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Endoscopic Management of Ureteral Strictures: an Update

Jacob W. Lucas [1] · Eric Ghiraldi [1] · Jeffrey Ellis [1] · Justin I. Friedlander [1,2]

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Abstract

Purpose of Review This review focuses on the role of endoscopic treatment of ureteral stricture disease (USD) in the era of minimally invasive surgery.

Recent Findings There is a relative paucity of recent literature regarding the endoscopic treatment of USD. Laser endopyelotomy and balloon dilation are associated with good outcomes in treatment-naïve patients with short (< 2 cm), non-ischemic, benign ureteral strictures with a functional renal unit. If stricture recurs, repetitive dilation and laser endopyleotomy is not recommended, as success rates are low in this scenario. Patients with low-complexity ureteroenteric strictures and transplant strictures may benefit from endoscopic treatment options, although formal reconstruction offers higher rates of success.

Summary Formal ureteral reconstruction remains the gold-standard treatment for ureteral stricture disease as it is associated with higher rates of complete resolution. However, in carefully selected patients, endoscopic treatment modalities provide a low-cost, low-morbidity alternative.

Keywords Ureteral stricture · Endoscopy · Balloon dilation · Laser · Stents

Introduction

Ureteral stricture disease (USD) represents a somewhat rare, but increasingly common urologic condition with a wide-variety of causes and a wide-range of management options. In evaluating USD, it is helpful to classify as extrinsic or intrinsic as this may help guide optimal management.

Extrinsic ureteral strictures may be caused by any number of abdominopelvic malignancies (colorectal, gynecologic, hematologic, retroperitoneal, or urologic), primary or secondary retroperitoneal fibrosis (RPF), and mass effect from large-vessel aneurysms, trauma, or iatrogenic injury. Intrinsic ureteral strictures may be caused by ureterolithiasis, radiation, ureteral malignancy, or iatrogenic injury from surgery. The incidence of USD varies by cause, but can be seen in 1% of patients' post-ureteroscopy, 5–24% with stone impaction greater than 2 months, 2–3% post-radiation, 1.4–15% in ureterointestinal anastomoses, and 3–8% post renal transplantation [1–3].

Patients with USD may or may not be symptomatic depending on both the degree of obstruction and the chronicity of the stricture. Symptomatic patients may experience ipsilateral flank pain, nausea, vomiting, hematuria, urinary tract infections, or urinary calculi. Diagnosis is made by history, physical examination, and basic laboratory tests (metabolic panel, urinalysis, urine culture), as well as any number of imaging techniques. Depending on clinical scenario, clinicians may opt to use computed tomography-urography (CT-U), magnetic resonance-urography (MR-U), diuretic renal scintigraphy, or antegrade/retrograde urography. Diuretic renal scan, most commonly with 99^{m}Tc-MAG3, and MR-U confer the advantage of identifying both renal function and

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✉ Justin I. Friedlander
Friedlaj@einstein.edu

Jacob W. Lucas
lucasjac@einstein.edu

Eric Ghiraldi
ghiralde@einstein.edu

Jeffrey Ellis
ellisjef@einstein.edu

1 Department of Urology, Einstein Healthcare Network, 1200 Tabor Road, 3rd Floor Sley Building, Philadelphia, PA 19141, USA

2 Division of Urology and Urologic Oncology, Temple Health and the Fox Chase Cancer Center, Philadelphia, PA, USA

degree of obstruction, which is an important aspect for surgical planning, especially if endoscopic management will be attempted. Typically, T½ greater than 20 min has been used as a cutoff to define obstruction, although renal function, patient hydration, and bladder dysfunction may significantly alter excretory times. It is often recommended to insert a urethral catheter for the duration of the exam to eliminate any potential interference from bladder outlet obstruction or bladder dysfunction.

Although the use of ureteroscopy has increased exponentially in the last two decades and has increased the number of tools in the urologists' armamentarium, endoscopic management of ureteral strictures should be used only in select cases. Whether a clinician chooses balloon dilation, endoureterotomy, or both, there are numerous factors to consider which may affect functional success: anatomic location, stricture length and etiology, incisional length and depth, dilation duration and pressure, stent duration and size, and preoperative renal function. In this review, we aim to discuss the technical aspects and contemporary outcomes of the endoscopic management options for ureteral stricture disease in the era of minimally invasive surgery.

Endoscopic Management of Ureteral Stricture Disease

Balloon Dilation

Two oft-used modalities for ureteral strictures are balloon dilation and endoureterotomy, which are frequently used in-concert. There are several commonly used devices for balloon dilation available in the USA: UroMax Ultra High Pressure balloon (Boston Scientific, Boston, MA, USA), Balloon Ureteral Dilator (Cook Medical, Bloomington, IN, USA), the Uroforce Balloon Dilation Catheter (Bard Medical, Covington, GA, USA), and the Acucise device (Applied Medical, Rancho Santa Margarita, CA, USA). These dilators are sold with a wide-variety of catheter lengths, catheter diameters, and balloon diameters, making them suitable for strictures of various lengths, thickness, and locations.

Byun and colleagues performed a prospective series assessing outcomes of retrograde balloon dilation in both benign and malignant ureteral strictures in 37 patients [4]. In their series, they used Uromax balloon to perform dilation for 5–10 min under various pressures (2–18 ATM) with a 7-French stent for 3 weeks post-operatively. Success, as defined radiographically and symptomatically, was seen in 57% of benign strictures and 14% of malignant strictures at 36 months of follow-up. Importantly, there was a 0% success rate in strictures longer than 2 cm. This study highlights several important characteristics of balloon dilation that are echoed by numerous other series: balloon dilation appears to be most successful in short (< 2 cm), benign, and non-ischemic ureteral strictures [5–8]. Interestingly, this particular study did not see association between stricture location and success rates; this is in contrast to numerous other studies which found location in mid-ureter to be associated with higher rates of failure [9]. Overall, successful treatment of ureteral strictures with balloon dilation appears to be in the range of 33–100% amongst all populations [9, 10].

Amongst the literature pertaining to balloon dilation of ureteral strictures, there is a high-degree of heterogeneity regarding the optimal balloon diameter and the pressure used, as well as the duration of dilation. Corcoran et al. performed balloon dilation for benign ureteral strictures using UroMax balloon with 15-Fr outer diameter with pressures of 12–14 atmospheres (ATM) for a time period of 4–10 min [11]. In their cohort, close to 85% of patients with strictures shorter than 2 cm were treated successfully. In the same vein, Richter and colleagues utilized a 4–6 mm diameter balloon and dilated at pressure of 2 ATM for 90 s with success noted in 89% of short-segment strictures with intact vascular supply [12]. Not surprisingly, dilation of long-segment strictures (> 2 cm) in this cohort yielded dismal results with 38 and 17% success in strictures with intact and compromised vascular supply, respectively. The two studies highlight opposite ends of the spectrum: large diameter, high-pressure, and long-duration versus small diameter, low-pressure, and short-duration ureteral stricture dilation, with each producing favorable results in short-segment strictures. To date, there does not appear to be compelling evidence for any set of balloon parameter over others and surgeon preference is likely the driving factor in absence of prospective, randomized data.

Endoureterotomy

Endoureterotomy can be accomplished in antegrade, retrograde, or combined fashion using a cold knife, electrosurgical probe, or laser fiber (most commonly Holmium: YAG). Stricture location affects both the technique utilized, as well as the success rate of dilation. Classically, full-thickness incisions are carried into periureteral fat several millimeters proximally and distally to the stricture. Incisions are made posterolaterally for proximal strictures, and distal strictures are incised anteromedially to avoid incidental vascular injury [9, 13]. It is somewhat difficult to evaluate the efficacy of endoureterotomy due to the understandable lack of standardization and long-term follow-up in the literature, but there is a high number of studies reporting outcomes for the various modalities. Hafez and Wolf performed an extensive literature review of all-modality endoureterotomy and reported success rates of 60–86%, which were dependent on stricture location [9].

Decision to perform endoureterotomy must be considered in the context of renal function. Wolf and colleagues studied a series of 69 patients undergoing a total of 77 endoureterotomies for both benign ureteral and ureteroenteric strictures. In their series, all nine procedures where the ipsilateral kidney provided less than 25% of total function failed entirely based on both objective radiographic findings and patients' symptomology [14]. In these cases, the symptomatic patient is often best served with nephrectomy, thus minimizing morbidity.

Laser endoureterotomy with Holmium:YAG fiber is frequently used due to its precision, ability to fragment concomitant urinary tract calculi, and its ability to be used in either flexible or rigid ureteroscopes in any portion of the ureter, unlike electrocautery or cold knife. The European Association of Urology laser technology guidelines recommend laser endoureterotomy as a first-line treatment of ureteral strictures, although with a level of evidence (LE) of 3, and still consider open surgical repair as the gold standard [15]. Gnessin and colleagues performed a retrospective evaluation of holmium laser endoureterotomy for benign strictures using a 550-μm laser fiber followed by balloon dilation and/or endopyelotomy [16]. A total of 35 patients were included with mean follow-up of 27 months. Results showed 82% symptomatic improvement and 79% radiographic improvement; unsurprisingly, those with non-ischemic strictures less than 1 cm saw the most benefit. In another retrospective review, Hibi et al. reviewed their outcomes of 20 laser ureterotomies for mostly benign strictures with a large-caliber (12 Fr) ureteral stent post-operatively for a period of 6 weeks [17]. Although they experienced an 80% overall success rate, interestingly, they saw no association of stricture length to outcomes. This study highlights one of the remaining controversial topics in the endoscopic management of USD, size, and duration of ureteral stenting post-operatively. A wide variety of stent sizes has been utilized in the literature (6–16 Fr) with varying rates of success [9, 14, 18, 19]. Ibrahim and colleagues performed a randomized control trial of single versus dual stenting in 55 patients undergoing laser endoureterotomy and balloon dilation [20]. After 25.7 months of follow-up, the dual-stent group had an 82% success rate compared to the 39% for the single-stent group. However, at this time, there is still no definitive evidence supporting any particular stenting practice, and stent management remains under surgeon discretion.

Endoureterotomy with non-laser technologies seems to carry success rates of 53–82% for benign strictures, although much of the literature utilizes multi-modality endoscopic treatments [10, 14]. One of the larger series by Wolf et al. utilizes both Acucise balloon incision and/or electrocautery coupled with balloon dilation in a total of 69 patients undergoing 77 total procedures [14]. In the series, they achieved an 80% success rate for benign strictures and 72% percent for ureteroenteric strictures, especially for short, non-ischemic strictures. Meretyk reported a success rate of 62% at average of 20 months of follow-up for 13 patients undergoing endoureterotomy [21]. Both studies utilized adjunctive injections of triamcinolone in select patients who had unfavorable stricture beds, but neither found significant improvement in overall success rate.

A concern with many of the studies regarding endoscopic management of USD is limited follow-up. Since it often takes months to even years to develop fibrosis and form scar and strictures, it is very possible that more long-term follow-up would demonstrate re-stricture and hence failure of endoscopic management.

Chronic Indwelling Ureteral Stents/Nephrostomy

Ureteral stent placement is unique to other endoscopic treatments for USD as it can serve as a temporary treatment modality until more definitive treatment is planned, has the ability to decompress an acutely obstructed renal unit, and its utilization is not restricted based on length of stricture. The primary limiting factor for ureteral stent placement is if the ureteral orifice cannot be properly identified or stent passage is not possible based on the severity of obstruction. Since the beginning of ureteral stent use, modifications in materials used to produce ureteral stents have helped to make this treatment modality more cost-efficient and more tolerable for the patient.

Ureteral stent placement for USD is indicated for both intrinsic and extrinsic etiologies. Several studies have investigated clinical and radiologic parameters predicting ureteral stent failure. Yossepowitch and colleagues performed a prospective study of 92 patients with ureteral obstruction managed with retrograde ureteral stent placement [22]. On multivariate logistic regression, distal extrinsic compression and the degree of hydronephrosis prior to stent placement were the only predictors of stent failure at 3 months. Another retrospective study of 38 patients with intrinsic ureteral obstruction identified male sex, increased creatinine level as a presenting symptom, and more severe preoperative hydronephrosis as predictors of stent failure [23].

Success rates for ureteral stent placement have been shown to be higher for intrinsic etiologies of USD. Yossepowitch and colleagues found that retrograde ureteral stent placement was successful in 94 and 73% of patients with intrinsic and extrinsic obstruction, respectively [22]. At 3 months follow-up, stent function was maintained in 100% of patients with intrinsic ureteral obstruction compared to 56.4% of patient with extrinsic obstruction. A retrospective review at the University of Michigan investigated the success rates of placing stents in patients with different etiologies of extrinsic USD [24]. The overall success rate was 84%, with malignancy, retroperitoneal fibrosis, and benign masses having an 81, 85, and 100% success rate, respectively.

Looking specifically at stent management in malignant extrinsic ureteral obstruction, Ganatra et al. retrospectively reviewed 157 patients and experienced a total failure rate of 35.7% [25]. The high-failure rate of ureteral stent placement in the setting of malignant ureteral obstruction has prompted the search for novel techniques for stent placement. Liu et al. published their early experience of four patients who failed management of malignant extrinsic ureteral compression with a single double-J ureteral stent. In all patients, parallel 4.7 Fr double-J stents were exchanged for the failed single 6 Fr double-J stents, and all patients had resolution of flank pain, azotemia, and hydronephrosis [26]. A later study by Rotariu and colleagues reported their experience of using two ipsilateral ureteral stents for malignant extrinsic ureteral compression with similar results [27]. Elsamra et al. also looked at use of tandem ureteral stents (TUS) in patients with both benign and malignant ureteral strictures and noted failure in only 12.8% of malignant strictures and 0% of benign USD [28•]. Interestingly, stent failure in malignant obstruction was associated with median survival of 66 days compared to 432 days in those without stent failure.

Since the first report of the all-metal Resonance stent in 2006, a number of studies have aimed to determine the efficacy and safety of using metal stents for USD [29]. Liatsikos and colleagues aimed to determine short- and medium-term effectiveness of the Resonance stent in malignant and benign ureteral obstruction by evaluating technical success rate, stricture patency rate, complications, and the presence and type of encrustation [30]. The stricture patency rate for patients with malignant extrinsic ureteral obstruction was 100%, although concerns of stent encrustation (12/54 stents) and difficulties with stent exchange in nine cases arose from the study. Kadlec and colleagues retrospectively reviewed a total of 139 Resonance Metallic ureteral stents placed in 47 patients from early 2007 to late 2011 [31]. Stent failure occurred in 13 patients (28%), including four patients with benign etiology (20%) and nine patients with malignant etiology (33%). In a more recent study, Baumgarten and colleagues investigated the cost-effectiveness of managing chronic ureteral obstruction with metallic stents versus more traditional polymer stents [32]. The estimated cost for traditional polymer stents exchanged every 90 days was $9648–$13,128, while the estimated cost for metallic stents was $4211–$5313. The study identified a reduction in cost per patient-year between 56.4 and 59.5%, concluding the cost-effectiveness of metallic stents versus polymer stents. Other commonly used metallic stents are the Memokath 051 stent, the Allium stent, and the Uventa stent, which have shown similar results [33–37].

Special Populations: Ureterointestinal and Renal Transplant Strictures

Ureterointestinal Anastomotic Strictures

Patients who develop ureteroenteric anastomotic strictures comprise a special patient population in which management decisions can be challenging for the treating urologist. The longest follow-up data available in regard to ureteroenteric anastomotic strictures are of patients who had urinary conduits, in which the rate is between 4 and 8% [38]. Ahmed et al. recently retrospectively reviewed their robot-assisted radical cystectomy database to identify patients in whom ureteroenteric strictures develop, with 12, 16, and 19% of patients developing ureteroenteric strictures at 1, 3, and 5 years, respectively [39]. In another retrospective review of 478 patients who underwent radical cystectomy at Vanderbilt University Medical Center, 45 patients (9.4%) were diagnosed with ureteroenteric anastomotic stricture at a median of 5.3 months postoperatively [40].

For patients with ureteroenteric anastomotic stricture, endoscopic management is the initial approach of choice. In contrast to management of benign ureteral strictures, management of ureteroenteric and ureterocolic strictures favors antegrade management due to the inherent difficulties of retrograde access. Although endoscopic management is the preferred initial approach for managing ureteroenteric strictures, overall long-term patency for most endoscopic procedures is poor; regardless, such approaches are still used preferentially as the initial intervention, reserving major—and potentially morbid procedures—for those patients failing endoscopic management [41].

A number of studies have compared different endourologic modalities to open repair for ureteroenteric strictures. Schondorf and colleagues compared long-term results of minimally invasive endourological intervention and open-surgical revision in patients with nonmalignant ureteroileal stricture. Endourologic treatments included balloon dilation (anterograde and retrograde), and Acucise or Ho:YAG laser endoureterotomy [42•]. The overall success rate was only 26% (25/96) for endourologic intervention vs 91% (32/35) for open-surgical revision. Breakdown of success rate per endourologic treatment was 25% for balloon dilation, 33% for Acucise endoureterotomy, and 33% for Ho:YAG laser endoureterotomy. Furthermore, stricture length was found to be strongly and inversely associated with successful outcome in both endourologic treatment and open repair. The study concluded that endourologic management of ureteroileal stricture is only acceptable for strictures 1 cm or less.

With endourologic management having a low-success rate and open repair having the potential for significant morbidity, one study specifically investigated outcomes in observing patients with ureteroenteric strictures. Baten and colleagues identified 22 patients diagnosed with ureteroenteric stricture after radical cystectomy and ileal conduit urinary diversion. Patients were observed for a mean follow-up time of 33 months, unless they developed a decline in renal function, flank pain, or urinary tract infections. Out of the remaining 22 patients, 12 (54.5%) remained asymptomatic during the follow-up period and required no active treatment, suggesting a role for conservative management in asymptomatic patients with stable renal function [43].

Renal Transplant Strictures

A significant number of kidney transplant recipients experience urologic complications. Of these complications, ureteral obstruction secondary to stricture of the transplant ureter has been well described, with a reported incidence of 1 to 4% [44–46]. The management of USD in the transplant ureter can be approached with endoscopic techniques or open reconstruction.

The historical management for USD of the transplant ureter in patients who were symptomatic or had declining renal function was temporary decompression with a stent or nephrostomy tube followed by definitive stricture repair. Indications for interval stent exchanges or nephrostomy tube exchanges also extend to patients who are not medically fit to undergo a high-risk surgery or patients who prefer ureteral stent exchange or nephrostomy tube exchanges. Retrograde stent placement is a technically challenging procedure as the ureterovesical anastomosis is often located at the bladder dome. Halstuch et al. described a specific technique used for transplant ureteral stent placement and exchange in 32 renal transplants [47]. The technique describes the utility of placing a 14/16-Fr ureteral access sheath up to the proximal ureter and then passing the ureteral stent over an ultra-stiff wire through the sheath. Median operating room time was 24 min, and the authors report a 96.9% success rate with only one reported failure that required nephrostomy tube placement.

With advances in endoscopic techniques, procedures such as balloon dilation, cold knife, Acucise, or laser endoureterotomy have gained popularity as success with these procedures can help patients avoid high-risk surgery. Gil-Sousa et al. reviewed 33 patients who developed ureteral stenosis after kidney transplant that were managed by balloon dilation [48]. The total recurrence rate was 47% with a mean global time from treatment to ureteral stricture recurrence of 6.9 months. Success of balloon dilation was not associated with stenosis length, time between transplant and stricture, or stricture length; however, there was a trend towards higher success rates with small strictures (< 1.5 cm). Uflacker et al. investigated the potential effects of balloon dilation on graft survival and long-term patency of USD in transplant patients [49]. This retrospective study compared success, defined as removal of nephroureteral stent at any time with < 30% residual stenosis, in patients managed with a nephroureteral stent ($n = 28$) or nephroureteral stent and balloon dilation ($n = 42$). Nephroureteral stent plus balloon dilation did not improve graft survival or patency compared with nephroureteral stent alone. Although both procedures were found to be safe and effective, the study highlights that there was no advantage of performing balloon dilation in addition to stent placement. Holmium:YAG laser endoureterotomy has not been investigated as much as stent placement or balloon dilation for management of USD in transplant patients. In a retrospective series of 12 kidney transplants that developed stricture, Gdor et al. investigated the success of laser endoureterotomy [50]. Amongst the six patients treated with balloon dilation and Ho:YAG laser endoureterotomy, the success rate was 67%, and both strictures that failed were greater than 1 cm; of the eight strictures that were 1 cm or less, there was an overall success rate of 75% with 52 months follow-up, which included 100% (5/5) success rate in the laser endoureterotomy group, and 33% (1/3) in the group that only received balloon dilation.

Mano et al. evaluated long-term outcomes and complications of retrograde endoureterotomy in patients who developed recurrent ureterovesical anastomotic strictures after one or multiple failed antegrade balloon dilation procedures [44]. A total of 12 patients in their series were treated with either cold knife ($n = 9$), holmium:YAG laser ($n = 2$), or bugbee electrode ($n = 1$) for strictures all less than 1 cm in length. An overall success rate of 83% was reported over a mean follow-up period of 4.7 months. The study concluded that retrograde endoureterotomy is an effective salvage procedure for well-selected patients with short ureterovesical anastomotic strictures. Other studies have argued against multiple attempts at endourologic interventions secondary to the high-failure rate. In a cohort of seven patients followed over a 4-year period, Bromwich and colleagues reported that only 25% of patients had success with undergoing multiple dilations suggesting that patients should undergo open surgery if the first dilation fails [51].

In regard to management of USD in the transplant patient, the literature is limited with most studies involving small patient populations. An identifiable trend is a higher success rate with endourologic management for shorter ureteral strictures, specifically < 1.0 cm in length. We would recommend an endourologic treatment modality initially as success has been reported in the literature, and it can potentially save a patient from high-risk surgery. Choosing a specific endourologic modality to use for USD in the transplant patient is another challenge as there is not enough evidence to favor one modality over another, and there is no evidence suggesting that one modality is safer than the other. This decision should be based on the comfort of the treating urologist with the specific modality they choose.

Conclusions

Recent literature highlighting the success and safety of endoscopic treatment modalities would suggest that it has a role in the treatment of ureteral stricture disease. This is especially true for the patient that is not a good surgical candidate or is less motivated to undergo a high risk and morbid surgery. It is important to note that, although successes have been reported in contemporary studies regarding endoscopic management, surgical reconstructive repair—open, laparoscopic, or robotic—is still considered the definitive treatment with much higher long-term success rates and for a wider variety of patients [52–56]. Proper counseling is necessary for patients to make an informed decision with an understanding that choosing a less invasive endoscopic approach has a higher potential for recurrence. Below are several patient and stricture characteristics we feel are important in selecting the optimal patient for endoscopic management of ureteral stricture disease:

- Benign or non-ischemic etiology
- Poor surgical candidate
- Proximal or distal stricture location
- Short-segment stricture (< 2 cm)
- Treatment-naïve disease

Compliance with Ethical Standards

Conflict of Interest Jacob W. Lucas, Eric Ghiraldi, and Jeffrey Ellis each declare no potential conflicts of interest.

Justin I. Friedlander reports personal fees from Retrophin, outside the submitted work.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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