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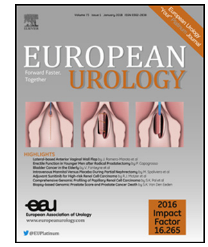

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Surgery in Motion

Robotic Ureteral Reconstruction Using Buccal Mucosa Grafts: A Multi-institutional Experience

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Abstract

Background: Minimally invasive treatment of long, multifocal ureteral strictures or failed pyeloplasty is challenging. Robot-assisted buccal mucosa graft ureteroplasty (RBU) is a technique for ureteral reconstruction that avoids the morbidity of bowel interposition or autotransplantation.
Objective: To evaluate outcomes for RBU in a multi-institutional cohort of patients treated for revision ureteropelvic junction obstruction and long or multifocal ureteral stricture at three tertiary referral centers.
Design, setting, and participants: This retrospective study involved data for 19 patients treated with RBU at three high-volume centers between October 2013 and July 2016.
Surgical procedure: RBU was performed using either an onlay graft after incising the stricture or an augmented anastomotic repair in which the ureter was transected and re-anastomosed primarily on one side, and a graft was placed on the other side.
Outcome measurements and statistical analysis: Preoperative, intraoperative, and post-operative variables and outcomes were assessed. A descriptive statistical analysis was performed.
Results and limitations: The onlay technique was used for 79%, while repair was carried out using the augmented anastomotic technique for the remaining cases. The reconstruction was reinforced with omentum in 95% of cases. The ureteral stricture location was proximal in 74% and mid in 26% of cases. A prior failed ureteral reconstruction was present in 53% of patients. The median stricture length was 4.0 cm (range 2.0–8.0), operative time was 200 min (range 136–397), estimated blood loss was 95 ml (range 25–420), and length of stay was 2 d (range 1–15). There were no intraoperative complications. At median follow-up of 26 mo, the overall success rate was 90%.
Conclusions: RBU is a feasible and effective technique for managing complex proximal and mid ureteral strictures.
Patient summary: We studied robotic surgery for long ureteral strictures using grafts at three referral centers. Our results demonstrate that robotic buccal mucosa graft ureteroplasty is a feasible and effective technique for ureteral reconstruction.

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1. Introduction

Long strictures of the mid and proximal ureter are difficult to repair and are often treated by replacement of the ureter with a segment of ileum or autotransplantation of the kidney. These treatment options can have significant morbidity associated with bowel substitution and vascular complications [1–7]. To avoid the morbidity of bowel substitution or vascular anastomosis, we described an initial series of robot-assisted ureteral reconstructions using buccal mucosa grafts (BMGs) in 2015 [8].

BMG use for ureteral reconstruction was first described by Somerville and Naude [9] in an animal model in 1984. A BMG has a pan-laminar vascular plexus ideal for graft take and a thick non-keratinized "wet" epithelium. Over the past 25 yr, BMG has become the graft of choice for urethroplasty [10,11]. A buccal graft can be supported by a variety of different surfaces including corpus spongiosum, tunica albuginea of the corpora cavernosa, tunica dartos, and gracilis muscle [12–14]. In the initial report, the graft was tubularized to replace a segment of the ureter, and supported with pedicled omentum [9,15]. The first use of BMG for ureteral reconstruction in humans was described in 1999, and BMG use in the open repair of ureteral strictures has subsequently been reported in several case series [15–19].

Robotic assistance for ureteral reconstruction has several advantages: magnification, three-dimensional visualization, smaller incisions, and articulated instruments that allow for delicate and precise suturing [20]. Intravascular indocyanine green (ICG) fluorescence imaging [21] can be used to assess ureteral viability. Intraureteral ICG, or a flexible ureteroscope with a fluorescence lens, can help to identify the ureter in a bed of fibrosis and the exact location of the ureteral stricture [8,22]. Since our previous report on robotic BMG ureteroplasty (RBU) [8], the procedure has been replicated in multiple centers. We now report on the multi-institutional collaborative experience of RBU in three centers.

2. Patients and methods

Between October 2013 and July 2016, we performed RBU procedures on 19 patients at three institutions. The primary selection criterion for the procedure was a benign proximal or mid ureteral stricture not amenable to primary anastomosis because of stricture length or extensive fibrosis. Distal ureteral strictures were excluded, as these patients could be treated with ureteroneocystostomy. Our ureteroplasty technique involves onlay of BMG, so patients were excluded if they had complete absence of a large (>5 cm) portion of the ureter, such as after oncologic resection or ureteral avulsion. Those patients underwent alternative reconstructive techniques such as appendiceal interposition, ileal ureter, or autotransplantation.

2.1. *Preoperative preparation*

Before surgery, we prefer to remove the ureteral stent to help in clearly defining the location and length of the obstruction. Having a stent in the ureter creates edema that obscures the true length of the stricture. For patients who were stent-dependent, a nephrostomy tube was placed.

2.2. *Surgical technique*

While the surgical technique has been described previously, we have made some modifications based on more mature experience [8].

Patients are positioned in a lateral decubitus position with the genitalia prepped into the field to allow for access to the bladder and urethra. For male patients, the penis is prepared into the field. For female patients, the leg is placed in a modified lithotomy position (Fig. 1) to allow access to the urethra and concomitant ureteroscopy. Alternatively, the patient may be placed in the lithotomy position first, and a ureteral stent is inserted into the affected ureter up to the stricture. The endotracheal tube is secured on the dependent side of the mouth, and the mouth is draped separately from the abdominal field in preparation for BMG harvest. BMG harvest can be performed concurrently with robotic surgery, or with the robot undocked, depending on the preference of the surgeon.

Port placement is similar to that for pyeloplasty [23]. Four robotic ports are placed, one at the costal margin, another above the umbilicus at the lateral border of the rectus, and two between the umbilicus and anterior superior iliac spine to allow for adequate spacing of all ports. An assistant port is placed medial to the robotic ports, between the camera port and inferior robotic port. The robot is then docked at a 90° angle to the patient.

During dissection we use monopolar scissors or a hook in one hand, bipolar forceps in another, and ProGrasp forceps in a third for retraction. During the reconstruction we switch to two needle drivers in the right and left hands. Ureterotomy may be performed using robotic tenotomy scissors. For harvest of the omentum, a vessel sealer may be useful.

After incision of the line of Toldt and medialization of the colon, the ureteral stricture can be identified via several techniques. Intraureteral ICG (a 5-ml aliquot of 2.5 mg diluted in 25 ml) may be injected into the ureter via the ureteral stent or nephrostomy tube [22]. We find that use of ICG is very helpful in assessing both the location of the ureteral obstruction and the extent of the ureteral pathology before reconstruction. Intravascular ICG can be used to evaluate the viability of the ureter (intravenous injection of an aliquot of 1–3 ml of 2.5 mg diluted in 25 ml). The major drawback with intraureteral ICG is that once the ureter is incised, the ICG spills out and stains the entire field green. At that point, intravascular ICG is no longer useful for evaluation of viability.

Alternatively, intraoperative ureteroscopy may be used to identify the stricture. The ureteroscope is placed up to the distal extent of stricture, at which point the near-infrared fluorescence modality of the da Vinci Si or Xi robot allows visualization of the ureteroscope light (Fig. 2). After identification of the ureteral stricture, a stay suture helps to mark the stricture and allows for retraction of the ureter.

Ureteroscopy during robotic surgery may be cumbersome as it requires additional video equipment, access to the lower tract, and a bedside surgeon who can perform ureteroscopy without fluoroscopy. Thus, we carefully choose whether intraureteral or intravascular ICG is useful for each particular reconstructive case. For cases in which evaluation of ureteral viability is particularly important, we do not use intraureteral ICG, and perform ureteroscopy for identification of the ureteral stricture.

Once the length of the stricture is determined, BMG harvest may be performed. Since the head is in the flank position, a headlamp is useful for visualization. The cheek is elevated superiorly using holding sutures on the lip, and Stenson's duct is identified. Hydrodissection of the buccal mucosa is performed using lidocaine and epinephrine. The grafts are tailored to match the length of the ureteral stricture and 1–1.5 cm in width. Back table preparation of the BMG is performed in which submucosal tissue is removed from the graft.

While the graft is being harvested, ureterotomy is performed over the previously demarcated stricture and the graft site is prepared. The choice between incision of the ureter and the augmented repair depends on the