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Review

NO Residual Stones after Flexible Ureteroscopy for Renal Stones – Update 2021. A Narrative Brief Review

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ABSTRACT

Urolithiasis is a major health problem which is on the rise worldwide. New procedures and technological tools have arisen, providing the urologist with a vast arsenal of options for stone disease management. The goal of this narrative review is to summarize the most recent advancements and demonstrate their efficacy in reducing complications and increasing surgical efficacy. The latest modern advances in increasing stone rate after flexible ureteroscopy were included. The ureteral access sheet concept represents one of the most important parts in this procedure and new performances achieved in this field like suction and pressure control were evaluated. Another important aspect in flexible ureteroscopy is related to laser fibres. The latest achievements in Holmium and Thulium fibres were analysed and compared using both dusting and fragmenting techniques. After analysing these aspects, the conclusion was that suction improved visualization by removing "stone storm" and bleeding during the procedure and Thulium laser had the potential to become the new "gold standard" in the pursuit of obtaining a higher stone free rate.

Keywords: flexible ureteroscopy, residual stones, stone-free rate, Holmium laser, Thulium laser.

INTRODUCTION

Urolithiasis is a major health problem that is on a continuous rise around the world (1). Kidney stones are becoming more common in the United States, with a lifetime frequency of 7.1% for women and 10.6% for males (2).

Shockwave lithotripsy and ureteroscopic fragmentation and retrieval are frequently used for stones smaller than 1 cm in diameter; ureteroscopy delivers greater stone-free rates and fewer treatments than shockwave lithotripsy for stones in the 1-2 cm range (3, 4). Extracorporeal shockwave lithotripsy was indicated for treating renal calculi less than 2 cm in diameter, while PCNL was advised for treating renal calculi greater than 2 cm in diameter, according to the 2014 European Association of Urology (EAU) guideline (5).

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New procedures and technological tools have arisen, providing urologists with a vast arsenal of options for stone disease management.

Many years have passed since Marshall (6) and Fernstrom and Johansson (7) first introduced flexible ureteroscopy (fURS) and percutaneous nephrolithotomy (PCNL). Over the past decade, ureteroscopy has surpassed shock wave lithotripsy as the most commonly performed surgery for upper urinary tract stones (8).

Improvements in scope size, design, and optics have significantly facilitated this change. Another important factor that has aided the rise of ureteroscopy is the availability of a wide range of disposable devices that have improved the capacity to treat stones with ever-increasing efficiency and precision. The use of normal saline for irrigation remains a crucial component of many endoscopic procedures.

The latter is required in order to improve stone clearance, intraoperative visibility, and tissue heating impact. Pyelovenous and pyelolymphatic backflow of fluids are associated to high intrarenal pressure secondary to high perfusion rate of normal saline. This may result in systemic absorption of microorganisms and their toxins (4) as well as the development of life-threatening sepsis following URS (0–4.5%) (9).

As a result of efforts to regulate high renal pelvic pressure, ureteral access sheaths were developed, which somewhat alleviate this condition (10). Stone-free rates (SFR) after fURS have been reported to range from 73% to 93.2% in the current literature (11-13). Flexible ureteroscopy is becoming more widely employed for the treatment of renal stones as a result of technological advancements (14).

Because stone recurrence is not uncommon, preventing future stone occurrences, in addition to SFR, is a critical outcome. When the goal is fragmentation and basket extraction, standard procedures for fragment evacuation revolve around active retrieval of fragments using a variety of flexible stone baskets, frequently in conjunction with a ureteral access sheath (15).

Suction has been used in endourology for over 25 years, primarily in conjunction with ultrasound and ballistic devices during PCNL to evacuate stone gravels more quickly (16).

The goal of this narrative review is to summarize the most recent advancements and demonstrate their efficacy in reducing complications and increasing surgical efficacy.

Ureteral access sheets – concepts

Ureteral access sheaths (UASs) are a type of disposable device that allows stone retrieval by providing a secure passage for the scope from outside the body to the upper urinary tract. Hisao Takayasu and Yoshio Aso invented the first UAS in 1974 as a "guide tube" to aid in the insertion of the ureteroscope (URS) into the ureter. This first model, made of polytetrafluoroethylene, had a diameter of 3 mm and a length of 38 cm, through which a flexible URS was advanced (17).

The UAS has undergone extensive technological changes to reduce buckling, kinking, and the risk of ureteral damage.

Current models are typically made up of two disposable pieces: a tapered inner obturator that is passed over a working wire and an outer sheath that is designed to traverse the ureter and exit the body at the urethral meatus.

The UASs are now designed in a large variety of sizes.

In general, using a UAS during ureteroscopic procedures has several advantages, including allowing repeated passes of the instrument to the kidney as well as easing movement and handling of the scope itself. It can also alter irrigation flow dynamics, allowing for better visibility at lower pressures within the kidney. Lower pressures, in turn, can reduce the risk of pyelo-venous backflow and collecting system damage, both of which have been linked to systemic inflammatory response and sepsis *via* the spread of toxins and bacteria (18, 19).

Suction capabilities through the UAS

Stone dusting, in which the stone is fragmented into small particles, has been advocated as one method of avoiding this process; however, whether or not this stone debris will eventually pass remains debatable (9). One emerging solution to this limitation is to apply suction to the end of a UAS (20).

Zeng and colleagues (10) described a modified UAS with an evacuation side port intended for use with a negative pressure vent connected to continuous negative suction to clear small stone fragments during and immediately after ureteroscopic lithotripsy. The authors employed negative pressure settings ranging from 150 to

200 mm Hg. Much of the stone debris would be aspirated through the side port during laser lithotripsy. When stone fragments were too large to pass through this route, they could be evacuated by withdrawing the scope to the bifurcation of the connection side port at the proximal end of the sheath, allowing stone evacuation through the side port. The immediate SFR was 97% in 74 patients with ureteral stones treated with the modified UAS (21).

Zhu and colleagues recently described a separate UAS with suction capabilities (12). On its proximal end, this sheath has two separate channels: one for suction and one for pressure venting. The sheath has a 12F inner obturator and a 14F outer sheath. Among 165 patients undergoing ureteroscopy, the authors used a matched-pair analysis to compare outcomes using the suctioning UAS to those using a standard UAS. The suction UAS cohort had a shorter mean operative time (50 *vs* 57 min) and a higher immediate SFR on postoperative day 1 (83% *vs* 72%). The one-month stone-free rates were comparable between the two groups. There was also a lower complication rate (12% *vs* 25%) and fewer infectious postoperative complications in the suction UAS cohort (22).

Pressure control through UAS

The addition of suction at the sheath's end is also part of a larger effort to use sheaths to control. The ability to insulate the kidney from high irrigation and intrapelvic pressures *via* increased irrigation outflow through the sheath is a significant advantage of ureteroscopy with a UAS over unsheathed ureteroscopy.

This is critical as higher renal pelvic pressure risks ureteral and parenchymal injury as well as pyelo-venous backflow, and has the potential for systemic inflammatory response (8.1%) or sepsis (0%–4.5%) (23). Physiologic RPP has been estimated to be 4 to 7 mm Hg, with an RPP safety threshold of 30 to 40 mm Hg recommended to reduce the risk of pyelovenous backflow. Prior research has found that exceeding these thresholds without a sheath is quite possible, with one study measuring an RPP of 59 cm H_2O under irrigation pressures of 200 cm H_2O and another identifying a peak RPP of 446 cm H_2O with forced irrigation for the purpose of improving vision (24, 25).

In most cases, URS with a UAS can keep the renal pelvic pressure below this threshold, even when the inflow pressures through the scope are high (23).

Deng and colleagues created a novel pressure sensing UAS platform that enables automated or semi-automatic real-time inflow pressure control by regulating irrigation flow and suctioning pressures. This UAS has a pressure transducer at its distal tip as well as two channels at its proximal end, which are linked to a suction vacuum device and a pressure-monitoring feedback device, respectively (26). This sheath has a 15F outer diameter and an 11.5F working channel. It is also available in various lengths.

The ability of the sheath and suction platform to provide real-time RPP readings and automatically regulate pressure is one of its distinguishing features. The system can provide a pressure warning value (default 20 mm Hg) as well as a pressure limit value (30 mm Hg).

It also has a semiautomatic mode as well as pure perfusion and pure suction modes, of which the latter could theoretically aid in stone removal *via* suction through the sheath itself.

The authors claimed excellent SFRs (96% at 30 days), with clear visual fields in all cases and intelligent pressure monitoring that kept the RPP under 20 mm Hg.

They also presented positive clinical data on the use of this UAS/pressure-monitoring system in 40 patients with solitary kidneys.

Suction and operative time

Increased procedural time is associated with higher rates of SIRS and/or fever/sepsis, particularly in patients with infectious stones (28).

The operative time for URS and retrograde intrarenal surgery (RIRS) for stones up to 20 mm in size ranged between 25 and 65 minutes (29).

This working time is less than the 90-minute critical time limit. Better intraoperative visualization by removing stone particles and bleeding as well as the ability to use higher perfusion flow rates of normal saline without exceeding critical RPP values may all contribute to a shorter operative time when using suction. Improved stone particle removal *via* suctioning could also shorten the procedure (30).

Given that renal injury begins in pigs after 60 minutes of RPP > 15 mm Hg and that each minute of RIRS results in absorption of 1 mL of irrigation fluid, time reduction becomes a significant benefit of using suctioning technology (31).

Infections related to URS with UAS

Endoscopic procedures for urolithiasis management are frequently accompanied by infectious complications ranging from fever to SIRS or sepsis.

Zeng *et al* reported a 1.9% fever rate during URS using a modified UAS connected to a negative pressure aspirator (21).

This proportion is consistent with CROES findings and is smaller than the 6.9% rate of postoperative fever (POF) observed by Southern *et al* in their study (32). When suctioning was used, this percentage dropped between 4.3% and 13.1%, even for stones as large as 20–30 mm, and none of these patients had sepsis (26, 27). Postoperative fever following URS/RIRS accounts for 3.4–14.2% of emergency department visits, with nearly half of these patients requiring hospitalization (32). Sepsis is the dreadful sequelae of postoperative fever, with mortality rates as high as 41.1% (33). Suctioning use can thus improve endourologic procedure safety even in more complicated cases by lowering the incidence of postoperative fever.

Stone free rate associated with fURS

Although the definition of SFR varies between studies (usually referring to no residual fragments larger than 2–4 mm), it is the main effectiveness index for surgical techniques used to manage the stone disease.

Several studies reported good percentages for stone-free rates when using different types of modified access sheets.

In their study, Zeng *et al* reported a 97.3% immediate and a 100% one-month SFR when using their modified UAS to treat ureteral stones in various segments (21). These results are better than those already existing in the literature.

Small/medium stone fragments were passed through with continuous aspiration, while larger fragments were removed by drifting them while withdrawing the ureteroscope. The saline flow was unhindered due to the ability to maintain constant renal pelvic pressure by suctioning, and this created a vortex that improved stone clearance and achieved a better visual field (21). As a result, no baskets or forceps were required, reducing the possibility of renal/ureteral injury.

During URS/RIRS using suctioning, similar results were reported with an immediate SFR of 87.5–95.7% and a delayed (1–3 months) SFR of 92.5–95.6% (26, 27).

Comparative studies

1. fURS* vs *mPCNL with suction system

Mini-PCNL is gaining popularity and is being used for an increasing number of indications. Xu *et al* created a nephroscope that was linked to a perfusion pump, allowing for continuous aspiration, and used it to treat patients with renal stones and urinary tract infections (UTIs) (34).

In a recent study, Yang *et al* compared a patented mPCNL system with the suction capability to rigid ureteroscopy for treating impacted upper ureteral stones (35).

The impacted stones are those that have been in the same location for more than two months, and the distal ureter is not visible during CT urography, even in delayed studies (36).

Endourologists face significant therapeutic challenges with this type of stone because the surrounding ureteral mucosa becomes inflamed, and polyps with fibrosis and narrowing develop quickly.

Ureteroscopy provides a potential solution in that the safety wire can pass alongside the impacted stone without causing perforation or ureteral injury. In a recent meta-analysis, Deng compared several therapeutic options for proximal impacted ureteral stones and found that PCNL, either standard or mini, results in a better immediate and one-month stone-free rate than URS. In terms of complications, PCNL was distinguished by lower ureteral injury rates and more frequent transfusions, while postoperative fever showed no significant differences (36).

When compared to rigid URS, suctioning during mPCNL resulted in lower operative time (27.4 *vs* 45.2 min, p=0.001), lower fever rate (5.5% *vs* 15.4%, p = 0.029), higher immediate (97.8% *vs* 71.4%, p=0.001), and one month SFR (100% *vs* 89%, p=0.001), and lower ureteral stricture. According to the authors, this difference in SFR may be observed due to the vacuum effect, which creates a low RPP and avoids stone migration, whereas rigid ureteroscope use suffers from easier stone migration and occasional problematic insertion distal to stone location. Better visualization, achieved by vacuum aspirating the bleeding caused by inflamed mucosa, ensures faster stone disintegration, a higher stone-free rate, and fewer complications (35).

Large renal stones larger than 2 cm in diameter are typically managed with PCNL, but endourologists are increasingly turning to RIRS for these stones (37-39).

A retrospective study of 91 individuals with a single kidney stone measuring between 2 and 3 centimeters was carried out by Chen *et al*. Patients were treated with either fURS utilizing a 12/14 Fr pressure-measuring and suctioning access sheath, which provided the benefit of contemporaneous monitoring of RPP and suctioning, or mPCNL utilizing a 16 Fr suctioning sheath (40). The final stone-free rate at one month after one treatment session was 95.5% for mPCNL and 93.1% for the control group, although the difference was not statistically significant (p=0.65). The SFR that was achieved with fURS and suctioning was comparable to that which was reported by Aboumarzouk. He discovered a maximum SFR of 98% for stones that were 2–3 centimeters in size, but only after a mean of 1.4–1.6 fURS procedures. In contrast, another study shows that the SFR does not exceed 75% (39, 41). Chen did not find any significant differences between the two approaches in terms of the amount of time it took to do the operation (56.23 *vs* 65.62 minutes, p=0.83), but the mPCNL group saw a higher incidence of total complications (28.8% *vs* 11.3%, p=0.039) (40).

The authors came to the conclusion that smaller fragments of stone measuring less than 0.1 centimeters were extracted using suction between the ureteroscope and the sheath, while larger fragments measuring between 0.1 and 0.3 centimeters were extracted using a combination of suctioning and the removal of the ureteroscope from the kidney. Patients in the fURS group were pre-stented for a period of two weeks prior to surgery. This could be a potential confounding factor that has an effect on the outcomes (40).

2. fURS with suction vs *standard fURS*

Access sheaths have the dual purpose of lowering the intrarenal pressure that occurs during fURS and creating a channel into the ureter *via* which stone pebbles can be passed intraoperatively (42). Because of the higher RPP, the use of smaller UAS is a risk factor for systemic inflammatory stress response (SIRS), yet bigger diameter UAS can contribute to ureteral trauma and ischemia injury (43).

Ureteral access sheaths that are equipped with suctioning channels were designed in an effort to combine the benefits of smaller UAS with improved SFR and fewer difficulties.

Comparing a conventional UAS to a suctioning UAS of the same size, 12/14 Fr, in 165 patients having fURS for renal with/without ureteric calculi of equal sizes, Zhu *et al* found that the traditional UAS was more effective than the suctioning UAS (22). In this particular research, the use of suctioning resulted in a shorter procedure time (49.7 minutes as opposed to 57 minutes, p=0.001), a higher immediate SFR (82.4% as opposed to 71.5%, p=0.02), a lower fever (5.5% as opposed to 13.9%, p=0.009), and a lower sepsis rate (1.8% as opposed to 6.7%, p=0.029). On the other hand, neither the SFR at one month nor the septic shock rate nor the length of stay differed substantially across the groups.

Laser fibers and ureteroscopy

An important step forward in the development of this subspecialty of surgery was the introduction of laser (Light Amplification by the Stimulated Emission of Radiation) technology. The holmium: yttrium-aluminium-garnet (Ho:YAG) laser, which is referred to as the holmium laser in this article because it operates at a wavelength of 2120 nm, has served as the cornerstone laser platform for intracorporeal endoscopic stone lithotripsy for more than 20 years, despite the development of numerous other options (44, 45). As a result of this, it is suggested as the "gold standard" among a number of different international guidelines (46). It is necessary to provide evidence that a new laser possesses a number of essential qualities before it can be recognized as a viable option and put into widespread use. This consists of things like clinical efficacy, most importantly a high SFR, as well as safety and longevity. Delivery in a small fiber, in particular if pulse energy (PE – the total energy delivered from the fiber in a single pulse) is not compromised, minimizes retropulsion and supports improved manipulation of a flexible scope in addition to augmenting irrigation (47).

Since its use for stone lithotripsy was first described in 2005 as part of an in vitro study (48), the thulium fiber laser (TFL) is the most recent advancement in laser technology. It has gained increased attention for its role in stone lithotripsy since its application for this purpose was first described. Since that time, an increasing number of research have been conducted to investigate its application in preclinical as well as clinical settings.

Holmium laser

Since its introduction to urology practice in 1992, the holmium laser has quickly established itself as the industry standard, surpassing earlier lasers such as the pulsed dye laser (49). To produce stone fragmentation, its mode of action relies on a photothermal effect rather than a photoacoustic effect (50), in contrast to the latter and the neodymium:YAG laser.

Research that is still ongoing has been a driving force in the evolution that led to its current condition (51). Using systems of the next generation, the surgeon can now manage not only these parameters but also the pulse duration, which is also referred to as pulse width. These days, a wide variety of hybrid approaches can also be used. This includes the capability to combine low energy (for example, 0.2–5 J) and high frequency (for example, 40–50 Hz) in contact mode, which has resulted in the phenomena of 'dusting,' in which the stone is pulverized into fine particles (submillimetre) that spontaneously evacuate (52).

Switching to non-contact lithotripsy, often known as the "pop-dusting" or "popcorn" approach, is one way in which stone clearance can be improved even further. This eliminates the potential requirement for basket retrieval and has the potential to cut down on operational time as well as the utilization of a ureteric access sheath (UAS), both of which can result in extra problems (53). It is important to note that this approach can be carried out using either a low-powered laser (for example, 30–40 W) or a high-powered laser (for example, 100–120 W). The inability of the holmium laser to transmit energy across water and its ineffectiveness as a means of propulsion (54) are two of the most significant drawbacks associated with the technology.

More recently, Moses technologyTM, which employs a 120 W generator (Lumenis Pulse P120H) as well as the Vapor TunnelTM (Quanta System, Samarate, Italy), was introduced as an additional possible solution to this problem. This technology, which has made adaptations based on the previously described principle of the 'Moses effect' (54), was developed by Quanta System. Energy is given in two distinct stages thanks to the pulse-shaped modulation that is unique of this technique. First, the water that is located between the laser fibre tip and the stone is separated, and then the energy is sent to the stone by way of a channel that is referred to as a "vapour cavity." The occurrence of a phenomenon known as a split pulse ultimately leads to a reduction in the amount of energy that is wasted during transmission. Both the contact mode (referred to as "Moses A") with a distance of 1 mm and the distance mode (referred to as "Moses B") with a distance of 2 mm can be used (54).

Thulium laser

In comparison to the holmium laser, the larger water absorption coefficient (WAC) and shorter aqueous optical penetration depth result in a lower ablation threshold (up to four times) (55, 56). Instead of a flash bulb system, the TFL makes use of a light source known as a diode. Because of this, there is minimal loss of energy in the form of heat, and all that is necessary is a built-in air-cooling system that is rather straightforward (8). The utilization of this kind of cooling technology makes it possible to achieve high-power settings (up to 500 W in super pulse mode).

The gadget weighs around 30 kilograms, and it may be powered by a regular electrical outlet that operates between 120 and 240 volts (57). There is hardly any audible disturbance. The beam profile of the TFL is very close to being a single mode (58). Because the PE can be set as low as 0.025 J, it is possible to modify the energy density in order to compensate for the smaller fiber. As a result, it is capable of producing incredibly fine dust particles. Despite the wider range of possible frequency choices, the total amount of time spent operating does not decrease. However, it is important to note that to this day, not a single study has reported using frequency settings that are higher than 500 Hz (59).

Thulium laser advantages

TFL has many benefits, such as an easy cooling system, a smaller fiber diameter, improved irrigation and visibility, and decreased retropulsion, a higher rate of absorption in water, can work with any kind of stone, there is a possibility of huge stones, higher frequency, the possibility of low PE, less collateral damage to tissue, and shorter lithotripsy periods. Even while PCNL is suggested as the first-line treatment for big stones, the TFL may offer URS a greater chance for successfully treating stones that fall into this group. As a possible additional benefit, this may potentially lessen the requirement for tiered operations. When compared to the normal ureteroscope, which has an inner diameter of 1.2 millimeters, a smaller size fiber (an ultra-small fibre with a diameter of 50 micrometers is also available) enables enhanced irrigation and, as a consequence, visibility. If irrigation is improved, there may be less stone migration and other issues connected with pressurised pumps. Because of the tiny size of the fibers, the flexibility of the scope is also improved, which may improve the outcomes in situations such as lower pole stones with an acute infundibulopelvic angle (IPA), in which extreme deflection may be required. Additionally, it opens the door to the prospect of miniaturizing ureteroscopes in a manner analogous to that of PCNL (60).

It is hoped that the ablation characteristics of the TFL will lessen the amount of bleeding that occurs as a consequence of collateral tissue damage. Holmium generators require additional care while being handled due to the fact that the internal mirror arrangement can be easily broken. This is in addition to the fact that they are larger and less practical than other types of generators. In contrast, the TFL generator is portable and can be used with a conventional power outlet. As a result, the electrical danger concerns associated with using the TFL generator are significantly decreased. Modifications to the laser fibre tip will assist maintain against degradation, and when combined with the extended life duration of laser diodes compared to flash bulbs, it appears that the TFL's durability has a good chance of succeeding.

Thulium laser disadvantages

In spite of these undeniable benefits, there are still concerns to be answered and potential drawbacks linked with following: lack of clinical studies, cost efficiency not known, optimal stting not established. There have been numerous attempts in the past to create new laser technologies that can compete with the holmium laser, but none of them have been successful. In contrast to the TFL, the holmium laser has an extensive body of published data to back up its efficiency, which is something that the TFL lacks at the moment. The cost profile will have a significant influence on the degree to which it is adopted, therefore this will be an important factor. There has been no progress made toward determining the optimal parameters for the TFL (61). In principle, it is feasible to have frequency values that are higher than 2000 Hz; however, in clinical practice, it is extremely improbable that such limitations will be implemented. Using an in vitro ureter model, Hardy *et al* (48) evaluated temperature changes at different frequency settings. The researchers measured the temperature changes at a distance of 3 mm from the tip of the laser fiber. Up until and including 300 Hz, there was no change in the temperature, which remained at 33 °C (35 mJ).

However, after this value was exceeded, the temperature started to increase (500 Hz = 39 °C). Accordingly, the authors suggested capping the frequency at no more than 300 Hz. Because of the potential risks associated with this, it seems likely that its application in the actual world will settle for significantly lower numbers on a day-to-day basis. It is also important to keep the frequencies in the ureter at a lower level (62, 63).

Surgical technique – fragmentation and dusting

1. Dusting technique and outcomes

The stone must be broken up into very little fragments, or "dust," in order for it to be able to flow naturally through the dusting process. To do this, the holmium laser is operated at a very high frequency while exerting just a very little amount of energy. Dusting is a process that entails working tangentially from the very edge of the stone with the laser fiber while being careful not to break off huge chunks from the primary stone. This is done in order to create a smooth surface. In this scenario, the settings for the laser are quite important for helping to produce smaller bits of dust. The surgeon needs to continue to treat the edges of the stone circumferentially or from one leading edge as the surgery moves forward.

The second principle that is involved in dusting is keeping the laser fiber a small distance away from the stone in order to "defocus" it and reduce the mechanical acoustic effect that the laser energy has. By defocusing the laser, one can create more fragments of a smaller size. It is essential to take into account the movement of the respiratory and renal systems. The surgeon will be able to "paint" the stone from the edge toward the middle of the stone by making very fine movements with either the hand that is holding the tip of the ureteroscope as it enters into the urethra or by making very fine movements with the thumb that is activated the deflecting cables. Because the laser energy at the beginning of the instance is often lower than the mass of the stone, the stone does not have a tendency to move very much and instead tends to remain in its current location. The laser intensity will become greater than the stone fragment once the stone has been ablated down to a smaller mass, and the stone will begin to bounce within the calyx, making it more difficult to shave the stone from the edges. When this occurs, one has two options: either they can extract the remaining pieces, or you can set the laser fiber in a secure location in the middle of the calyx and continue discharging the laser as fragments come into contact with the fiber. This is a method that is referred to as "popcorning."

It is possible that the particles are small enough to pass inspection based on a number of visual indicators. The technique that is utilized the most frequently is one in which the size of the fragments is measured in comparison to the diameter of the laser fiber that is being utilized in the ureteroscope. Second, if only a few bits are taken out of the whole, then they can be evaluated and measured separately from the rest of the body.

A recent prospective multicenter study compared the use of dusting to fragmentation with stone retrieval for renal stones smaller than 15 millimeters in diameter. The study found that in the short term, there was no difference in readmission rates, reintervention rates, or the number of patients who became symptomatic from residual fragment (53). Another trial that was conducted not too long ago found that active fragment retrieval utilizing a nitinol basket was not linked with improvements in stone free rates when it was used in conjunction with ureteroscopy and lithotripsy for stones ranging in size from 10 to 40 millimeters (64).

Dusting may also give advantages in patient outcomes by minimizing the chance for postoperative problems, which can be a disadvantage for patients. During the stone fragmentation process, lower power and higher frequency settings are related with decreased stone retropulsion. These settings are employed for dusting (65). Reduced stone movement and retropulsion may make ureteral stone therapy more effective by reducing the need to "chase" ureteral stones that have moved cephalad. This is because decreased stone movement and retropulsion occur less frequently. In addition, other studies have shown that stone retropulsion may increase the necessity for secondary procedures to treat clinically significant stone fragments that have migrated from the ureter to the proximal ureter or the kidney. These findings support the hypothesis that stone fragments may be more difficult to treat after they have moved (66).

Because dusting does not require active fragment retrieval, it is possible that it will result in lower overall operative times. The dusting technique has been shown in two recent investigations to result in a decrease in operative times that is either 20% or 40% greater than the control technique (53, 67). Another possible benefit of dusting is a reduction in the number of ureteral access sheaths that need to be used, which could result in less ureteral damage. The initial group of patients who participated in the Post-Ureteroscopic Lesion Scale study reported that the use of ureteral access sheaths was related with some form of ureteral trauma in 57% of cases (superficial or submucosal lesion) (68).

Recent years have seen an uptick in the number of studies that investigate the effects of *in vivo* renal stone dusting. However, a number of these have used a retrospective approach, which should be acknowledged because there is a possibility of bias in selection when using this method. A stone-free rate of 67.2% was found in a retrospective study that investigated the dusting of intrarenal stones utilizing settings ranging from 0.2 to 0.5 J and 30 to 80 Hz (69)

In another study, the same group analyzed the effectiveness of dusting with 60–100 Watt Holmium lasers in comparison to dusting with a 120 Watt Holmium laser (70). In the group that was treated with the 120 Watt laser, the authors utilized settings of 0.2–0.5 J and 30–50 Hz, while in the group that was treated with the lower powered lasers, they used settings of 0.2–0.5 J and 30–80 Hz. The group that was treated with the 120 Watt laser had a stone free rate of 66%, but the group that was treated with the 60–100 Watt laser only had a stone free rate of 39% (p 0.05).

2. Fragmentation and extraction

In practice, the "normal" laser settings that have been utilized ever since the Ho:YAG lithotripsy was first introduced are the ones that need to be applied in order to accomplish fragmentation with extraction. Urologists would typically use combination energy settings such as 0.6 to 1.0 Joules coupled with speeds of 6 to 10 Hz back when holmium laser technology was in its infancy. This was necessary due to the limitations of early Holmium laser technology. *In vitro* investigations have also shown that the size of fragments produced by stone breaking is directly related to the amount of energy used (71).

In most cases, the extraction method of fragmentation requires a lower frequency and a larger pulse energy (ranging from 0.6 to 1.2 Joules) (6 to 10 Hz). It has been established both *in vitro* and in clinical practice that these conditions produce stone pieces that are bigger and are therefore ideally suited for removal using extraction tools. A frequent strategy is to start with an energy and rate setting that is relatively modest (for example, 0.6 J, 6 Hz), and then only increase them if it is required to do so. During lithotripsy, this method not only preserves the laser tip to the greatest possible extent but also reduces the amount of stone movement and retropulsion that occurs.

When ureteral access to proximal ureteral or renal stones is problematic, implantation of a ureteral access sheath may hasten access, fragmentation, and ultimately clearance of the targeted stone. This is because the sheath allows for easier passage through the ureter. However, based on the experiences of many surgeons, an access sheath is not always necessary in a ureter that has an adequate amount of capacity. It is possible that the access sheath places a size restriction on the stone shards that can be retrieved; as a result, prudent omission might be something to think about.

The middle of the stone is often the first area that is attacked, with the intention of splintering the stone in two equal parts. Starting in the middle of the stone increases the margin of safety between the laser fiber and the ureteral or renal wall. This is especially important when beginning the procedure. After then, the pieces that were formed can be successively fragmented further in the same manner until they appear to be of a size that can be retrieved. Stone clearance is accomplished through the utilization of a tiny caliber nitinol grasper or basket. The active extraction process will continue until all fragments that can be seen have been removed.

There is a possibility that there are multiple benefits associated with the procedure of kidney stone fragmentation and removal. Stone composition can assist target metabolic action to help prevent future stone episodes; if this information is not available, patient counselling may be limited in its ability to be particular. Patients may also be at an elevated risk for future stone occurrences if residual stone material is left behind at the time of initial stone treatment. Only 56% of patients required no intervention and remained asymptomatic when Chew and colleagues investigated the natural history of asymptomatic stone fragments left behind after URS. This was discovered by looking at the natural history of the stone fragments. Intervention was necessary in 29% of patients, and because there was a greater risk associated with larger fragments, the researchers came to the conclusion that being completely stone-free is the most effective way to limit the number of stone events that occur after ureteroscopy (71)

When reporting stone free outcomes for flexible ureteroscopic stone extraction, one must take into consideration stone free rates, imaging used to establish stone-free rates, as well as safety and cost. The concept of stone free is not established, and there is a large deal of variation across different pieces of research. According to the findings of several research, "stone free" refers to postoperative imaging that shows totally no calcifications. Other researchers consider patients to be "stone free" if they have fragments less than 2 millimeters, while others consider fragments smaller than 5 millimeters to be "stone free," arguing that such fragments are clinically inconsequential. Additionally, the timing of stone free determination is not consistent. It is debated whether the term "stone free" should be measured within days, weeks, or months of the treatment. This is due to the fact that fragments of stones may flow from the kidney for a length of time after ureteroscopic surgeries. ❑

CONCLUSION

Endourology is always being pushed forward by ongoing developments and equipment improvements as a direct result of the rising incidence and prevalence of stone disease. After lithotripsy procedures, bacterial germs typically nest within renal and ureteral calculi, causing fever and systemic inflammatory response syndrome, which can progress into a life-threatening condition called sepsis. This complication is linked to an increase in the amount of time needed for the operation, as well as an increase in the pressure placed on the renal pelvis and renal tissue damage. During lithotripsy, suctioning has been put through a variety of tests, including *in vivo* and *ex vivo* investigations as well as a number of clinical comparative and non-comparative research throughout the course of the past few years. Suctioning seems to offer higher SFR, less post-infectious complications, and faster stone disintegration time compared to other techniques, such as URS, mPCNL, and PCNL, which have been studied for different indications, such as renal stones 10 mm, 10–20 mm, 20–30 mm, ureteral stones, and impacted stones. The ability to monitor renal pelvic pressure and maintain it at safely low levels of 20–30 mm Hg, as well as the more efficient removal of stone gravel through suctioning, are the main proposed contributing factors for suctioning superiority. Suctioning also improves visualization by removing "stone storm" and bleeding during the procedure. RCTs with higher sample numbers are required in order to obtain safer conclusions and adopt suctioning devices into regular urological practice. This is because many of the studies are observational and not randomized.

In the field of stone lithotripsy, the TFL represents an innovative new technological setup. It possesses the characteristics of a little fibre in addition to the possibility of having low PE while maintaining a high frequency, which makes it possible to achieve potentially increased stone clearing. It has the potential to become the next 'gold standard,' thanks in large part to the presence of these essential characteristics. However, additional clinical data are required before its formal status in stone lithotripsy can be determined. This is a legitimate requirement. ❑

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