Ureteral Rest is Associated With Improved Outcomes in Patients Undergoing Robotic Ureteral Reconstruction of Proximal and Middle Ureteral Strictures

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OBJECTIVES To evaluate the effect of ureteral rest on outcomes of robotic ureteral reconstruction.

METHODS We retrospectively reviewed all patients who underwent robotic ureteral reconstruction of proximal and/or middle ureteral strictures in our multi-institutional database between 2/2012—03/2019 with ≥12 months follow-up. All patients were recommended to undergo ureteral rest, which we defined as the absence of hardware (ie. double-J stent or percutaneous nephroureteral tube) across a ureteral stricture ≥4 weeks prior to reconstruction. However, patients who refused percutaneous nephrostomy tube placement did not undergo ureteral rest. Perioperative outcomes were compared after grouping patients according to whether or not they underwent ureteral rest. Continuous and categorical variables were compared using Mann-Whitney *U* and 2-tailed chi-squared tests, respectively; $P < .05$ was considered significant.

RESULTS Of 234 total patients, 194 (82.9%) underwent ureteral rest and 40 (17.1%) did not undergo ureteral rest prior to ureteral reconstruction. Patients undergoing ureteral rest were associated with a higher success rate compared to those not undergoing ureteral rest (90.7% versus 77.5%, respectively; $P = .027$). Also, patients undergoing ureteral rest were associated with lower estimated blood loss (50 versus 75 milliliters, respectively; p<0.001) and less likely to undergo buccal mucosa graft ureteroplasty (20.1% versus 37.5%, respectively; p=0.023).

CONCLUSIONS Implementing ureteral rest prior to ureteral reconstruction may allow for stricture maturation and is associated higher surgical success rates, lower estimated blood loss, and decreased utilization of buccal mucosa graft ureteroplasty. UROLOGY 152: 160−166, 2021.

Urethral rest, defined as freedom from urethral instrumentation for a period of time, is routinely implemented in patients with a urethral stricture prior to urethroplasty. Recent urethral instrumentation, such as endoscopic treatment (ie, urethral dilation or direct vision internal urethrotomy), intermittent self-catheterization, and/or the presence of an indwelling Foley catheter, may profoundly alter stricture characteristics. Urethral rest allows for tissue recovery and stricture maturation, which ultimately allows for accurate determination of the extent and quality of a urethral stricture at time of definitive repair.[1,2]

Although the role of rest has been firmly established prior to urethral reconstruction, the role of rest prior to ureteral reconstruction has yet to be evaluated. Patients with ureteral strictures are often temporized with endoscopic management (ie. balloon dilation or endoureterotomy) and/or double-J stents prior to definitive ureteral reconstruction.[3] There is currently little guidance available in the urologic literature regarding the timing and efficacy of ureteral reconstruction after recent endoscopic manipulation and/or the presence of hardware (ie, double-J stent or percutaneous nephroureteral [PCNU] tube) across a ureteral stricture at time of surgery. Furthermore, studies regarding ureteral reconstruction do not routinely discuss the method of urinary drainage in patients with ureteral strictures at time of definitive repair.[4-6]

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The purpose of our study was to utilize our multi-institutional database to evaluate the effect of ureteral rest on outcomes of robotic ureteral reconstruction (RUR) of proximal and/or middle ureteral strictures. We hypothesize that recent ureteral instrumentation and/or the presence of hardware across a ureteral stricture (ie, double-J stent or PCNU tube) at time of RUR alters stricture characteristics and causes peri-ureteral inflammation, ultimately adversely affecting surgical outcomes.

MATERIALS AND METHODS

We performed a multi-institutional Institutional Review Board approved retrospective review of all patients who underwent RUR of proximal and/or middle ureteral strictures at three institutions between 2/2012—03/2019 in the Collaborative of Reconstructive Robotic Ureteral Surgery (CORRUS) database. The procedures were performed using the da Vinci® Surgical System (Intuitive Surgical, Sunnyvale, USA). All patients had benign ureteral strictures located between the ureteropelvic junction and the lower border of the sacroiliac joint. Patients with strictures spanning any portion of the distal ureter were excluded. Also, patients with proximal and/or middle ureteral strictures who underwent ureteroneocystotomy with or without psoas hitch and/or Boari flap were excluded as we believe that ureteral reconstructions involving the bladder represent a distinct surgical entity given the different maneuvers used to achieve a tension-free anastomosis and robust blood supply to the bladder.[7] Furthermore, patients with less than 12 months follow-up were excluded.

All patients were recommended to undergo a period of ureteral rest prior to RUR. We defined ureteral rest as the absence of hardware (ie, double-J stent or PCNU tube) across a ureteral stricture for at least 4 weeks prior to RUR. As such, patients with a double-J stent or PCNU tube at time of initial evaluation were advised to have their hardware removed prior to definitive repair to allow for tissue recovery and stricture maturation. Patients with significant flank pain in the absence of a double-J stent or PCNU tube were recommended to undergo percutaneous nephrostomy (PCN) tube placement. However, patients who refused the possibility of a PCN tube maintained their double-J stent or PCNU tube until definitive repair. As such, patients undergoing ureteral rest had a PCN tube or no hardware for at least 4 weeks prior to RUR, and patients not undergoing ureteral rest had a double-J stent or PCNU tube at time of RUR.

After grouping patients according to whether or not they underwent ureteral rest prior to RUR, we compared perioperative outcomes. The primary outcome was surgical success, which we defined as ureteral patency. In the postoperative setting, all patients underwent clinical evaluation for the presence of flank pain suggestive of ureteral obstruction and radiographic evaluation via renal scan for washout kinetics suggestive of ureteral obstruction ($T^{1/2}$>15 minutes). Patients with concern for a recurrent stricture underwent an intraoperative evaluation for ureteral patency using a 7.5 French flexible ureteroscope. The ureter was deemed patent if the ureteroscope was able to be navigated across the reconstructed ureter. The secondary outcomes were estimated blood loss (EBL), utilization of buccal mucosa graft (BMG) ureteroplasty, and proportion of patients with obliterated strictures. Stricture length was measured using a ruler, which was inserted intracorporeally at time of RUR.

Continuous variables were compared using the Mann-Whitney U test, and categorical variables were compared using Fisher's exact test. In all cases, P <.05 was considered statistically significant. Statistical analyses were conducted using IBM SPSS® Statistics 26.0 (IBM, Armonk, NY).

Stricture Evaluation

All patients underwent fluoroscopic imaging of the ureteral stricture prior to RUR via retrograde and/or antegrade (those with percutaneous upper tract access) pyelography. For patients undergoing ureteral rest, fluoroscopic imaging was performed after at least 4 weeks of ureteral rest. However, fluoroscopic imaging prior to the implementation of ureteral rest was not consistently performed. Patients with a double-J stent or PCNU tube desiring to undergo ureteral rest prior to RUR generally had their hardware removed in the office in the absence of fluoroscopic imaging. Also, patients undergoing PCN tube placement generally did not undergo fluoroscopic imaging to assess the ureteral stricture. As fluoroscopic imaging protocols were not standardized across all institutions and only a minority of patients underwent fluoroscopic imaging both before and after the implementation of rest (Fig. 1), an analysis of radiographic changes to a ureteral stricture after a period of ureteral rest was not performed.

Surgical Technique

We have previously described our approach and technique for management of proximal, and middle ureteral strictures.[8-13] Although the specific technique utilized for RUR was determined at time of surgery based on clinical history and intraoperative findings, all primary surgeons followed a unified algorithmic reconstructive approach. In general, our preference was to perform an excision and primary anastomosis (EPA) repair such as an Anderson-Hynes pyeloplasty or ureteroureterostomy.[9,13] However, in patients with complicated ureteral strictures, which we defined as those not amenable to EPA due to stricture length and/or extensive peri-ureteral fibrosis, we performed robotic BMG ureteroplasty. In patients with complicated ureteral strictures, those with a narrowed lumen underwent an onlay BMG ureteroplasty, while patients with an obliterated or a near-obliterated lumen underwent an augmented anastomotic BMG ureteroplasty.[11,12] In all cases, a double-J stent was inserted into the reconstruction ureter at time of RUR.

Follow-up

Postoperative follow-up was subject to minor variations based on patient history and surgeon preference. Double-J stents were removed 4-6 weeks postoperatively. Patients were generally instructed to follow-up once between 2-4 months, once or twice between 6-12 months, and at least once annually thereafter. Renal scans were obtained 1-2 times during the first postoperative year, and yearly intervals thereafter.

RESULTS

Of 228 patients included in our analysis, 188 (82.5%) underwent ureteral rest and 40 (17.5%) did not undergo ureteral rest prior to RUR. Patient and stricture characteristics are summarized in Table 1. There was no difference in median age (P = .750), body mass index (P = .359), and stricture length (P = .157) between patients undergoing and not undergoing ureteral rest. There was no difference in the proportion of patients who underwent RUR

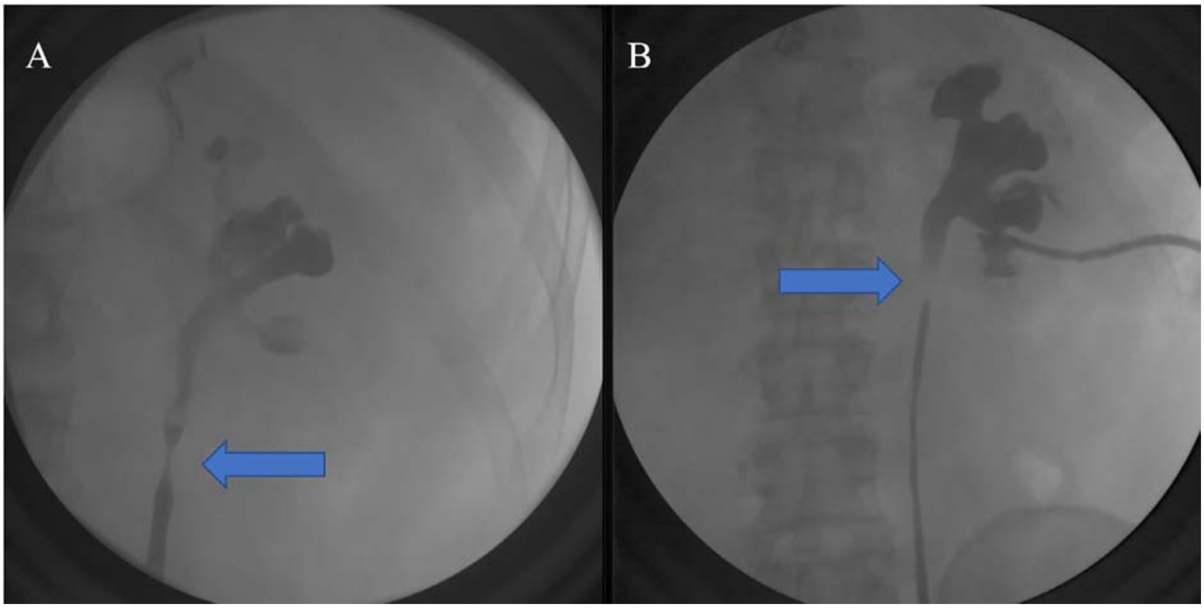

Figure 1. (A) Retrograde pyelogram of a proximal ureteral stricture in patient with a chronic double-J stent prior to a course of ureteral rest. Arrow depicts narrowed proximal ureteral stricture. (B) Concomitant antegrade and retrograde pyelogram in the same patient after implementing 4-weeks of ureteral rest. Arrow depicts completely obliterated proximal ureteral stricture after a course of ureteral rest. (Color version available online.)

for a previously failed ureteral reconstruction (P = .403), and patients with strictures located in the ureteropelvic junction (P = .215), proximal ureter (P >.999), middle ureter (P = .328), and proximal and middle ureter (P >.999). Patients undergoing ureteral rest were more likely to have an obliterated stricture, compared to patients not undergoing ureteral rest (8.5% vs 0.0%, respectively; P = .048).

Surgical technique and perioperative outcomes are summarized in Table 2. In patients who underwent ureteral rest, 149/188 (79.3%) underwent an EPA repair (113/149 [75.8%] underwent an Anderson-Hynes pyeloplasty and 36/149 [24.2%] underwent a ureteroureterostomy) and 39/188 (20.7%) underwent a BMG ureteroplasty (31/39 [79.5%] underwent an onlay repair and 8/39 [20.5%] underwent an augmented anastomotic repair). In patients who did not undergo ureteral rest, 25/40 (62.5%) underwent an EPA repair (19/40 [47.5%] underwent an Anderson-Hynes pyeloplasty and 6/40 [15.0%] underwent a ureteroureterostomy) and 15/40 [37.5%] underwent a BMG ureteroplasty (12/15 [80.0%] underwent an onlay repair and 3/15 [20.0%] underwent an augmented anastomotic repair). Patients undergoing ureteral rest required BMG ureteroplasty less frequently compared to patients not undergoing ureteral rest (20.7% vs 37.5%, respectively; p = 0.039).

There was no difference in median operative time (P = .505) and length of stay (P = .642), and proportion of patients with 30-day major (Clavien >2) postoperative complications (P = .660). However, patients undergoing ureteral rest had a lower median EBL compared to patients not undergoing ureteral rest (50 vs 75 milliliters, respectively; P <.001). At a median follow-up of 23 (IQR 15-35) months in patients undergoing ureteral rest and 22 (IQR 15-43) months in patients not undergoing ureteral rest (P = .558), patients undergoing ureteral rest had a higher success rate compared to those not undergoing ureteral rest prior to RUR (90.4% vs 77.5%, respectively; P = .030).

Subgroup analysis of surgical success by technique is summarized in Table 3. The surgical success rate of patients undergoing an EPA repair was 135 of 149 (90.6%) in patients who underwent ureteral rest and 19/25 (76.0%) in patients who did not undergo ureteral rest. In patients who underwent Anderson-Hynes Pyeloplasty and ureteroureterostomy, the surgical success rate was 102 of 113 (90.3%) and 33 of 36 (91.7%) in patients

Table 1. Patient and stricture characteristics

Variable	Ureteral Rest (N=188)	No Ureteral Rest (N=40)	P Value
Median Age (IQR), years	46 (33-62)	51 (26-60)	.750
Median Body Mass Index (IQR), kg/m^2	25.1 (21.9-29.1)	27.0 (22.2-31.7)	.359
Previously Failed Ureteral Reconstruction (%)	19/188 (10.1%)	6/40 (15.0%)	.403
Stricture Location:			
Ureteropelvic junction (%)	119/188 (63.3%)	23/40 (57.5%)	.215
Proximal (%)	47/188 (25.0%)	10/40 (25.0%)	>.999
Middle (%)	13/188 (6.9%)	5/40 (12.5%)	.328
Proximal and Middle (%)	9/188 (4.8%)	2/40 (5.0%)	>.999
Median Stricture Length (IQR), centimeters	1.5 (1.0-2.0), max 8	1.5 (1.0-3.0), max 6	.157
Obliterated Stricture (%)	16/188 (8.5%)	0/40 (0.0%)	.048

Table 2. Surgical Technique and Perioperative Outcomes

Variable	Ureteral Rest (*N*=188)	No Ureteral Rest (*N*=40)	*P* Value
Surgical Technique:			
Excision and Primary Anastomosis	149/188 (79.3%)	25/40 (62.5%)	
Anderson-Hynes Pyeloplasty	113/149 (75.8%)	19/40 (47.5%)	
Ureteroureterostomy	36/149 (24.2%)	6/40 (15.0%)	
Buccal Mucosa Graft Ureteroplasty	39/188 (20.7%)	15/40 (37.5%)	.039
Onlay Buccal Mucosa Graft Ureteroplasty	31/39 (79.5%)	12/15 (80.0%)	
Augmented Anastomotic Buccal Mucosa Graft Ureteroplasty	8/39 (20.5%)	3/15 (20.0%)	
Median Operative Time (IQR), minutes	167.0 (119.8-206.5)	169.0 (124.5-217.0)	.505
Median Estimated Blood Loss (IQR), milliliters	50 (25-67)	75 (50-100)	<.001
Median Length of Stay (IQR), days	1 (1-2)	1 (1-2)	.642
Major Postoperative Complications (%)	7/188 (3.7%)	2/40 (5.0%)	.660
Median Follow-up (IQR), months	23 (15-35)	22 (15-43)	.674
Overall Surgical Success (%)	170/188 (90.4%)	31/40 (77.5%)	.030

Table 3. Subgroup Analysis of Surgical Success by Technique

	Ureteral Rest (*N*=188)	No Ureteral Rest (*N*=40)
Excision and Primary Anastomosis Surgical Success (%)	135/149 (90.6%)	19/25 (76.0%)
Anderson-Hynes Pyeloplasty Surgical Success (%)	102/113 (90.3%)	15/19 (78.9%)
Ureteroureterostomy Surgical Success (%)	33/36 (91.7%)	4/6 (66.7%)
Buccal Mucosa Graft Ureteroplasty Surgical Success (%)	35/39 (89.7%)	12/15 (80.0%)
Onlay Type Buccal Mucosa Graft Ureteroplasty Surgical Success (%)	29/31 (93.5%)	10/12 (83.3%)
Augmented Anastomotic Type Buccal Mucosa Graft Ureteroplasty Surgical Success (%)	6/8 (75.0%)	2/3 (66.7%)

who underwent ureteral rest, and 15 of 19 (78.9%) and 4 of 6 (66.7%) in patients who did not undergo ureteral rest, respectively. The surgical success rate of patients undergoing BMG ureteroplasty was 35 of 39 (89.7%) in patients who underwent ureteral rest and 12/15 (80.0%) in patients who did not undergo ureteral rest. In patients who underwent onlay BMG ureteroplasty and augmented anastomotic BMG ureteroplasty, the surgical success rate was 29 of 31 (93.5%) and 6 of 8 (75.0%) in patients who underwent ureteral rest, and 10 of 12 (83.3%) and 2 of 3 (66.7%) in patients who did not undergo ureteral rest, respectively.

COMMENT

Implementing a period of rest prior to urethroplasty has been shown to initiate a process of stricture maturation.[1,2] Terlecki et al. noted that urethral rest allowed for radiographic delineation of unstable pathologic features of a stricture and was important for successful urethroplasty.[2] Moncrief et al. evaluated 29 men who underwent retrograde urethrogram and voiding cystourethrogram before and after a period of urethral rest, which was defined as placement of a suprapubic tube for at least 4 weeks. Urethral rest was associated with more than doubling in the frequency of urethral obliteration (23% to 58%, $P = .0005$) and a change in the operative plan 47% of the time. Although stricture length was noted to be longer by 0.4 centimeters after a period of urethral rest, this was not statistically significant ($p = .1000$).[1]

To our knowledge, there are currently no studies evaluating the role of rest prior to ureteral reconstruction. As such, there is a paucity of evidence-based guidance pertaining to the timing of ureteral reconstruction in patients with recent ureteral instrumentation and/or the presence of hardware across the ureteral stricture. Indeed, the majority of studies regarding ureteral reconstruction do not mention the method of urinary drainage across a stricture at time of definitive surgery.[4-6] Some authors have even recommended placement of a ureteral stent prior to ureteral reconstruction as it may facilitate intraoperative delineation of ureteral anatomy[14] and prevent complete obliteration of a strictured ureteral lumen.[15]

Our rationale for implementing ureteral rest prior to definitive reconstruction is based on an understanding of wound healing, a dynamic process consisting of three overlapping phases. The inflammatory phase is initiated by vascular injury, which results in the activation of the coagulation cascade and blood clot formation.[16,17] In the proliferative phase, macrophages and activated fibroblasts migrate into the wound to form granulation tissue. Wound contraction also occurs as fibroblast-like cells called myofibroblasts pull the wound edges together.[18] Keratinocytes migrate into the wound to reform the epithelial layer. In the maturation phase, the extracellular matrix of the wound undergoes constant remodeling. Also, thin collagen fibrils are resorbed and replaced with thicker fibrils, and the deposited collagen becomes crosslinked, which increases the tensile strength of the wound. Although extracellular matrix and collagen remodeling generally equilibrates to a steady state approximately 3 weeks after injury, remodeling may continue for up to 12 months.[19] We hypothesize that ureteral rest allows for uninterrupted progression through the stages of wound healing and stricture stabilization, while the presence of hardware across a ureteral stricture impedes wound healing by causing microvascular injury and perpetuating the inflammatory phase of wound healing.

In our study, we compared peri-operative outcomes between patients undergoing and not undergoing rest prior to RUR of a proximal and/or middle ureteral stricture. Most notably, we found that patients undergoing ureteral rest were associated with a higher surgical success rate. In those undergoing ureteral rest, at a median follow-up of 23 (IQR 15-35) months, the surgical success rate was 90.4%; in those not undergoing ureteral rest, at a median follow-up of 22 (IQR 15-43) months, the surgical success rate was 77.5% ($P = .030$). We believe that implementing ureteral rest allows for stricture maturation and stabilization, which may ultimately result in more successful reconstruction. However, hardware across a stricture at time of RUR re-initiates the wound healing process and inhibits accurate delineation of stricture characteristics. Additionally, subgroup analysis of surgical success by technique demonstrated that patients undergoing ureteral rest had higher rates of surgical success compared to those not undergoing ureteral rest regardless of technique. However, given the paucity of patients who did not undergo ureteral rest in each subgroup, we were unable to perform meaningful statistical comparisons of surgical success stratified by technique. Further studies are necessary to evaluate the effect of surgical technique on the relationship between ureteral rest and surgical success.

Also, we found that patients undergoing ureteral rest, compared to those not undergoing ureteral rest, were associated with lower median EBL (50 vs 75 milliliters, respectively; $P < .001$) and lower utilization of BMG ureteroplasty (20.7% vs 37.5%, respectively; $P = .039$). We believe that these results may be explained by an increase in peri-ureteral inflammation in patients not undergoing rest. Although we have subjectively noted that patients with hardware across a ureteral stricture at time of ureteral reconstruction tend to have more peri-ureteral inflammation, the degree and etiology of peri-ureteral inflammation is difficult to quantify. We believe that the increased median EBL noted in patients not undergoing ureteral rest could be explained by an increase in peri-ureteral inflammation, resulting in more tissue vascularity.[20] It should be noted, however, that the median difference in EBL between those undergoing ureteral rest vs those not undergoing ureteral rest was only 25 milliliters. Nevertheless, we believe that this difference can be attributed to increased peri-ureteral inflammation in patients not undergoing ureteral rest, rather than a Type 1 error. Also, we suspect that the increased frequency with which BMG ureteroplasty was performed in patients not undergoing ureteral rest was due to the inability to identify the exact margins of the stricture since there was no difference in the median stricture lengths between patients undergoing and not undergoing ureteral rest ($P = .157$). When the margins of a stricture are unclear, there is a tendency to use a repair that can treat a presumably longer stricture (ie, BMG ureteroplasty) rather than primary anastomosis.

Lastly, we found that patients undergoing ureteral rest, compared those not undergoing ureteral rest, were more likely to have obliterated strictures (8.5% vs 0.0%, respectively; $P = .048$). We believe that initiating a period of rest prior to ureteral reconstruction allows for stricture maturation, which may ultimately progress to obliteration. However, the presence of hardware across a ureteral stricture prevents the lumen from completely obliterating. This is particularly important because stricture quality (ie, obliterated versus narrowed) has implications on the selection of an appropriate RUR technique. For example, patients with an obliterated ureteral segment must undergo a transecting repair (ie, Anderson-Hynes pyeloplasty, ureteroureterostomy, or augmented anastomotic BMG ureteroplasty) while patients with a narrowed ureteral segment may undergo a non-transecting repair (ie, onlay BMG ureteroplasty). Despite this, as radiographic evaluation of the ureteral stricture before and after implementation of ureteral rest was not standardized across all institutions, it is unclear whether patients in the ureteral rest group had obliterated strictures to begin with or whether ureteral rest allowed the obliteration to manifest. Further studies evaluating radiographic changes to a ureteral stricture after a period of ureteral rest, and development of a means to quantify these changes are necessary.

The results of our study must be interpreted in the context of its limitations. As our study was retrospective in nature and patients were not randomized to undergo ureteral rest, our results are subject to selection bias. However, given the theoretical basis for implementing ureteral rest and the expected difficulty in randomizing patients for ureteral rest, we believed that the results of our multi-institutional study provide significant insight into the benefits of implementing ureteral rest prior to reconstruction. Also, although all patients were initially counselled to undergo ureteral rest, the decision was ultimately made by the patient. Patients refusing ureteral rest were generally those who strongly preferred to have an internalized double-J stent rather than an externalized PCN tube. Future studies assessing patient attitudes towards internalized versus externalized hardware prior to reconstruction are necessary to develop effective counseling strategies. Furthermore, although we subjectively noted changes in stricture characteristics after implementing a period of ureteral rest, we did not standardize fluoroscopic imaging protocols across all institutions. As such, we were unable to adequately analyze and quantify radiographic changes of a ureteral stricture after a period of rest. Lastly, the optimal duration of ureteral rest prior to reconstruction is currently unclear. Our rationale for implementing ureteral rest for at least 4 weeks prior to RUR was because extracellular matrix and collagen remodeling in the maturation phase generally equilibrates to a steady state approximately 3 weeks after injury.[19] Prospective studies evaluating histopathologic and radiographic changes with ureteral rest may provide additional insight into the basis for our findings.

CONCLUSIONS

Ureteral rest, which may allow for tissue recovery and stricture maturation, is associated with improved outcomes in patients undergoing RUR for proximal and/or middle ureteral strictures. Specifically, ureteral rest is associated with higher surgical success rates, lower EBL, and decreased utilization of BMG ureteroplasty. Patients should be counselled on the potential benefits of ureteral rest prior to RUR.

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EDITORIAL COMMENT

This is a well written manuscript that parallels the concept of "rest" described by Dr. Allen Morey's group for urethral strictures. However, urethral strictures differ from their ureteral counterparts in that an obliterative urethral stricture will become acutely evident requiring immediate intervention, whereas complete unilateral ureteral obstruction with a contralateral functioning system may occur without any clinical signs or symptoms, resulting in a delay in recognition leading to irreversible renal damage. We know that renal functional recovery is related to the degree and duration of obstruction. Therefore, it is important to have accurate functional information before foregoing urinary diversion. Because of the potential for silent or even progressive obstruction in that setting, often the safest option is to drain the collecting system.

Although a Percutaneous nephrostomy (PCN) tube bypasses the ureter and avoids the inflammatory sequelae of internal stents, it is an invasive procedure and may not be well tolerated. The short-term inconvenience of a PCN tube must be balanced against the benefits of ureteral rest in improving surgical outcomes. The authors' findings can be used to persuade patients who are reluctant to have a PCN tube placed, that this approach is preferrable for both renal preservation and improved surgical outcomes.

The authors should be commended for this original preliminary collaborative effort. However, there are many unanswered questions with regard to ureteral/urethral rest. In patients who have been previously stented/catheterized it is hypothesized that the internally placed tube may initiate de-novo wound healing which can alter stricture characteristics. What about the effects of "rest" in patients not previously stented/catheterized? What is the optimal duration for "rest" and how does it affect stricture characteristics, including the degree and extent of luminal contracture? The latter question can be elucidated clinically using consistent radiographic standardization, and histologically by tissue sampling including measuring inflammatory cytokines. Additional studies using a prospective randomized design are needed to answer these important questions.

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AUTHOR REPLY

We thank you for your insightful comments. In patients with recent instrumentation of a ureteral stricture and/or the presence of hardware across a ureteral stricture, our preference is to initiate a period of rest after placing a percutaneous nephrostomy tube. This practice is based on our hypothesis that rest allows for uninterrupted progression through the stages of wound healing and stricture stabilization, while the presence of hardware across a stricture impedes wound healing by perpetuating the inflammatory phase of wound healing. Prior to our study, counselling patients on the presumed benefits of placing a percutaneous nephrostomy tube before ureteral reconstruction was difficult at times, especially in those without significant flank pain and those with stable baseline renal function (which is generally the case in patients with two kidneys and normal baseline renal function). Our hope is that our data provide more concrete evidence to improve patient counseling regarding the potential benefits of rest prior to ureteral reconstruction.

Despite this, additional studies are necessary to more clearly understand the role and utility of rest prior to ureteral reconstruction. Within our cohort of patients who underwent ureteral rest, we did not distinguish between patients with and without a percutaneous nephrostomy tube (ie, as long as patients did not undergo any ureteral stricture manipulation for at least 4 weeks, they were considered to have undergone ureteral rest regardless of the need for a percutaneous nephrostomy tube). As such, the clinical implications of placing a percutaneous nephrostomy tube in patients without a history of recent ureteral stricture manipulation and/or hardware are not clear. When considering the pathophysiology of urethral stricture disease, the hydrostatic pressure of voiding against a non-distensible and non-elastic fibrotic urethral stricture may cause damage to the epithelium and subsequent proximal progression of spongiofibrosis.[1,2] However, urinary flow across a urethral stricture is not entirely analogous to urinary flow across a ureteral stricture for a multitude of reasons. As such, further studies assessing differences in histopathologic and radiographic characteristics, and surgical outcomes in patients undergoing ureteral rest with and without a percutaneous nephrostomy tubes may be helpful in further defining the role of ureteral rest.

Also, although our rationale for implementing ureteral rest for at least 4 weeks prior to RUR was based on our understanding that the maturation phase of wound healing generally equilibrates to a steady state approximately 3 weeks after injury,[3] the optimal duration of rest is not clear. Furthermore, the precise radiographic and histopathologic changes that occur to a ureteral stricture during a period of rest are not unknown. A longitudinal study assessing radiographic changes to a ureteral stricture as a function of time during a period of rest would be particularly informative. As ureteral stricture disease is relatively rare, we believe that multi-institutional collaborative efforts with centralized and standardized radiographic and histologic review will be critical in answering these questions.

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