Minimally-Invasive Ureteral Reconstruction for Ureteral Complications of Kidney Transplants

Kevin K Yang, Alireza Moinzadeh, and Andrea Sorcini

OBJECTIVE To present the technique, feasibility and results of minimally-invasive reconstruction of the transplanted ureter using the native ipsilateral ureter in post-transplant ureteral strictures and vesicoureteral reflux (VUR) causing graft pyelonephritis. Ureteral complications after kidney transplantation represent a significant cause of morbidity potentially leading to graft dysfunction or loss.

METHODS A prospective database from October 2011 to August 2018 identified renal transplant recipients who underwent minimally-invasive pyeloureterostomies or ureteroureterostomies using the ipsilateral ureter. Indications for either transplant ureteral stricture or VUR correction were assessed. Preoperative evaluation included a technetium-99m mercaptoacetyltriglycine renal scan to assess residual native renal function and either a video cysto-urethrogram or cystoscopy and retrograde pyelography. Postoperative patency was evaluated with either cystograms or antegrade nephrograms in conjunction with a technetium-99m mercaptoacetyltriglycine study.

RESULTS Seven patients were followed with a mean follow-up time of 20.9 months (range 4.7-64.8 months). Three cases of VUR causing graft pyelonephritis and 4 cases of transplant ureteral stricture were identified. Five minimally-invasive transplant-to-native pyeloureterostomies and 2 transplant-to-native ureteroureterostomies were performed. Six cases were performed robotically and 1 laparoscopically. No recurrent episodes of pyelonephritis were observed for patients treated for VUR causing graft pyelonephritis. Postoperative renal scans and contrast studies demonstrated no evidence of obstruction or urinary leaks in all cases.

CONCLUSION Minimally-invasive reconstruction of the transplant ureter by pyeloureterostomy or ureteroureterostomy using the ipsilateral native ureter is feasible and can be safely performed with graft survival and acceptable complication rates.

UROLOGY 126: 227−231, 2019.

Ureteral complications are the most common urological complications after kidney transplantation, representing a significant cause of morbidity and potentially leading to graft dysfunction or loss. The most common postrenal transplant ureteral complications are ureteral strictures and vesicoureteral reflux (VUR). The incidence of ureteral strictures has been reported to range between 2% and 10.5%.[1] While VUR after kidney transplantation is common, reflux associated with graft pyelonephritis is reportedly relatively rare in contemporary series (1.4%-2.8%).[2-3] Ureteral strictures are usually, initially managed by decompression with either retrograde stenting, or percutaneous nephrostomy tube placement, and endoscopic dilation. As these conservative methods carry a recurrence rate of up to 45%, surgical ureteral reconstruction has been regarded the most definitive method of treatment.[4-5] Preferred ureteral reconstructive techniques include transplant pelvis to native ipsilateral ureter pyeloureterostomies (PU) and transplant ureter to native ipsilateral ureter ureteroureterostomy (UU). These procedures were traditionally performed with the open approach. In anuric patients, end-to-end PU or UU can be safely performed with ligation of the proximal native ureter. The need for ipsilateral native nephrectomy prior or at the time of the abovementioned procedures in kidney(s) which still produce urine is not well established. To our knowledge, we report the first series of minimally-invasive ureteral reconstructions with PUs and UUs in kidney transplant patients primarily utilizing the robotic-assisted laparoscopic approach.

MATERIALS AND METHODS

Among 262 patients who received a kidney transplant at our institution between April 2009 and September 2016, 7 patients were prospectively followed with the focus on ureteral complications. Seven patients required surgical correction (2.6%). Type of donor

Financial Disclosure: *The authors declare that they have no relevant financial interests.*

From the Lahey Hospital & Medical Center, Burlington, MA

Address correspondence to: Kevin K Yang, M.D., Lahey Hospital & Medical Center, Institute of Urology, 41 Mall Road, Burlington, MA 01805. E-mail: kevinyg@gmail.com

Submitted: September 11, 2018, accepted (with revisions): January 8, 2019

https://doi.org/10.1016/j.urology.2019.01.002
0090-4295

Table 1. Patient characteristics and indications before ureteral reconstruction

Patient ID	Age (y)	Sex	BMI	Original Transplant Indication	Ureteral Complication	Prior Interventions
1	32.9	F	31.6	Congenital dysgenesis, preclampsia	VUR and pyelonephritis	Ureteral orifice collagen injection
2	73.5	F	28.0	Hemolytic uremic syndrome	VUR and pyelonephritis	None
3	78.2	M	24.4	FSGS, solitary R kidney	Midureteral stricture	Nephrostomy tube placement, antegrade dilation
4	40.5	F	44.6	Familial amyloidosis	Ureterovesical junction stricture	Nephrostomy tube placement
5	43.8	F	26.4	Autosomal dominant polycystic kidney disease	VUR and pyelonephritis	None
6	55.3	M	33.3	Calcineurin toxicity	Midureteral stricture	Nephrostomy tube placement
7	63.4	M	26.6	Medication side effect	Midureteral stricture	Ureteral stent, nephrostomy tube placement

allograft and time between original transplantation and ureteral complications were recorded.

The surgical approach (laparoscopic vs robotic-assisted) was recorded in addition to any incidence of conversion to an open operation. Robotic-assisted laparoscopic surgery was carried out using the Intuitive Surgical da Vinci Si or Xi surgical system. Preoperative indications for surgical correction were: complete ureteral obstruction, strictures longer than 2 cm and failure of previous endoscopic treatment. Ureteral reconstruction was also indicated in every case of graft pyelonephritis associated with documented transplant VUR. For patients with ureteral strictures, a nephrostogram and percutaneous nephrostomy tube placement into the transplant kidney were performed for diagnosis and initial treatment. Retrograde or antegrade balloon dilation and placement of JJ stent were performed in strictures amenable to endoscopic treatment.

For patients with VUR and graft pyelonephritis, diagnostic criteria was defined as at least one episode of fever >38°C, a urine culture showing >50,000 colonies/mL and graft tenderness. Every patient with suspected VUR was evaluated with a voiding cystourethrogram (VCUG), cystoscopy, retrograde ureteropyelogram and selective urine culture from renal graft and native kidneys. They were kept on prophylactic antibiotic therapy until definitive surgery. Immediate postoperative hospital stay was recorded. Serum creatine was followed at its nadir post-transplant, at the diagnosis of post-transplant ureteral complication and at 1- and 6-months postureteral reconstruction. Postoperative cystograms were performed to assess for urinary leakage. Postoperative technetium-99m mercaptoacetyltriglycine renal scans (MAG3) were obtained 4 months after surgery (8 weeks after removal of indwelling ureteral stent) for all patients to ensure adequate drainage in the reconstructed ureters. Complications were reported based on the Clavien-Dindo classification system.

RESULTS

Between October 2011 and March 2018, 7 patients were identified to have undergone ureteral reconstructions following renal transplantation in a single surgeon, single institution setting. Four of the patients with ureteral complications following renal transplantation were women and 3 were men (See Table 1). Mean age at the time of ureteral reconstruction and body mass index were 55.4 years (range 32.9-78.2 years) and 30.7, respectively. Mean time between transplantation and ureteral reconstruction was 20.5 months (range 4.9-39.7 months). There were 3 cases of VUR causing graft pyelonephritis and 4 cases of transplant ureteral strictures (See Table 2).

For the 3 VUR patients, diagnoses were confirmed with VCUG and reflux was Grade 3 for all patients. One patient underwent a cystoscopy and submucosal injection of collagen at the transplant ureteral orifice, which was unsuccessful. For the 4 ureteral stricture patients, initial diagnoses of obstruction was suspected due to increased serum creatinine in association with evidence of hydronephrosis with renal allograft ultrasonography.

Table 2. Operative details of ureteral reconstruction and outcomes for all 7 patients

Patient ID	Time Between Original Transplant and Ureteral Reconstruction (mo)	Operative Details	Outcomes
1	29.9	Laparoscopic transplant to R native ureteroureterostomy, R native nephrectomy	No recurrent pyelonephritis, developed chronic rejection
2	39.7	Robotic transplant to R native pyeloureterostomy	No recurrent pyelonephritis
3	11.7	Robotic transplant to R native pyeloureterostomy	Normal drainage on MAG3
4	4.9	Robotic transplant to R native pyeloureterostomy	Normal drainage on MAG3
5	32.7	Robotic transplant to L native ureteroureterostomy	No recurrent pyelonephritis
6	6.0	Robotic transplant to R native pyeloureterostomy. Conversion to open	Normal drainage on MAG3
7	19.0	Robotic transplant to L native pyeloureterostomy	Normal drainage on MAG3

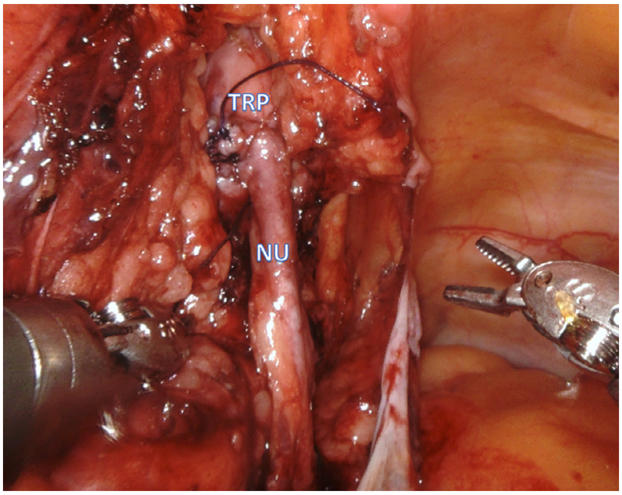

Figure 1. Transabdominal view of Patient #7's native-to-transplant pyeloureterostomy. NU, native ureter; TRP, transplant renal pelvis. (Color version available online.)

The presence of obstruction was confirmed with antegrade nephrostograms and/or a MAG3 renal scan.

Five transplant-to-native PUs and 2 transplant-to-native UUs were performed. Exposure of the dissection for a PU is shown in Figure 1. For the 2 cases, in which a UU was performed, the transplant renal pelvis was difficult to identify due to fibrosis in one case and a left sided transplant allograft placed in the ipsilateral iliac fossa with the renal pelvis posterior to allograft hilum in the other case. Both cases of UUs were performed for VUR with graft pyelonephritis. Mean operative time was 236 minutes (range 150-353 minutes).

Patient #6 required conversion to an open approach due to difficulty identifying the transplanted renal pelvis. In this case, the transplant allograft was placed in the ipsilateral (right) iliac fossa as well.

Double-J ureteral stents were placed in all reconstructed ureters. For all patients, except for Patient #7, cystograms were performed 2-4 weeks postoperatively for patients. Cystograms did not show urinary leakage and the ureteral stents were removed thereafter. For Patient #7, an antegrade nephrostogram was performed showing no urinary leakage prior to nephrostomy tube removal. Median hospital stay was 3 days (range 2-4). For the 3 VUR patients, there was no evidence of recurrent pyelonephritis after their ureteral reconstruction. For the 4 ureteral stricture patients, postoperative MAG3 studies of the reconstructive ureter demonstrated no obstructive parameters ($t^{1}/_{2}$ <20 minutes). There was no difference in serum creatinine between preoperative levels and postoperative levels at 1 month and 6 months (preoperative mean 1.6 mg/dL, 1 month postoperative mean 1.5 mg/dL and 6 month postoperative mean of 1.6 mg/dL).

Patient #1 experienced biopsy-confirmed chronic rejection 5 years after her ureteral reconstruction and required a new allograft transplant. Patient #2 experienced a Clavien Grade IIIa complication during her immediate postoperative course caused by kinking of her JJ ureteral stent. After transient decompression with a nephrostomy tube, both the ureteral stent and nephrostomy tube were removed. Patient #7 was readmitted on postoperative day #9 for a febrile urinary tract infection that resolved with antibiotics.

No other immediate postoperative complications were noted. There was no graft loss related to ureteral reconstructions.

DISCUSSION

Ureteral complications after kidney transplantation are relatively rare, but are significant causes of morbidity and potential graft loss. Surgical alternatives to endoscopic treatment of ureteral stricture after transplantation are direct reanastomosis of transplanted ureter, if enough ureteral length is available, ureteral reconstruction with native ipsilateral ureter with PU or UU or direct anastomosis between bladder and renal pelvis in cases of ureteral strictures, if the bladder capacity allows it.

Using the native ureter provides several advantages, obviating the need of a more intensive, often difficult, dissection of the distal transplant ureter and bladder and preventing a potentially refluxing anastomosis by incorporating the antireflux mechanism of the native intramural ureter. Furthermore the native ureteral orifice provides excellent access for potential future endoscopic procedures.

Taking advantage of minimally invasive platforms such as laparoscopy and robotics may furthermore reduce morbidity and time of convalescence. Our first case was performed laparoscopically and the following cases robotically. In a pilot case report of a 35-year-old female undergoing a robotic PU for a long segment ureteral stricture, Orvieto et al showed initial feasibility with this technique.[6] Our series provided reproducibility among 7 patients and expanded the technique to UUs. There are several, specific points of interest in ureteral reconstructions for renal transplantation allografts worth to be discussed.

Ureteral Strictures

Ureteral strictures are the most common urologic complications after renal transplantation. The etiology of the strictures is usually related to either ureteral ischemia, or technical error in performing the anastomosis. Most of these strictures present within the first 3 months after transplantation and are the result of ureteral ischemia.[7] Late strictures (>6 months) are likely the result of chronic vascular insufficiency or retroperitoneal fibrosis. Delayed graft function, donor age, creation of antireflux anastomosis and not utilizing double J ureteral stents at the time of transplantation have been associated with an increased incidence of strictures.

Usually the initial treatment for ureteral strictures is an endoscopic approach with nephrostomy tube placement, antegrade or, less commonly, retrograde balloon dilation and stent placement. The estimated long-term success rate of the endoscopic treatment of ureteral strictures after kidney transplant has been reported to be up to 64.3% in modern series.[5] Strictures caused by ischemia are more likely to be long and less likely to respond to endoscopic treatment.

Surgical approaches to ureteral stricture after transplantation include ureteroneocystostomy of the transplanted ureter if enough ureteral length is available. Adjunct techniques such as a Boari flap for extra length have been described.[7] Abdul-Mushsin et al report a series of 5 patients who have undergone robotic-assisted transplant ureteral reimplantations or pyelovesicostomies for ureteral strictures.[8] The authors highlight the benefits of a minimally invasive approach with a median length of stay of 1 day. However, concerns exist with reimplantations for transplant ureteral strictures. Most salient, the ability of reimplanting the ureter is limited by to length of the stricture. If, as in most cases, the stricture is secondary to ischemia, it is often difficult to establish the proper length of ureter to excise to avoid recurrence and additional dissection of the transplanted ureter could cause further ischemia. Our preferred technique of transplant-to-native PU allows drainage of the transplanted kidney even in cases of complete obliteration of the entire length of the ureter.

The use of the native ureter to reconstruct the strictured transplant ureter has been well-described in the transplant literature as an open technique.[9] In our series, we attempted to confer the benefits of a minimally invasive approach by adopting the laparoscopic and subsequently robotic technique.

VUR and Graft Pyelonephritis

The need to construct an antireflux anastomosis at the time of renal transplantation is still an open debate. Creation of antireflux anastomosis is associated with an increased incidence of ureteral obstruction and a high antireflux failure rate.[10] Thus, most transplant surgeons make no attempt to create an antireflux mechanism for fear of ureteral obstruction. For this reason, VUR after renal transplantation is very common. In spite of that, the incidence of graft pyelonephritis secondary to VUR is relatively low.[2-3]

Initial treatment of VUR after transplantation may be endoscopic with submucosal injection of bulking agents. Results are commonly temporary and multiple injections are usually necessary. Eventual progression to surgical intervention as with Patient #1 is often necessary. Direct reimplantation of the transplant ureter has the same potential for failure with VUR recurrence and is often limited by the difficulty to preserve an adequate length of ureter. Furthermore in these cases, one should be cautioned on the risk of stricture due to ischemia after repeated ureteral reimplantations. Finally, the selection of ureteral length that needs to be resected in order to cut back to vascularized tissue is often unclear. The utilization of native ureter for ureteral reconstruction provides a reliable native antireflux mechanism and allows an excellent access should endoscopic treatment be necessary for de-novo ureteral strictures.

Ureteral Reconstructions for Ipsilateral Iliac Fossa Grafts

In our series, 3 renal allografts were transplanted into the ipsilateral iliac fossa (2 in the left recipient iliac fossa, one in the right right). In these cases, access to the renal pelvis was very difficult as it lay behind the graft hilum. In theory, exposure of the pelvis could have been obtained by dissecting the graft off the psoas muscle fascia. For Patient #5, we thought that this maneuver was too morbid with potential harm to the transplanted kidney in the setting of a scarred renal pelvis. Thus, a robotic-assisted transplant-to-native UU was performed with minimal manipulation to the allograft kidney. The indication to reconstruct the ureter in this patient was graft pyelonephritis secondary to VUR and a UU provided an excellent correction to the reflux. Patient #6 required a conversion to an open technique in order to adequately expose the renal pelvis through the secondary branches of the renal hilum. Patient #7 required the utilization of indocyanine green injection with near-infrared fluorescence technology via the nephrostomy tube in order to identify the lower third of the renal pelvis behind the lower pole of the graft (Supplemental Figure 1). The presence of a renal allograft transplanted in the ipsilateral iliac fossa represented a marked increase in the complexity of the procedure.

Native Nephrectomy

The need for native nephrectomy at the time of ureteral reconstruction with ipsilateral native ureter has been debated in the literature.[11] The performance of native nephrectomy at the time of ureteral reconstruction adds a significant time to the procedure, with need of a larger incision in open cases and need for repositioning and an extraction incision in minimally invasive cases. In one series, native nephrectomy was eventually performed in patients who developed symptomatic hydronephrosis or sepsis.[12] A careful history was taken as to ascertain if the patient was anuric before his or her original renal transplantation. We have adopted the use of preoperative MAG3 renal scan to assess residual native renal function for all patients undergoing a ureteral reconstruction using the native ureter. In our series, Patient #1 underwent a planned native nephrectomy at the time of ureteral reconstruction and 2 patients developed asymptomatic native kidney hydronephrosis without symptoms. Patient #5 required bilateral native nephrectomies 20 months after ureteral reconstruction because of symptoms caused by the presence of large polycystic kidneys. No patients in our series required a subsequent native nephrectomy due to symptomatic hydronephrosis after their ureteral reconstruction. However, close monitoring for symptoms is imperative.

Robotic-Assisted Laparoscopic Technical Considerations

For the latter 6 cases in our series, a robotic-assisted laparoscopic approach was utilized for UU and PU repairs. Trocar placement was in a fan disposition with the camera port approximately 4-5 cm cranial to the umbilicus. A representative port setup for a left-sided PU with an Xi surgical system is shown in Supplemental Figure 2. The transabdominal portion of the operation is performed in a moderate Trendelenburg position.

Identification of the transplant renal pelvis may pose significant difficulties in the setting of prior surgery and infection. If technically feasible, we recommend cystoscopic placement of open-ended ureteral catheters into the ipsilateral native ureter and ipsilateral transplant ureter if the indication is for transplant ureter VUR or partial obstruction. This allows for retrograde injection of saline to dilate the transplant renal pelvis for easier identification. If there is a complete obstruction, then preoperative placement of a nephrostomy tube into the transplant kidney followed by saline instillation may be of use. As discussed in our most recent case, Patient #7, we used a near-infrared fluorescence filter in conjunction with indocyanine green injected via the nephrostomy tube to easily identify the renal pelvis (Supplemental Figure 1). The feature is available in select Si cameras and all Xi robotic platforms and has been reported in multiple series for ureteral reconstructions [13]. The PU or UU anastomosis was performed with color-coded interrupted 4-0 Vicryl with the insertion of a double-J ureteral stent prior to the closure of the anterior plate. Patient #2 is shown as a demonstrative technical video in Supplementary Video 1.

CONCLUSION

Minimally invasive ureteral reconstruction of the transplanted ureter or renal pelvis with native ureter by PU or UU is feasible and safe for post-transplant ureteral strictures or symptomatic VUR. Our series demonstrate outcomes comparable to the open technique with potential advantages of the minimally invasive approach.

SUPPLEMENTARY MATERIALS

Supplementary material associated with this article can be found, in the online version, at https://doi.org/10.1016/j.urology.2019.01.002.

References

1. Breda A, Bui MH, Liao JC, et al. Incidence of ureteral strictures after laparoscopic donor nephrectomy. *J Urol*. 2006;176:1065–1068.
2. Choi YS, Kim KS, Choi SW, et al. Ureteral complications in kidney transplantation: analysis and management of 853 consecutive laparoscopic living-donor nephrectomies in a single center. *Transplant Proc*. 2016;48:2684–2688.
3. Praz V, Leisinger HJ, Pascual M, Jichlinski P. Urological complications in renal transplantation from cadaveric donor grafts: a retrospective analysis of 20 years. *Urol Int*. 2005;75:144–149.
4. Juaneda B, Alcaraz A, Bujons A, et al. Endourological management is better in early-onset ureteral stenosis in kidney transplantation. *Transplant Proc*. 2005;37:3825–3827.
5. Kwong J, Schiefer D, Aboalsamh G, Archambault J, Luke PP, Sener A. Optimal management of distal ureteric strictures following renal transplantation: a systematic review. *Transpl Int*. 2016;29:579–588.
6. Orvieto MA, Chien GW, Shalav AL, Tolhurst SR, Rapp DE, Galocy RM. Case report: robot-assisted laparoscopic pyeloureterostomy in a transplanted kidney with ureteral stricture. *J Endourol*. 2006;20:31–32.
7. Pike TW, Pandanaboyana S, Hope-Johnson T, Hostert L, Ahmand N. Ureteric reconstruction for the management of transplant ureteric stricture: a decade of experience from a single center. *Transpl Int*. 2015;28:529–534.
8. Abdul-Muhsin HM, McAdams SB, Nuñez RN, Katariya NN, Castle EP. Robot-assisted transplanted ureteral stricture management. *Urology*. 2017;105:197–201.
9. Salomon L, Saporta F, Amsellem D, et al. Results of pyeloureterostomy after ureterovesical anastomosis complications in renal transplantation. *Urology*. 1999;53:908–912.
10. Alberts VP, Idu MM, Legemate DA, Laguna Pes MP, Minnee RC. Ureterovesical anastomotic techniques for kidney transplantation: a systematic review and meta-analysis. *Transpl Int*. 2014;27:593–605.
11. Baquero A, Ginsberg PC, Kaschak D, et al. Experience with pyeloureterostomy associated with simple ligation of native ureter without ipsilateral nephrectomy in renal transplantation. *J Urol*. 1985;133:386–387.
12. Sandhu K, Masters J, Ehrlich Y. Ureteropyelostomy using the native ureter for the management of ureteric obstruction or symptomatic reflux following renal transplantation. *Urol*. 2012;79:929–932.
13. Lee Z, Moore B, Giusto L, Eun DD. Use of indocyanine green during robot-assisted ureteral reconstructions. *Eur Urol*. 2015;67:291–298.