57 Ureteroscopy for Ureteric Stones

Gerhard J. Fuchs and Steven G. Koopman

Abstract

Endoscopic stone treatment technique and the use of extracorporeal shock wave lithotripsy have revolutionized the interventional management of ureteric stones. While extracorporeal shock wave lithotripsy is truly noninvasive in nature, complete freedom of stone and resolution of symptoms in one treatment session are not predictable; therefore, the minimally invasive endoscopic surgical approach—over time—has become more attractive to many urologic surgeons. In particular, the downsizing of the ureteroscopes and the development of flexible ureteroscopes have facilitated access to the entire course of the ureter. In addition, with the advent of the holmium laser technology, stone fragmentation and vaporization can be achieved in practically all cases. Newer data approximate the success in terms of freedom of stones and resolution of symptoms to almost 100 % over the entire course of the ureter. These techniques have proven safe, efficient, and reproducible and with adherence to detail complications can be kept to a minimum. In this chapter, we provide a comprehensive review of present techniques for interventional management of ureteric stones with detailed description of safe endoscopic treatment techniques.

Keywords

Ureteric stone diagnosis • Differential treatment of ureteric stones • Energy sources for ureteric stone fragmentation • Success rates of ureteric stone treatment • Complications of ureteric stone treatment

Introduction

Ureteroscopy for the management of ureteral stones in the entire course of the ureter is a well-established, minimally invasive, highly effective, outpatient procedure. In addition to stone treatment, ureteroscopy is employed for the diagnostic evaluation of unilateral upper tract bleeding, for further evaluation of radiological filling defects, as well as for management of ureteral and ureteropelvic junction strictures, urothelial tumors, and removal of migrated and encrusted stents [1–4]. Ureteroscopic surgery (URS) is safe and efficacious when performed on the appropriate patient, using the appropriate instrumentation with the appropriate technique.

In this chapter, we will give a step-by-step description of the technical aspects of successful ureteroscopic surgery for stone treatment in the ureter using rigid and flexible instrumentation and present a short review of the results, and management of complications.

G.J. Fuchs, M.D., FACS (✉) • S.G. Koopman, M.D.
Department of Surgery, Minimally Invasive Urology Institute, Cedars-Sinai Medical Center, 8635 West Third Street, Suite 1070, Los Angeles, CA, 90048, USA
e-mail: gerhard.fuchs@cshs.org

J.J. Talati et al. (eds.), *Urolithiasis*,
DOI 10.1007/978-1-4471-4387-1_57,

Indications

Ureteroscopic surgery can access the entire ureter. When rigid and flexible ureteroscopy are combined, a complete and thorough evaluation and treatment of the entire ureter and, if necessary, the kidney(s) can be achieved with minimal invasiveness [1–4]. The most common indication for ureteroscopic surgery is the treatment of stones in the course of the ureter with low likelihood for spontaneous passage. Alternative treatment such as extracorporeal shock wave lithotripsy (ESWL) and respective results are well covered in the literature [5]. Ureteroscopic stone surgery is safe, effective, and reliable for the treatment of ureteral stones and therefore in many institutions the first choice for most ureteral stones. The indications for ureteroscopy are listed in Table 57.1.

Ureteroscopic surgery can render the ureter stone-free in greater than 90 % of cases, regardless of stone size, stone composition, and stone location (Tables 57.2 and 57.3) [6–12, 15–20, 23]. Stone-free rates with ESWL on the contrary are highly variable, and individual outcomes can vary significantly as ESWL results are highly dependent on patient selection (body habitus, patient mobility) and stone characteristics (size, hardness, location, degree of impaction), choice of lithotripter (first vs. later generations), and selection of the time to intervene (stone embedded in edema) (see Tables 57.2 and 57.3) [8, 10, 11, 13–16, 21–23]. Acceptable results with SWL (greater than 80 % stone free, one treatment session) can be achieved for smaller stones (less than 7 mm) of calcium-dihydrate composition in the distal third of the ureter and short duration of stone location in the stone bed (lesser amount of edema) [13, 15, 16, 21–23]. Stone-free rates with calcium oxalate monohydrate and larger stones have significantly lower stone-free rates—especially when located in the proximal ureter—and higher rates of complications requiring secondary sessions and auxiliary procedures [5, 23, 24]. Both procedures are usually performed in an outpatient setting with anesthesia requirements ranging from oral pain management (piezoelectric lithotripter) over intravenous sedation (both) to general or epidural anesthesia (first-generation lithotripter, complex URS, proximal ureteral URS). Postoperative morbidity and energy-related injury for both procedures are low [5, 23–25]. After uretero-

Table 57.2 Results of URS versus ESWL for proximal ureteral stones

	Number of patients	Stone size mean (mm)	Stone-free rate (%)
Ureteroscopic treatment of proximal ureteral calculi <1 cm			
Fong et al. [6]	51	9.0	90
Krambeck et al. [7]	237	5.9	87
Salem [8]	59	6.8	100
Best and Nakada [9]	55	9.1	86
Ureteroscopic treatment of proximal ureteral calculi >1 cm			
Wu et al. [10]	39	15.1	92
Lee et al. [11]	20	18.5	35
Mugiya et al. [12]	54	20.4	87
Salem [8]	48	12.2	88
ESWL treatment of proximal ureteral calculi			
Wu et al. [10]	51	12.1	35
	68	6.9	85
Lee et al. [11]	21	18.5	64
Tiselius [13]	580	4.2	73
Ziaee et al. [14]	126	10–15	78
Salem [8]	42	12.5	60
	58	6.2	80

Table 57.1 Indications for ureteroscopic surgery (URS)

Stone disease
Primary treatment for all stones below crossing with iliac vessels
Failed ESWL procedures (especially proximal ureter)
Obstructive radiolucent stones (after failed medical therapy)
Concomitant ureteral and renal stones (when renal stone <1.0 cm)
Encrusted/calcified retained ureteral stents
Stones and urinary diversion (conduit)
Morbidly obese patients with ureteral stones
Patients with ureteral stones and coagulopathy
Aviation pilots (need to be free of stones)
Strictures
Strictures of ureter (shorter than 1 cm)
Strictures of ureteropelvic junction (with mild/moderate hydronephrosis)
Strictures of uretero-enteric anastomosis (ileum conduit)
Tumors
Tissue diagnosis and removal of select ureteral TCC (low grade, papillary)

Table 57.3 Results of URS versus ESWL for distal ureteral stones

	Number of patients	Stone size mean (mm)	Stone-free rate (%)
Ureteroscopic treatment of distal ureteral calculi <1 cm			
Pearle et al. [15]	32	6.4	91
Zeng et al. [16]	180	6–20	93
Aghamir et al. [17]	247	<10	96
Sozen et al. [18]	464	8.8	95
Krambeck et al. [7]	342	5.9	94
Ureteroscopic treatment of distal ureteral calculi >1 cm			
Sofer et al. [19]	348	10.3	99
Zeng et al. [16]	180	6–20	93
Elashry et al. [20]	3,542	10.9	97
ESWL treatment of distal ureteral calculi			
Pearle et al. [15]	32	7.4	91
Zeng et al. [16]	210	5–21	78
Hochreiter et al. [22]	518	9	91
Tiselius [13]	580	4.2	83

scopic surgery patient discomfort is related to the commonly used indwelling ureteral stent, and in the ESWL patients the episodes of obstruction with stone colic and need for secondary procedures are rather common problems [5, 23].

Contraindications

Ureteroscopic surgery for ureteral stone is absolutely contraindicated in the presence of an active urinary tract infection (UTI). Even if the urine cultures from the bladder are negatives, the appearance of purulent urine from above the stone should be an indication to abort the procedure with placement of a ureteral stent; otherwise, septic complications are likely. After drainage and appropriate antibiotic treatment, a second-stage URS procedure can be performed once sterile urine has been confirmed. URS may be relatively contraindicated in pregnancy and anticoagulation, with complex anatomical variations, and in patients with poor medical status. In these patients, the use of URS, on a case-by-case selection, can be successful without increasing the risk of complications. The use of URS with lithotripsy has been shown to be safe and efficacious during pregnancy [26, 27], but its use has not gained wide acceptance and therefore has remained listed as a relative contraindication (Table 57.4). Likewise, URS with a direct contact laser energy source (holmium or thulium laser) can be performed safely and successfully on the anticoagulated patient, whereas the risk of bleeding increases when other energy sources such as ultrasound or the pneumatic lithoclast are employed. By optimizing the patient's medical condition and lowering anesthesia risk (IV sedation, local anesthesia), patients who have poor performance and medical status may be treated safely with ureteroscopic surgery techniques (see Table 57.4) [28].

Table 57.4 Contraindications for ureteroscopic surgery (URS)

Infection of urinary tract:
Absolute: Untreated urinary tract infection (UTI)
Treat according to C&S with antibiotics for 10 days
If obstruction, start antibiotic and manage obstruction with ureteral stent or PCN tube
Caution: Infection stone or history of UTIs
Pretreat with broad-spectrum abx for 10 days even if culture negative
Pregnancy: Anesthesia and obstetric monitoring, radiation exposure
Coagulopathy and anticoagulation:
Relative: Preferred management to correct coagulopathy if medically safe
Relative: Untreated coagulopathy
Cautious treatment with direct contact laser (holmium, thulium)
Use access sheath to reduce bleeding (prostate, frequent passage up/down ureter)

Instrumentation

The success of ureteroscopic surgery depends on the surgeon's skill and the availability of ureteroscopes, working instruments, accessories, and energy sources. Instrument manufacturers have developed their own ureteroscope design and offer endoscopic camera systems and various accessories [29]. Endoscopic camera systems are now routinely used to facilitate surgery (ergonomic and safety aspects for surgeon, increased team involvement through visualization). Basically, all scopes are similar in design and well suited for ureteroscopic surgery. The differences lie in the outer diameter, length, eyepiece position, and the number and size of working channels. Most ureteroscopes come in two different lengths. The shorter scopes (31–34 cm) are ideal for distal pathology that is below the iliac vessels; above this point we prefer to use the longer scopes (41–43 cm), which reach the proximal ureter and commonly the renal pelvis as well. Both lengths of the semirigid scopes and a flexible ureteroscope should be available at the time of surgery.

Different wires, stone retrieval devices, ureteral catheters, and stents are essential when planning URS. Wires for urologic procedures vary in diameter, length, and composition. Diameter varies from 0.025 in. (0.64 mm) to 0.038 in. (0.97 mm). Lengths are available ranging from 80 to 260 cm. The usual length for ureteroscopic work is 145–150 cm. The outer coating can be Teflon, polytetrafluoroethylene (PTFE), or hydrophilic polymer. Most wires have a soft tip with an angled, J-shaped, or straight tip. We prefer Teflon-coated, straight tip, 0.038 wires with a length of about 150 cm. These wires are atraumatic yet fairly inexpensive and sturdy (floppy tip and stiff body), and do not readily slip out of the ureter. When a tight stricture (narrow stone bed) or a tortuous ureter is encountered and the regular Teflon wire cannot negotiate its way past, a hydrophilic-coated wire, like a glidewire, may be helpful to bypass those areas. As soon as access to the kidney is achieved with a hydrophilic-type wire, it should be exchanged for a regular Teflon-coated wire. By advancing the angiographic catheter above the obstruction first, it is assured that the wire will be in the correct position. If this maneuver is omitted, wire slippage out of the ureter may occur, thus losing an already established difficult access to the ureter and kidney.

Ureteral dilators for sequential, coaxial, or balloon dilation are frequently used to facilitate access for URS to the upper tract [30]. Ureteral dilation should always be performed over a second guidewire to avoid losing the safety wire in an already tenuous situation. Overaggressive dilation against resistance may result in ureteral tears and subsequent submucosal passage of a "blindly" placed guidewire with the risk of more severe ureteral damage if an instrument is advanced over such a wire; it is advisable to use a coaxial access sheath for placement of a second wire (assures correct position) and then dilate over the second wire. Serial Teflon or coaxial Teflon dilators (inexpensive) or balloon dilators (expensive) may be used to facilitate access in difficult situations [5, 30]. Hydrophilic ureteral access sheaths, cobra catheters, coaxial introductory sheets, and Zebra or Amplatz super stiff wires are all important and useful tools to gain access to the ureter, but in our experience this is rarely needed.

Technique of Rigid Ureteroscopy

Rigid ureteroscopy of the upper urinary tract is a well-established procedure. With adherence to proper guidelines and following a step-by-step approach, access to the upper tract and successful treatment can be accomplished in the vast majority of patients with minimal morbidity and very few complications.

Preoperative Preparation

Immediate preoperative preparation includes confirmation of a sterile urine sample within 5 days of surgery, start of intravenous hydration in the preoperative area, and administration of perioperative antibiotic coverage (e.g., 1 dose of ampicillin and gentamicin). If the treatment is for stone disease or the patient has an indwelling stent, immediate preoperative imaging with a plain abdominal X-ray or fluoroscopy will confirm the patient's status. The patient then undergoes anesthesia (Table 57.5).

Anesthesia for URS

The choice of anesthesia may vary with the location of the stone, the patient's sex, and general medical condition. While general or epidural anesthesia is frequently the anesthesia of choice, intravenous sedation may well suffice for a distal ureteral stone, or in a female patient, or when dictated by the patient's medical status. Occasionally, a small retained stone in a stented patient can be removed in the office setting with topical anesthesia (Xylocaine jelly) to the urethra only.

Table 57.5 Patient preparation for ureteroscopic surgery (URS)

Patient selection (see Tables 57.1 and 57.2) and informed consent
Medical clearance for anesthesia and optimization of comorbidity
Sterile urine (negative C&S)
Preoperative PO antibiotics, if positive C&S or history of UTIs
IV hydration (>100 cc/h)
IV perioperative antibiotics (e.g., ampicillin + gentamicin)
KUB (for stones <1.0 cm to r/o spontaneous passage)
General anesthesia (regional, IV sedation, or local optional)

The patient is positioned in the low lithotomy position (cave: proper padding of pressure point areas). Modifications of positioning such as ipsilateral leg extension or patient rotation are not necessary or helpful in a patient with normal body habitus.

Access to the Ureter

The first procedural step is a cystoscopy (21 Fr. rigid or 15 Fr. flexible [in males, when IV sedation is used]) with inspection of the bladder and a retrograde pyelogram under fluoroscopic control (5-Fr. straight angiocatheter and floppy-tipped 0.038 Bentson guidewire) to assess the technical complexity of the case by delineating the course of the ureter [31]. Then, the Bentson wire is advanced up the ureter and into the kidney to serve as a safety wire. Placement of a safety wire is one of the essential steps for assuring success and reducing the risks of iatrogenic damage of ureteroscopic instrumentation. Once the safety wire has been advanced past the obstructing ureteral stone and into the kidney, the patient receives 20 mg of furosemide (weight adjusted; 0.25 mg/kg) to induce diuresis and reduce the risk of pyelorenal reflux and infectious complications (Table 57.6). Technical difficulty with safety wire placement can be encountered at the level of the intramural ureter (impacted stone, stricture, ureterocele, reimplanted ureter, tumor, large prostate middle lobe, female bladder descensus), or the level of an impacted stone, or by ureteral tortuosity. Iatrogenic damage of the ureteral mucosa in the intramural ureter should be consistently avoided with the use of a floppy-tipped Bentson wire and the angiographic catheter. If the guidewire cannot negotiate the intramural ureter, the next step is the use of a hydrophilic glidewire (straight or angled), which often will allow advancement well into the ureter. Before further manipulation is undertaken, one needs to confirm that the wire is correctly positioned in the ureter by advancing the angiographic catheter beyond the narrow segment, removing the wire, and observing for obstructive urine drip from the angiographic catheter; a small amount of dilute contrast is helpful to delineate the course of the ureter and confirm the correct position when no urine is seen. Note that if there is any indication of infected urine draining from the previously obstructed upper tract, the treatment should be terminated with placement of an indwelling stent, the urine sampled and cultured, and treatment of the ureteral pathology postponed until confirmation of sterile urine.

Provided the correct position of the angiocatheter is confirmed and there is no sign for infected urine from the obstructed upper tract, a regular Bentson wire is placed and advanced to the kidney (mind that the glidewire is a specialty wire and is only used for overcoming difficulty in access; it is best replaced as soon as proper access is established, for otherwise the risk of loss of access is likely). If a glidewire

Table 57.6 Essential procedural steps of ureteroscopic surgery (URS)

Steps	Goal	Execution	Equipment used
1	Evaluate bladder	Cystoscopy	Fluoroscopy X-ray table
	Assess upper tract anatomy for treatment planning	Retrograde pyelogram under fluoroscopic control	19- to 21-Fr. cystoscope
	Place safety guidewire		5-Fr. straight angiocatheter
			0.038 Bentson guidewire
2	Establish access to ureter	Optical dilation of ureter (working and safety wire in 6 and 12 o'clock position)	9.5-Fr. semirigid ureteroscope
			Second guidewire
3	Treat stone	Stone fragmentation and stone retrieval	Holmium/thulium laser
			Stone baskets/graspers
			Access sheath (optional)
4A	Treat stone (special situations)	Consider hydrophilic glidewire for safe passage of safety wire	Hydrophilic glidewire (straight and angle tip)
	Impacted stone	If wire cannot bypass stone, cautiously fragment stone until enough space created for guidewire passage	
		Exchange glidewire as soon as stone has been bypassed	
4B	Treat stone (special situations)	Advance the fulcrum; use angiographic catheter and guide- or glidewire to negotiate tortuosity	5-Fr. angiographic catheter
	Tortuous ureter below or above stone		5-Fr. angle-tip catheter
			Hydrophilic wire
4C	Treat stone (special situations)	Establish safety wire, see 4A, 4B	Holmium/thulium laser (possible ESWL combo)
	Steinstrasse	Consider use of energy source to fragment or dislodge impacted stone gravel	Hydrophilic glidewire
			Zero-tip nitinol basket
5	Safe exit from upper tract	Place indwelling ureteral drainage stent over safety wire	6/7-Fr. ureteral double pigtail stent

through the stabilizing angiocatheter will not advance, then the 9.5-Fr. semirigid ureteroscope is cautiously advanced into the intramural ureter. Under direct endoscopic control a guide- or glidewire can then often be successfully placed. In the very few cases where this may not be feasible (<2 %, authors' experience), careful fragmentation of an intramural stone until such time that a safety wire can be placed may be attempted. If this does not allow access or is deemed too dangerous, placement of a percutaneous drainage tube and subsequent percutaneous antegrade surgery is preferred. If the safety wire passes through the intramural ureter but cannot be advanced past a higher ureteral pathology, the first salvage step is the use of the angiocatheter to provide fulcrum for better wire manipulation. The angiocatheter is advanced to within 1/2 in. of the obstacle and then wire manipulation is again attempted. This being successful, the same procedural steps as previously described are followed to confirm correct position of the wire. If the regular wire does not negotiate the obstacle, a specialty glidewire (straight or angled) is utilized. Ureteroscopy up to the obstacle and manipulation of a wire under direct endoscopic control (but without the benefit of a safety wire) obviously is more risky but in experienced hands often successful and avoids the next level of invasiveness—the placement of a percutaneous access. If ureteral tortuosity is encountered, the combination of an angiographic catheter (advancing the fulcrum) and guide/glidewire will usually allow successful negotiation of the obstacle and placement of a safety wire. Advancing the angiographic catheter over the guidewire all the way up to the kidney oftentimes will straighten out the ureter. For placement of a working wire, a coaxial sheath (7 and 11 Fr.) or a dual guidewire introductory catheter is best used to assure correct position. If an impacted stone is located within a ureteral kink or right above a ureteral kink, safe manipulation of a guidewire may not be possible. In such rare cases, placement of a percutaneous drainage tube will drain the obstructed kidney and straighten the course of the ureter in a matter of 10 days. Then, retrograde ureteroscopic surgery will be most likely feasible; otherwise, percutaneous antegrade ureteroscopy can be performed after dilating the percutaneous access.

Once a safety wire is placed into the kidney, ureteroscopic access to the ureter is the next procedural step. Ureteroscopic access to the ureter using the ureteroscope as "optical dilator" with a 9.5-Fr. instrument is technically feasible in 97 % of cases (author's experience) without additional formal dilation of the intramural ureter or higher ureteral segments. In a female patient, the instrument often can be directly advanced alongside the safety wire. In the male patient, the use of a second wire (working wire) through the work channel of the instrument will allow proper access. It is helpful to turn the scope clockwise and counterclockwise until the working wire (resting against the base of the orifice in the 6 o'clock position) and the safety wire (against the roof of the orifice in the 12 o'clock position) form an inverted V. This alignment of the guidewires will then allow the gradual advancement of the scope through the intramural and into the pelvic ureter. Note that the "real" narrowing is the junction from the intramural to the pelvic ureter not the orifice per se. In select complex cases where advancement of the scope is not possible (pelvic surgery, radiation, extrinsic compression, young muscular males, large prostate middle lobes, large cystoceles), placement of an indwelling stent is preferable over dilation of the orifice for it will allow easier and safe instrumentation in the entire ureter usually after 10–14 days. Scopes with smaller distal tip designs (6–7.5 Fr.) are of no advantage over the 9.5-Fr. bevel type instrument design. As a matter of fact, the square distal tip of many of these scopes is potentially more dangerous, and these instruments are best used over a guidewire. If the surgeon decides on dilating the ureteral orifice (or higher ureteral segments), a variety of methods are available. Natural caveats are not to dilate adjacent to a stone (risk of intramural or ureteral perforation) and to use a separate working wire and not the safety wire for placement of serial dilators or a balloon dilator. The intramural ureter "tolerates" dilation up to 30 Fr., which in reality will rarely be necessary since 12- to 15-Fr. dilation or "optical dilation" usually suffices.

Advancement of the scope should always be done under continuous visualization of the ureter. If difficulty is encountered (edema, tortuosity, relative narrowing), the use of a working wire is helpful. If visualization is impaired and safe advancement therefore not possible, placement of an indwelling stent and return to surgery in 10–14 days will avoid risks of iatrogenic damage and greatly facilitate the procedure and usually result in successful completion. Hydration pumps or other means of raising the pressure of irrigant are usually not helpful in negotiating the difficult ureter. On the contrary, there is increased risk of fluid overload, forniceal rupture with extravasation, and infectious complications (pyelorenal reflux).

Treatment of Ureteral Stone(s)

The goal of ureteroscopic surgery for the management of ureteral stone(s) is to render the ureter free of stone in a minimally invasive fashion in one outpatient treatment session. Once the stone is endoscopically approached, the next step is the choice of the appropriate means for stone removal, i.e., for intact removal with a basket or grasper or for fragmentation with an energy source (laser, pneumatic, ultrasound, electrohydraulic) [32, 33]. Stone size, degree of impaction, and ureteral anatomy will determine the mode of stone removal. Stones that can be positioned into a wide enough ureteral segment to be grasped with a 2-prong rigid 4.7-Fr. forceps can either be removed intact (usually size less than 4 mm, e.g., Steinstrasse or residual gravel in patients with previous ureteral stent) or mechanically fragmented using the forceps (calcium oxalate dihydrate) and then removed. Although nitinol baskets are most commonly used for ureteral stone retrieval, the use of the rigid forceps has several advantages in that it can cheaply fragment stones (calcium oxalate dihydrate, struvite, uric acid) as no energy source is needed. The grasper will avoid getting "stuck" with the stone above a narrow ureteral segment as might happen when a stone is trapped in a basket, and it is reusable (no extra cost). The rigid forceps necessitate the use of an ureteroscope with an offset lens and straight work channel of appropriate sizes (9.5 Fr. with 5-Fr. work channel).

If the stone is too large for intact removal, fragmentation with any of the energy sources is performed. Holmium laser energy is most popular for its efficient stone fragmentation regardless of stone composition and stone debulking capabilities (vaporization). Alternative, less expensive energy sources such as the pneumatic lithotrites, electrohydraulic energy, and ultrasound energy are not only less effective but also require somewhat more technical skills to overcome their inherent technical limitations (insufficient breakage of stone, upward migration of the stone, mild bleeding from energy delivery). Before fragmenting an impacted stone, it is always advisable to obtain a contrast imaging study to assess the degree of surrounding edema and to be forewarned if there is ureteral tortuosity involving the stone bed (increased risk of ureteral damage and perforation). If the ureter is dilated above the stone (which is usually the case) and the stone is not impacted (no significant narrowing and edema at the stone site), it is helpful to carefully dislodge the stone from the stone bed into the dilated portion of the ureter for there it can be handled easier (fragmentation and use of the rigid forceps). Using Holmium laser energy (5–10 W), any stone (regardless of composition) is readily fragmented and vaporized. The resultant gravel (any pieces larger than 2 mm as compared to the 1-mm size of the safety wire) is removed from the ureter using either a rigid forceps or any of the baskets. In male patients, we usually deposit the gravel in the bladder so as to avoid numerous passages through the urethra. With the use of baskets, one needs to be careful not to take larger stone pieces since negotiating a stone out of the basket in the ureter is technically difficult and may not be feasible, resulting in a "stuck" basket. If a basket gets "stuck" above a narrow ureteral segment (e.g., iliac vessel crossing, intramural ureter), no attempt should be made to pull forcefully (due to risk of ureteral avulsion).

The instrument should be withdrawn leaving the basket in place. If the stone gets "stuck" in the distal third of the ureter, the scope can be withdrawn and positioned outside the patient while leaving the basket intact. A second scope is then advanced into the ureter, and the stone is fragmented with careful avoidance of damaging/cutting the wires (pneumatic or ultrasound energy are safe; Holmium and electrohydraulic lithotripter [EHL] may cut the wires). Once the stone is fragmented sufficiently, the basket and stone gravel are removed from the ureter; provided the basket withstood the salvage maneuver, it can be used for the remainder of the case. If the basket is "stuck" higher up in the ureter, it has to be dismantled or cut to allow complete withdrawal of the ureteroscope. The same salvage maneuver is utilized, albeit at the expense of needing an additional basket to complete stone retrieval. Upward migration of a stone or stone pieces is not considered a complication unless the surgeon is not prepared to retrieve the pieces from the upper ureter or renal collecting system by having the appropriate instrumentation available (flexible ureteroscope) for retrograde intrarenal surgery.

Steinstrasse

Steinstrasse after ESWL is a complex ureteral stone scenario (ureter packed with stone gravel, encased in edema) and one of the challenges of ureteroscopic surgery. In these cases, even the passage of a safety wire may become a formidable task. For placement of a safety wire, the same maneuver for advancing the fulcrum—angiocatheter and guide- or glidewire—is successful as in the manipulation of a ureteral tortuosity. Length of the Steinstrasse and degree of stone impaction and surrounding edema will determine the complexity of the ureteroscopic procedure. A ureteral stent when already in place should not be removed before a safety wire is well established in the renal collecting system. When the ureter is tightly packed with stone gravel, it may not be possible to safely engage pieces with a basket or grasper. In those instances, the impacted gravel can be loosened using a direct contact energy source (holmium, ultrasound, or pneumatic). The cautious use of a direct contact energy source can fragment larger pieces and separate impacted gravel; EHL is not recommended in this setting because of the stone bed usually being edematous, and release of EHL energy will result in mild bleeding making the procedure technically more challenging with increased risk of ureteral injury. For removal of the dislodged pieces, the use of a 4-wire tipless basket (nitinol) is helpful. The basket is used like a parachute with the wires left open to separate the gravel until safe engagement of pieces small enough for retrieval can be ascertained. If stone impaction is very tight with copious edema and no stent is present, placement of an indwelling ureteral stent for 2 weeks will drain the kidney and passively dilate the ureter thus greatly facilitating the task of successful stone retrieval.

For the management of extensive Steinstrasse, use of a ureteral access sheath is often helpful, especially for proximal ureteral involvement. An access sheath placed below the level of the stone impaction in conjunction with a flexible ureteroscope and a holmium laser may expeditiously clear such a ureter. Also, with large amounts of gravel in the proximal ureter and additional renal stone burden, a combined retrograde/antegrade (percutaneous) approach should be considered in the interest of expeditious resolution of the situation.

Ureteroscopic Surgery in Patients with Skeletal Abnormalities

Patients with severe skeletal abnormalities may not be physically able to be positioned in low lithotomy position, the traditional position for URS. In most cases, ureteroscopic surgery can be successfully performed with the use of flexible scopes and occasionally using ultrasound instead of X-ray for stent position verification.

Ureteroscopic Surgery in Patients with Upper Tract Reconstruction

Patients with upper urinary tract reconstruction or urinary diversion may develop stones secondary to chronic UTI and/or reflux of infected urine. The conduit or neobladder reconstruction can usually be navigated with a flexible cystoscope for identification of the ureteral anastomosis and guidewire access. Initially all mucous should be evacuated from the conduit or continent pouch. Fluoroscopic evaluation with injection of contrast and use of a guidewire (contained in a 5-Fr. angiocatheter for advancing the fulcrum) can both be helpful when the bowel reservoir is tortuous. If the ureterointestinal anastomoses are of the refluxing type, fluoroscopy with contrast injection usually allows identification of the anastomoses (unless the anastomosis is obstructed by a stone or stricture). It is often helpful to have some knowledge of the implantation method that was used (Wallace type vs. single ureter anastomosis) and the topographical location of the anastomoses. When fluoroscopy with contrast does not identify the location of the anastomoses, we carefully search for sessile well-circumscribed areas in the reservoir/conduit wall, using a floppy-tipped guidewire to gently probe these areas. Administration of IV methylene blue can also be useful in directing the endoscopist to the area of upper tract access. Once identified, the ureteral orifice should be cannulated with a safety wire preloaded in a 5-Fr. angiocatheter. The wire should then be advanced under fluoroscopic control and coiled in the kidney prior to advancing the angiocatheter up the ureter. Contrast is then injected to define the upper tract anatomy. The hydrophilic glidewire is then exchanged for a regular Bentson type wire, and a coaxial access catheter set should then be used to place a second (working) wire. An access sheath will facilitate reaccess to the upper tract and reduce the risk of losing access in a tenuous situation. URS treatment of ureter stones should follow the principles previously described in this chapter. Frequently, a hydroureter is encountered, and upward migration of ureteral stone into the kidney is more common than in a regular ureter. Since most URS instrumentation in these patients is by use of flexible ureterorenoscopes, access to the kidney and treatment of those stones should not unduly complicate the treatment.

Ureteral Healing

Diagnostic ureteroscopy and ureteroscopic surgery are minimally invasive procedures. Patients undergoing a diagnostic procedure with a flexible instrument do well without stenting, while patients undergoing ureteral surgery usually do better with an indwelling stent [4, 34].

Although new controversy surrounds the routine use of stenting after uncomplicated ureteroscopic surgery for stone removal without the need for dilation of the orifice, we believe that most patients treated at a tertiary center for more complex stone scenarios fare better with an indwelling stent [4, 37]. After treatment of ureteral stones with uncomplicated access to the ureter, a small stone burden, without significant edema at the stone bed, and without gross hydronephrosis, a stent does not necessarily need to be placed. However, in our experience, we mostly encounter patients with larger stones, impacted stones, patients after failed previous treatment attempts, and with other complicating factors, and we therefore advocate the use of an indwelling stent for such patients. An indwelling time of 3–14 days (depending on the amount of edema) will invariably result in resolution of edema and hydronephrosis and after stent removal morbidity is minimal.

Postoperative Care

After surgery, the patient is recovered in the outpatient area. The Foley catheter is removed, and the patient discharged as soon as fully recovered from anesthesia and tolerating oral fluids and, if necessary, oral pain medication. Discharge medications are usually pyridium 100 mg TID for 5 days and Darvocet N-100 PRN; if a stent remains indwelling, we also prescribe Flomax 0.4 mg qhs during the indwelling time. Antibiotics are not routinely given. If treatment is performed on what appears to be an infection-induced stone, urine and stone is sampled for culture and sensitivity testing at the conclusion of the procedure, and oral antibiotics are given for 5 days. Patients return to clinic for a physical examination after between 3 and 14 days depending on the determination of the length of ureteral stenting. A physical examination is performed, and once a renal ultrasound confirms a normal kidney without residual hydronephrosis, the indwelling stent is removed under topical urethral anesthesia.

Complications of Ureteroscopic Surgery

Prevention

Complications of ureteroscopic surgery overall are exceedingly rare with strict adherence to safe surgery guidelines. Medically, urinary tract infection with symptoms ranging from mild postoperative temperature elevation to full septic complications (very rare) can be encountered. Potential surgical complications of ureteroscopic surgery include damage to the ureteral orifice, upper urinary tract perforation, and postoperative ureteral stricture.

Awareness of preoperative positive urine culture results with appropriate antibiotic treatment, the use of perioperative antimicrobial agents, and maintaining low pressures within the upper urinary tract during URS will help to reduce infectious complications to a minimum. As described earlier in this chapter, the routine use of a loop diuretic and avoidance of pressurized fluid flow will help to keep upper tract pressure low. Furthermore, use of a ureteral access sheath—especially for prolonged cases of stones in the proximal ureter—will also help to reduce intraoperative renal pelvis pressure and the risk of infectious complications.

Damage to the urinary tract can best be prevented by always visualizing the action of the ureteroscope, accessory instruments, and energy sources—avoiding blunt damage to the ureter, either by the scope itself or by the sharp tips of instruments and accessories (guidewires, baskets, and graspers) passed through the scope working channel. In addition, lithotripsy energy sources should never be activated unless the stone, the fiber/probe, and the ureteral wall are directly visualized. Always maintaining a safety wire access to the kidney will help in the management of URS complications; should one occur.

Table 57.7 Technical complications of ureteroscopic surgery and management

Complications (medical)	Prevention and management
Acute urinary retention	Avoid overdistention of bladder intraoperatively
	Voiding trial for male patients with large prostates
Infection	
Bacteremia, sepsis	Sterile urine preoperative, perioperative, IV antibiotics sterile technique, drainage (stent or PCN)
Urethritis, prostatitis, cystitis	Antibiotics and symptomatic (antispasmodic)
Periureteral fluid collection (extravasation)	
Hematoma (sterile/infected)	Observe (sterile); PCN – drain (infected)
Irrigation fluid	Observe (sterile); PCN – drain (infected)
Positional	
Nerve damage	Proper positioning and cushioning
	Evaluate, physical therapy
DVT (deep vein thrombosis)	Proper positioning and cushioning, pulsatile stockings
	Medical treatment

Table 57.8 Medical complications of ureteroscopic surgery and management

Complications (technical)	Management
Ureteral injury	
Mucosal tear with/without extravasation	Drainage (1. stent; 2. stent + Foley 3. stent + Foley + PCN)
False passage (guidewire)	Endoscopically correct guidewire placement and stent for 2 weeks
Perforation (with extravasation), false passage	Drainage with stent (safety wire!!), check with US/CT, PCN drainage of urinoma/hematoma
Ureteral bleeding (from scope or energy source)	Observe, mostly will cease unless perforation or damage of large, adjacent vessel
Ureteral intussusception/avulsion	Laparoscopic or open surgery required
Damage to adjacent structures (vessels, bowel)	Open surgery likely required

Management of Complications of Ureteroscopic Surgery

Sepsis complications can be severe, especially after treatment of infectious stones. If patients exhibit signs or symptoms of sepsis (high temperature, elevated white count, tachycardia, hypotension), they should be closely monitored and treated with broad-spectrum antimicrobial agents. Appropriate intravenous access should be in place, as blood pressure support and intensive care management may be required.

If bleeding from the use of an energy source or instrumentation occurs and vision is impaired, termination of the procedure with placement of an indwelling ureteral stent is the best course of action. Occasionally, a discreet bleeder can be identified and coagulated with the holmium (defocused beam) or Nd:YAG laser, but more commonly bleeding is more of a generalized oozing nature involving edema in the stone bed and will self-terminate in short order after placement of an indwelling stent. A second look for completion of the procedure can usually be safely performed within 7–10 days. Breech of the integrity of the ureteral wall (perforation) rarely occurs. In such instances, the area of perforation should be examined either with fluoroscopy and contrast injection of endoscopically.

In most situations, placement of an indwelling ureteral stent will allow the injury to heal, and the urologist can return at a later date to reassess the damaged area and complete the surgery. Severe injury, such as a circumferential ureteral tear, may require urgent operative intervention (Tables 57.7 and 57.8) [35–37].

Conclusion

In general, all stones in the ureter can be removed endoscopically regardless of size, composition, or complicating anatomical factors. Even in the setting of a tertiary care referral center, less than 4 % of patients need a second session, and less than 4 % need a combination with percutaneous antegrade techniques to achieve stone-free status. In more than 3,500 consecutive cases, there has been no incident of ureteral stricture or iatrogenic ureteral damage necessitating further action (authors' experience).

Ureteroscopic surgery with rigid and flexible instrumentation is a highly successful, minimally invasive treatment modality for patients with a variety of ureteral pathology. The indications are well established in particular for patients with stones in the entire course of the ureter. With the evolution of the ureteroscopic surgical technique and advances in instrumentation over the past 30 years as well as the advances in flexible ureteroscopy as an adjunct to the semirigid instruments, ureteroscopic surgery has become one of the essential surgical skills for any successful urologist. The surgical techniques can be easily learned, and the results are reproducible with a low rate of intra- and perioperative surgical complications.

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