ureteroscopy and SWL as second line options. Stones 10 to 20 mm can be treated with any modality, depending on the stone location\(^{(11)}\)

Until recently, percutaneous nephrolithotomy (PCNL) was recommended as the treatment of choice for renal pelvic calculi >2 cm in diameter; however the European Association of Urology (EAU) guidelines suggest that in such stones ureteroscopy (URS) is another option. This is because PCNL bears several drawbacks such as substantial morbidity, analgesic requirements and high anaesthesiological risk in patients with compromised cardiopulmonary status\(^{(12)}\).

Although it is well known that (F-URS) permits a detailed calyceal examinations and therapeutic interventions, S-URS is also often another sufficient means of reaching renal pelvis.

Technological advances and more sophisticated equipment have led to greater success rates and a low morbidity in the ureteroscopic treatment of renal pelvic stones. Strong indications for performing retrograde ureteroscopy to treat renal pelvic stones include those patients who need assurance of being stone-free (e.g. aircraft pilots) or those patients who specifically request this treatment based on past experience with other treatment modalities\(^{(13)}\).

Today, the vast majority of renal pelvis calculi are accessible and treatable using a retrograde ureterorenoscopic approach. Evolution of technique and miniaturization of instruments have changed the management of renal pelvic stone disease. Reduction in the size of ureteroscopes, improvements in the electronic imaging systems,
proliferation of auxiliary equipments, and improvement in endourological skills among urologists make ureteroscopic management of upper urinary tract stones a treatment of choice. \(^{(14)}\)

**Semi-rigid ureteroscopy (S-URS)**

The semi-rigid ureteroscope is the workhorse of endoscopic surgery, the practice of ureteroscopy began by happenstance when, ini912,Hugh Hampton Young introduced a pediatric cystoscope into the massively dilated ureter of a child with posterior urethral valves.\(^{(15)}\)

It was developed from the larger rigid ureteroscope primarily because of concerns about the inability of the rigid scope to access the upper ureter without causing significant damage to the urothelium. The “flexibility” and reduced size are primarily due to the introduction of fibre-optics which allows the shaft of the endoscope to become somewhat bendable along its vertical axis, hence the term *semirigid ureteroscope*.\(^{15}\)

The fibro-optic bundles (clad for image transmission, unclad for light transmission) are fixed at both ends which permits movement without loss of picture quality.

The shaft is usually tapered so that the distal diameter (4.5 -9 F) is less than the proximal (6.5-15F). The difference between proximal and distal diameter varies between manufacturers but is of the order of 2-4F. The scope length is described as being “short” at approximately 30 cm or long at 40+ cm. Short scopes are useful for the lower ureter in males and lower and upper ureter in females, in female patients the Semi-rigidureteroscope can frequently be passed safely in to the proximal ureter but this is less common in males . in male , a longer urethral length ,a relatively immobile prostatic urethra and more developed psoas muscle make semi rigid ureteroscope navigation past the iliac vessels difficult.\(^{(15)}\)
The long ureteroscope is best for visualization and treatment in the renal pelvis. Within the metallic sheath are the fibro-optic bundles and either one or two working channels. If two channels are being used, one tends to be larger to allow instrumentation and either continued of irrigation or a second working instrument. The distal end tends to be ovoid. A variety of accessories are available to improve irrigation flow but the vast majority of procedures are done using gravity, either alone or using pressurized irrigation bags\(^{(17)}\).

Semi-rigid ureteroscope are very durable instruments compared with flexible ureteroscopes. The biggest reason for failure is improper use or maintenance. Factors associated with failure are age, shaft design (tapered <stepped) length (long > short) and diameter (narrow > wider). While the instruments flexibility has increased its therapeutic potential, it also increases its susceptibility to breakage and deflections above 5 cm are said to be particularly damaging to the instrument\(^{(18)}\).

Both Karl Storz and Richard Wolf instruments manufactured a 40+cm ureteroscope with a sheath caliber of 7.5 to 9.8Fr. The development of this ureteroscope marked the beginning of modem ureteropyeloscopy. These new ureteroscopes could negotiate the distal ureter and reach the renal pelvis in some patients, allowing for evaluation and treatment of the upper urinary tract pathology\(^{(19)}\).

**Lithotrities and stone destruction**

Parallel to improvements in semi rigid ureteroscope design, Technological advances and more sophisticated equipment have led to greater success rates and a low morbidity in the ureteroscopic treatment of renal pelvic stones were advances in intra corporeal lithotripters,, allowing efficient stone fragmentation through the miniaturized modem
semi-rigid ureteroscopy such as laser, electrohydraulic (EHL), ultrasonic and ballistic lithotripsy. These can be divided into flexible (laser lithotripsy and EHL) and rigid (ultrasonic and ballistic lithotripsy).\(^{(20)}\)

**Stone manipulation and removal:**

A variety of working instruments 3Fr or less can be used within the semi-rigid ureteroscope including stone baskets and graspers. The most useful baskets design for intrarenal interventions are flat wire basket and tip-less nitinol (nickel-titanium) basket, which has the advantages of wire memory and kink resistance.\(^{(21)}\)

It allows for stone retrieval and stone maneuvering within the pelvicalyceal system. The 3-prong grasping forceps such as the Tri-claw (2.4Fr, UrogynMedicalInc., Valapraiso, Indiana) can be used to manipulate stones within the pelvicalyceal system as well.\(^{(22)}\)

**Laser lithotripsy:**

Laser is an energy which emit electromagnetic radiation through stimulated emission of photons. When an atom is stimulated by an external energy source, electrons become metastable and change their orbit. As this excited state decays, an emission of photons (light energy) occurs.

There are three differences between laser light and natural light: laser light is coherent (all photons are in phase), collimated (photons travel parallel to one another), and monochromatic (photons have the same wavelength). It is these characteristics that allow lasers to transmit high energy in a concentrated fashion.\(^{(23)}\) The first functioning laser was constructed by Theodore H. Maiman in 1960. In 1966 Parsons was the first to use laser technology in urology when he experimented with the
pulsed-ruby laser in canine bladders.\(^{(24)}\) In 1968 laser technology was first utilized for lithotripsy/\(^{(25)}\) Since the initial ruby laser, several lasers have been developed and implemented in intracorporeal lithotripsy including:


**The Holmium: E4G laser**

The introduction of the holmium: YAG laser represented a major advance in the armamentarium of laser lithotripsy devices, the holmium laser dramatically changed intracorporeal lithotripsy, and has become the energy of choice for most urologists performing retrograde ureteroscope lithotripsy. This laser type is particularly suited for urology, as it has a wavelength of 21 O0nm in the near-infrared portion of the electromagnetic spectrum Similar to other laser lithotripters, it operates in a pulsed manner with pulses of 350 sec., in duration at a rate of 5 Hz, and up to 50 Hz in some lasers which is absorbed in 3 mm of water and 0.5 to 1 mm of tissue. The laser delivers considerably higher energies per pulse than other commercial devices, ranging from 500 to 2,000 mJ.\(^{(26)}\)

The holmium laser is able to fragment stones of any composition by a photo-thermal reaction with the crystalline matrix of the stone. Additionally, flexible quartz fibers can be used with rigid and flexible ureteroscopes. The smallest diameter fibers (200 -pm) minimally impact flexible ureteroscope deflection, which allows in situ lithotripsy of stones in almost any location inside the pelvicalyceal system and is particularly important for stones that cannot be displaced from the lower pole. There are a bunch of techniques described for the disintegration of calculi depending on their size and structure: dancing/painting, chipping, drilling or the popcorn technique. \(^{(27)}\)(\(^{(28)}\)

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the laser can provide stone “dusting” or fragmentation depending on the settings used. Dusting involves pulverizing the stone to fragments small enough (1 to 2 mm) to pass easily out of the collecting system without pain or obstruction.\textsuperscript{29} Typical dusting settings on the laser unit would be 0.2 J at 50 Hz and fragmentation settings would be 1.0 J at 10 Hz, and both settings ultimately use the same amount of energy (10 W). The laser delivers considerably higher energies per pulse than other commercial devices, ranging from 500 to 2,000 mJ. The laser technique is straightforward and involves placing the fiber on the stone surface before activating the laser.

The end of the fiber must remain in contact with the stone for effective lithotripsy to occur. Lithotripsy depends on the pulse energy output and the diameter of the optical delivery fiber, implying that lithotripsy efficiency correlates with energy density.\textsuperscript{30}

With Holmium: YAG laser our general strategy was to start with the lowest power and the least frequency to assure safety and to adjust these variables on demand thereafter to achieve efficacy. We started with 1 J power and adjusted accordingly while started with 10 Hz frequency that increase to 15 Hz. Mucosal injury from misdirected lithotripsy fiber or from propulsion of stone fragments is a potential risk.

In preliminary ex vivo studies, Johnson and colleagues found that The stone fragments produced by the holmium: YAG laser have been demonstrated to be smaller compared to those produced by EHL, pneumatic lithotripters, or pulsed-dye lasers, in addition to the ability of the Holmium: YAG laser to produce fragments less than 2 mm in size results in less of a need to resort to ancillary procedures, such as stone basketing to remove the fragments, thereby shortening operative times.
The holmium: YAG laser has been successfully and safely used as an intracorporeal lithotripsy device in children. Also the Holmium: YAG laser has been demonstrated in several studies to be a safe option for lithotripsy in patients who have a bleeding diathesis. No significant bleeding complications occurred when the Holmium: YAG laser was the sole lithotripsy device\(^{(30)}\).

**Cautions:**

1- The perforation rates in clinical studies utilizing the Holmium: YAG laser for lithotripsy range up to 4%. Perforations can occur when the laser is activated while it is not in direct vision. The risk of perforation increases with high power settings, but because of the low (0.5 to 1.0 mm) depth of thermal injury, most perforations are small and superficial\(^{(3)}\).

2- The depth of thermal penetration of the holmium: YAG laser, as previously noted, is only 0.5 mm to 1.0 mm. Therefore, any damage that may occur to the eye would likely only occur at the level of the sclera or cornea, and permanent blindness is unlikely\(^{(31)*}\).

To evaluate the clinical utility, safety and outcomes of retrograde semi rigid ureteroscopy in the treatment of single renal pelvic stones< 30 mm size by using Holmium: YAG Laser.

**Material and Method:**

From October 2013 to October 2015, 50 patients were admitted to Urology Department of AL-Sadder Medical City in AL- Najaf and enrolled in this study, they were(28 females, 22 males )with single renal pelvic stone ranging in size from 13 to 27mm (mean of 21.8 mm) and mean volume of 0.98 cm\(^3\), they underwent ureteroscopic treatment for
their stones, their ages range from 11- 67 years (with a mean age 41.5

Table (1) Patients characteristics:

<table>
<thead>
<tr>
<th>No.</th>
<th>Female</th>
<th>Male</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>28</td>
<td>22</td>
<td>56%</td>
</tr>
<tr>
<td>Age(year)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;20</td>
<td>14</td>
<td></td>
<td>28%</td>
</tr>
<tr>
<td>20-40</td>
<td>13</td>
<td></td>
<td>26%</td>
</tr>
<tr>
<td>40-60</td>
<td>17</td>
<td></td>
<td>34%</td>
</tr>
<tr>
<td>&gt;60</td>
<td>6</td>
<td></td>
<td>12%</td>
</tr>
<tr>
<td>Previous urological intervention</td>
<td>ESWL (9)</td>
<td></td>
<td>18%</td>
</tr>
<tr>
<td></td>
<td>PCNL (1)</td>
<td></td>
<td>2%</td>
</tr>
<tr>
<td></td>
<td>Pyelolithotomy (2)</td>
<td></td>
<td>4%</td>
</tr>
<tr>
<td></td>
<td>JJ-stent (4)</td>
<td></td>
<td>8%</td>
</tr>
<tr>
<td></td>
<td>PCN (3)</td>
<td></td>
<td>6%</td>
</tr>
<tr>
<td>Azotemia</td>
<td></td>
<td>3</td>
<td>6%</td>
</tr>
<tr>
<td>Solitary kidney</td>
<td></td>
<td>3</td>
<td>6%</td>
</tr>
</tbody>
</table>

**Inclusion criteria** patients with single renal pelvic stone < 30 mm in maximum diameter with hydronephrosis regardless its composition and previous history of urological intervention.

**Exclusion criteria** from this study include :-

- 1-Stones associated with urinary tract anomalies or a non-functioning kidney, or patients with severe orthopedic deformities.

- 2-patients with active urinary tract infection.
3- stones that could not be accessed for whatever the reason (e.g. tortuosity of the ureter, angulations, strictures).

After we explain and discuss the options of treatment to the patients, all of them who were enrolled in our study preferred ureteroscopic procedures as therapeutic modality, and an informed consent form had been completed by all patients before the operation.

**PREOPERATIVE EVALUATION**

All patients were evaluated by history, physical examination, and laboratory investigations (including urinalysis and urine culture, full blood count, renal function tests, coagulation tests and virology screen). The stone size (maximum diameter), opacity, volume, degree of hydronephrosis were assessed by radiographic imaging studies including abdominal ultrasonography and plain abdominal KUB, Intravenous Pyelography IVU, and/or non-contrast abdominal CT-scan.

**OPERATIVE TECHNIQUE**

The operations were done under spinal/general anesthesia. All patients were received a prophylactic antibiotic at the time of induction of anesthesia.

Our equipments were:

1. The Holmium YAG laser lithotripsy system (Quanta system) with a wavelength of 2100nm.
2. A 550-p,m reusable laser fiber.
3. An 8 - 9.8 Fr. semi rigid ureteroscope with 5 Fr. Workingchannel and 12° lens.
4. Cystoscope equipments (22 F. sheath, 30° telescope lens and working bridge)

5. A 0.038- inch guide wire (Polytetrafluoroethylene (PTFE) coated guide wire).

6. Camera and video system.

7. Glycine (1.5%) as irrigation fluid.

8. Stone forceps and/or zero-tipped nitinol dormia basket.

Patients were placed in a standard lithotomy position, then semi-rigid ureteroscope (S-URS) were inserted into the ureter over a guide wire and advanced up to the renal pelvis under direct vision.

Continuous low-pressure fluid flow was necessary to maintain visibility. After reaching the stone, disintegration was completed by using Holmium : YAG laser, A 550 gm laser fiber with an energy output of 0.8-1.5 J at 8-15 Hz was used in a pulsed manner at 2100 wave length; but the Joule and hertz of energy could be changed during the operation according to the stone hardness and effectiveness of lithotripsy.

The main goal was to disintegrate the stones into small non-significant fragments under direct vision, until the remaining fragments were deemed small enough to pass spontaneously or extracted actively by using grasper or stone basket if it is relatively large.

Sometimes, the stone was entrapped by using dormia basket for easy disintegration, preventing its retropulsion and active extraction of stone fragments. With the basket engaged, the ureteroscope and stone are removed together, keeping the stone in view at all times.
A DJ stent was routinely inserted in all patients, and to be removed 1 week after successful procedure, and to be kept for a longer period of time if there is any large residual fragment.

A Foley’s catheter was inserted in all patients and removed at the same night or next morning in most of the patients.

On the first postoperative day, both plain abdominal X-ray (KUB), and abdominal ultrasonography were performed to all patients to assess stone free status and any complications.

Success (in term of clearance) was defined as <4mm, non-obstructing, non-infectious and asymptomatic residual fragments

Most of our patients were discharged on the first postoperative day. Operative time, any preoperative or postoperative complications, stone free rate and length of hospital stay were recorded.

**FOLLOW UP**

Patients with primary success were followed after one week and one month, each visit include clinical assessment, urinalysis and radiological evaluations.

If there is any clinically significant residual fragments (i.e. more than 4mm) patients were underwent ancillary procedures such as ESWL or ureteroscope or medical management and kept on regular visits at 1wk, one month and three months after last intervention.

**Results:**

Fifty patients were enrolled in our study and their characteristics was shown previously in table(I). They were treated by semi-rigid ureteroscopy and intracorporeal Holmium:YAG laser lithotripsy for
single renal pelvic stone. The parameters of treated stones in our patients were illustrated in Table (2) below.

**Table (2): Parameters of treated stones**

<table>
<thead>
<tr>
<th>Stone size (mm)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>10-20</td>
<td>34</td>
<td>68%</td>
</tr>
<tr>
<td>20-30</td>
<td>16</td>
<td>32%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Stone volume (cm$^3$)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1</td>
<td>38</td>
<td>76%</td>
</tr>
<tr>
<td>&gt;1</td>
<td>12</td>
<td>24%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Laterality</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Rt</td>
<td>28</td>
<td>56%</td>
</tr>
<tr>
<td>Lt</td>
<td>22</td>
<td>44%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Opacity</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Opaque</td>
<td>36</td>
<td>72%</td>
</tr>
<tr>
<td>Lucent</td>
<td>14</td>
<td>28%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hydronephrosis</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild</td>
<td>9</td>
<td>18%</td>
</tr>
<tr>
<td>Moderate</td>
<td>28</td>
<td>56%</td>
</tr>
<tr>
<td>Severe</td>
<td>13</td>
<td>26%</td>
</tr>
</tbody>
</table>

**Primary success** (stone free or insignificant residual fragments) was achieved in 34 patients (23 female, 11 male) 68% after a single ureteroscopic procedure at first post-operative day and increasing to 86%
in 43 patients (27 female, 16 male) after 1 month. The mean operative time was 72.4 minutes (ranging from 44.3 to 97.8 min.), which is greatly related to the stone size as illustrated in table (3) below:

**Table (3): Operative time in relation to the stone size:**

<table>
<thead>
<tr>
<th>Stone Size</th>
<th>Count</th>
<th>Mean Operative Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-15</td>
<td>6</td>
<td>44.3</td>
</tr>
<tr>
<td>15-20</td>
<td>28</td>
<td>61.7</td>
</tr>
<tr>
<td>20-25</td>
<td>13</td>
<td>78.2</td>
</tr>
<tr>
<td>25-30</td>
<td>3</td>
<td>97.8</td>
</tr>
<tr>
<td>Total</td>
<td>50</td>
<td>72.4</td>
</tr>
</tbody>
</table>

Primary success (in term of stone clearance) was not achieved in 16 patients (32%). Ancillary procedures were done for those patients, as follow:

- **ESWL;** in 3 patients with residual stones.
- **S-URS;** another session with S-URS in 2 patients.
- **Medical treatment** with observation in 4 patients.

Three of patients were lost to follow up and other 4 patients were failed to achieve the target to be considered as failed cases (in term of stone clearance) as illustrated in table (4).

No major perioperative complications were occurred in our patients, but minor intra and postoperative had been encountered, as illustrated in table (5). Mean hospitalization period in our study were (1.6 days) from 1 to 4 days.

**Compared to PCNL,** retrograde ureteroscopic lithotripsy, offer shorter post operative recovery, decreased overall morbidity and lower
complications risk\textsuperscript{(42)}. In particular, PCNL has been reported to have a substantial complication rate (0.03-10\%) counteracting its high efficacy (43-44)

In a recent randomized study in patients with renal stones >2 cm, S-URS, although less efficacious, was found to be advantageous over PCNL in terms of operating time, drop of haemoglobin and haematocrit, need for analgesia and duration of hospital stay \textsuperscript{(45)}.

\textbf{In our study} we routinely inserted a DJ stent in all patients after completion of the laser lithotripsy. Although there is much debate on whether stent insertion should be performed in every case of straightforward intracorporeal lithotripsy, stenting was deemed essential also to facilitate alleviation of the high intra pelvic pressure, which inevitably occurs during ureteroscopy causing intrarenal backflow and potentially infectious complications \textsuperscript{(46)}.

\textbf{Primary success rate} in our study was 68\% at the first postoperative day which is achieved in 34 patient. In those patients a DJ stent had been removed on the first follow up visit after one week post operatively, to be seen after 1 month from the operation. Finally, we achieved an 86\% \textbf{overall success rate} after 1 month by using ancillary procedure such as (ESWL ,URETEROSCOPY), for cases with significant stone fragments (i.e. more than 4 mm).

We used ESWL for residual fragment >10mm, which was successful in 3 patients, second session S-URS had been successfully done in 2 patients with large residual stone >15mm in size.

While in other patients with fragments less than 10mm, radiolucent fragments, kept on medical treatment with observation which was successful in achieving stone free-status in 4 patients.

However, 3 of patients were skipped and other 4 patients remain with
significant fragments after 1 month.

**Regarding follow-up** all patients kept on regular visits for follow-up at 1 week, 1 month, and 3 months after last intervention; each visit include clinical assessment, urinalysis and radiological evaluations.

Failure to achieve complete success is inevitable with any new surgical technique, but such failure can be compensated by the less invasiveness.

**Regarding the complications in our study** :-No major complications were encountered while dealing with the patients such as ureteric avulsion, bleeding or haematuria requiring blood transfusion, or septic complications.

I Regarding intraoperative complication: **mucosal laceration** which is minor and occurred in (11) patients due to laser energy or stone manipulation. In order to avoid the mucosal injury during the procedure, **Halbfauer et al** recommended that constant direct vision must be maintained and no energy is applied until and unless there is contact between stone and the probe.\(^{[47i]}\)

**Pelvic and ureteral wall injury** which occur in 3 patients, which was either due to the ureteroscope, guide wire, or laser energy and was managed with an DJ ureteral stent for 2 to 3 weeks.\(^{[48]}\) The risk of perforation from laser energy is negligible, because the depth of thermal injury is only 0.5 to 1 mm. Other complications include Intrarenal **bleeding** which occurs in (6) patients at different times during the procedure, which impedes visualization in few patients leading to termination of the procedure.

**Stones migration (calyceal retropulsion)** which occurred in (7) patients due to the irrigation fluid pressure or increasing pulse energy of laser.

So, in order to minimize calyceal retropulsion, we must use a low-pressure irrigation, decreased pulse energy of laser at time of lithotripsy.
or entrapping the stone by dormia before lithotripsy.

**Regarding post operative complications**

**Fever** which was of low grade in most of patients, except in 3 patients where a high grade fever developed due to urinary tract infection and was managed conservatively. **Haemturia** occurred in (9) patients, which was transient, self-limiting, and treated conservatively. **Dysuria and postoperative pain** which was mild and ameliorated successfully with medical treatment.

**Urinary extravasation (urinoma)** which is small in size, and occurred in 2 patients and treated conservatively.

**Hematoma (perinephric or subcapsular)** occurred in 3 patients, 2 of them were managed successfully by percutaneous drainage and the third one treated conservatively.

Generally, In our study; all of these complications, were approximately the same rates that observed in similar study done by Khaled Mursi, Mohammed S., Elshemy, Hany A. Morsi, et al. at Kasr Al-Ainy Hospitals, Cairo University, Cairo, Egypt in 2 June 2013\(^{(49)}\)

In our study the average hospitalization was 1 to 4 days (with in mean of 1.6 days), most of our patients discharged 24 hours post operatively except in few cases where complications prolonged their hospital stay to a maximum of 4 days.

In a similar study done by **Atis et al.**\(^{(50)}\) 47 patients with an isolated renal pelvic stone underwent S-URS and holmium laser lithotripsy, over a period of two years. The renal pelvic stones were accessed only in 25 out of the 47 patients, F-URS were performed in remaining 22 patients. The complication rate was 4% and the mean hospitalization period was 1.5 days. The mean operative time was 65.4 min, while the stone-free rate was 72% the 1 st postoperative day and 76% after 1 month. The authors
concluded that URS is a feasible alternative treatment modality for isolated renal pelvic stones, with no significant difference among two group in term of stone-free rate, complications rates and hospitalization. In another similar published study done by Mitsogiannis IC, Papatsoris A, et al. (2012) at University of Athens, Sismanoglio Hospital, Athens,: Semi-rigid Laser Ureterolithotripsy for Single Large Renal Pelvic Stones, this study was enrolled 20 patients with large renal pelvic stone more than 1.5 cm treated by semi-rigid ureteroscopy. Mean stone size 2.1 cm, mean operative time was 69.4 minute, primary stone free rate 70.6% at first post operative day increasing to 82.3% at 1 month post operatively, with a mean hospitalization 1.4 day, with no major complications. Adjuvant Extracorporeal Shockwave Lithotripsy (ESWL) was performed in 3 patients with residual stones.

The author concluded that: S-URS is an effective and safe alternative treatment for single large (>1.5 cm) renal pelvic stones (51).

Huffman et al. (52) reported for the first time in 1983 the use of semi-rigid ureteroscopy for the treatment of pyelic calculi.

In our presented study, we concluded that:-

1. Retrograde S-URS with Holmium:YAG laser lithotripsy, is an efficient and safe reliable alternative treatment modality for single renal pelvic stone <3 cm in size, in selected cases. Morbidity, hospital stay and complications are low with good stone free rate and no radiation fluoroscopy.

2. This technique is widely accepted modality of treatment among patients due to less invasiveness than PCNL and higher immediate stone-free rate than ESWL, and associated with few complications which were minor and mostly amenable for conservative treatment.
In view of the general trend in urology toward minimal invasive surgical procedures, our recommendations are:

Encouraging the use of retrograde S-URS with Holmium: YAG laser lithotripsy as a safe and effective way of treating selected patients with single renal pelvic stone <3 cm in diameter, asking for immediate clearance of their stones, or in patients with contraindication for other treatment modality.

Using a urinary tract as a natural access route to the renal pelvis, as a mode of widely promoted (Natural Orifice Transluminal Endoscopic Surgery) “NOTES”

Reduce fluoroscopy protocol, which improve procedures safety in terms of radiation exposure to the patients, surgeon and operating room staff.

4. Further studies with larger sample size for more accurate results.

5. Further comparative studies with other types of treatment modalities.

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