Journal of Surgery
Hwang AJ, et al. J Surg 9: 11029
www.doi.org/10.29011/2575-9760.011029
www.gavinpublishers.com
Case Series

Robotic Buccal Mucosa Graft Ureteroplasty for Complex Ureteral Stricture Disease: Early Outcomes at a Single Institution

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Citation: Hwang AJ, Talluri S, Tonzi MS, Singh A, Lange JN, et al. (2024) Robotic Buccal Mucosa Graft Ureteroplasty for Complex Ureteral Stricture Disease: Early Outcomes at a Single Institution. J Surg 9: 11029 DOI: 10.29011/2575-9760.11029

Received Date: 03 April 2024; **Accepted Date:** 08 April 2024; **Published Date:** 10 April 2024

Abstract

Background: Complex ureteral stricture disease is a challenging surgical problem. Traditional approaches, such as ileal ureter interposition or renal auto-transplantation, have significant associated morbidity. Robotic Buccal Mucosal Graft Ureteroplasty (RBMGU) is an alternative technique for managing complex ureteral stricture disease. This study aims to establish the safety and efficacy of RBMGU in managing Complex Ureteral Stricture Disease (CUSD).

Materials & Methods: A retrospective analysis of ten patients with benign CUSD who underwent RBMGU between 2019 and 2023 was conducted. Patient selection criteria included imaging evaluation, patient characteristics, and intraoperative findings. Demographic data, perioperative variables, and follow-up outcomes were analyzed using descriptive statistics. The primary outcome measure was successful stricture repair, defined as resolution of flank pain without the need for secondary intervention. Secondary outcomes included radiographic evidence of upper tract urinary obstruction resolution.

Results: All ten patients underwent technically successful RBMGU performed by a single surgeon. Ureterolithiasis was the etiology in nine cases, with one case involving prior retroperitoneal radiation. Prior interventions included ureteroscopy (n=7), ureteral balloon dilation (n=3), and failed robotic pyeloplasty (n=1). Strictures were predominantly in the proximal ureter (n=7). At a median follow-up of 10 months, 80% of patients reported pain resolution, while the remaining 20% showed improvement. Eight patients exhibited no evidence of obstruction on follow-up MAG3 renal scans. Median stricture length was 3.0 centimeters, with median operating room time of 301 minutes and estimated blood loss of 25 cc. No significant intraoperative complications were observed.

Conclusion: These findings indicate that RBMGU is a feasible and effective approach for managing CUSD, suggesting its potential for adoption by community-based robotic urologists.

Keywords: Buccal Mucosa Graft; Robotics**;** Ureteral Stricture Disease

Background

The landscape of surgical management for ureteral stricture disease has undergone significant transformation since the inception of open buccal ureteroplasty in 1999 [1]. A notable milestone occurred in 2013 with the introduction of Robotic-Assisted Laparoscopic Buccal Mucosal Graft Ureteroplasty (RBMGU) by Zhao [2], marking a pivotal advancement in the field. With continuous enhancements in robotic surgical technology and refinements in buccal ureteroplasty techniques, outcomes have substantially improved [3]. RBMGU emerges as a particularly valuable tool in addressing Complex Ureteral Stricture Disease (CUSD), typically characterized by strictures resistant to primary ureteroureterostomy [1]. The etiology of CUSD varies widely, often involving long or multi-segment strictures. Traditional approaches to managing such complex strictures, such as ileal ureter interposition or renal autotransplantation, are associated with considerable morbidity [4,5]. For instance, ileal ureter interposition may lead to metabolic acidosis and other bowel-related complications, while renal autotransplantation carries risks of hemorrhage and kidney failure [5]. RBMGU offers a less invasive alternative that mitigates many of the complications associated with conventional techniques. Although long-term follow-up data remain limited due to the novelty of the procedure, outcomes from the multi-institutional Collaborative Of Reconstructive Robotic Ureteral Surgery (CORRUS) group have shown promising results, including reduced postoperative morbidity, shorter hospital stays, and an impressive 87% surgical success rate [3]. Our objective is to present the safety and efficacy of RBMGU performed by a single surgeon over a five-year period, highlighting the potential for widespread adoption among community urologists with robotic surgical expertise.

Methods

Informed consent was obtained from all subjects upon enrollment. Over the period spanning 2019 to 2023, ten patients underwent Robotic Buccal Mucosa Graft Ureteroplasty (RBMGU) for benign ureteral stricture disease at a single institution. The Da Vinci Xi platform was uniformly employed for all procedures. Clinical outcomes were retrospectively reviewed. The decision to proceed with RBMGU was made by the primary surgeon at the time of operation following meticulous analysis of preoperative imaging, patient characteristics, and intraoperative findings. Preoperative evaluation encompassed retrograde pyelography, Computed Tomography (CT), and MAG3 Lasix renography. For patients with ureteral stents, we advocate preoperative stent removal and ipsilateral nephrostomy tube placement to allow for four weeks of ureteral rest. This facilitates a more comprehensive delineation of the true stricture length before definitive repair [6]. Immediate preoperative retrograde and/or anterograde pyelography aids in precisely determining stricture location and length. A 5-French ureteral catheter is retrogradely advanced under fluoroscopy with a cystoscope to the site of obstruction and secured to a Foley catheter drainage system for intraoperative identification through retrograde, intraureteral injection of Indigo Carmine Green (ICG). The robotic portion of the procedure employs two patient positions based on stricture location: a full flank position for upper ureter strictures and a modified flank position for mid or distal ureteral strictures, or long segment strictures (Figure 1; [6]). Patients are placed in the dorsal lithotomy position with extremities in Yellofin® stirrups, arms extended laterally, and chest secured with padded tape. Trendelenburg positioning and airplaning facilitate optimal bowel displacement. After robotic docking, precise ureteral dissection is undertaken with minimal manipulation to preserve ureteral adventitia and periureteral fat. We avoid circumferential dissection to minimize disruption of ureteral blood supply and utilize the Da Vinci Firefly integrated Near-Infrared Fluorescence (NIRF) system to visualize the vascular network and to delineate the strictured segment. Intraureteral injection of ICG assists in identifying strictured segments, particularly in cases of altered retroperitoneal anatomy or prior radiation [7]. The strictured ureter is incised along its ventral surface until healthy, bleeding tissue is encountered on both ends.

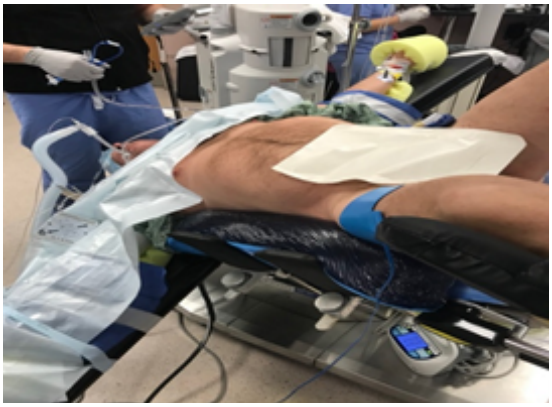

Figure 1: Patient in supine, modified flank position on robotic operating table

Buccal mucosal graft sizing is facilitated with a ruler (Figure 2), and procurement can occur simultaneously with robotic dissection or in a stepwise manner. Graft defatting and tagging with a silk stay suture ensure safe introduction into the abdomen.The graft is introduced via a 12 mm airseal port and sutured to the apex of the strictured segment using 4-0 Monocryl on an RB-1 needle. Intraoperative sharp trimming of the graft is occasionally needed to achieve a proper fit. One side of the graft is then secured in a running manner. We are careful to ensure ureteral plate mucosa to

graft mucosa apposition when suturing the graft. A variable-length pyeloplasty ureteral stent is advanced in an antegrade manner after being brought through the 12 mm assistant port. Once the stent is in proper position, the second side of the graft is secured similarly, and the two sutures are tied together. Adequate vascularized tissue backing, typically provided by the omentum, ensures graft viability and structural support. We typically secure the graft to the omentum using several interrupted absorbable sutures to facilitate graft inculcation and inosculation. In select mid-ureteral strictures when a dorsal onlay is required and circumferential ureteral mobilization is necessary, the graft can be directly fixed to the psoas muscle to provide blood supply to the dorsal graft. The omentum is carefully secured to the fascia psoas or quadratus muscle fascia using a 2-0 V-loc suture. In cases where omental tissue is insufficient, alternative vascularized tissues such as the colonic mesentery are utilized. Patient demographics, perioperative data, and follow-up were retrospectively reviewed to evaluate primary and secondary outcomes, with surgical success defined as resolution of flank pain and absence of ureteral obstruction on follow-up imaging without the need for secondary intervention. Clavien-Dindo complications were documented and reported.

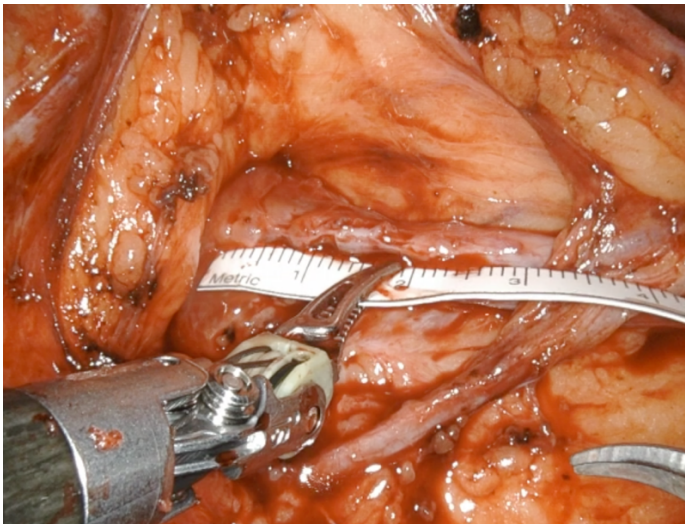

Figure 2: Intracorporeal measurement of ureteral stricture after ventral incision to determine graft length

Results

All ten patients underwent technically successful RBMGU under the expertise of a single robotic surgeon. Stricture etiology varied, with eight patients experiencing a combination of recurrent ureterolithiasis and iatrogenic endoscopic injury. One patient developed a ureteral stricture due to radiation therapy for testicular cancer, while another had a prior failed pyeloplasty attempting to manage a proximal ureteral stricture resulting from previous ureteroscopic instrumentation. Notably, four patients had undergone previous surgical interventions for their ureteral strictures. Preoperatively, five patients had nephrostomy tubes in place, and three had experienced recurrence following ureteral balloon dilation. The majority of strictures (70%) were located in the proximal ureter, with two in the middle ureter and one in the distal ureter. At a median follow-up of 10 months, the majority (80%) of patients reported no residual pain, with two patients noting improvement. Most patients (89%) exhibited no evidence of obstruction on follow-up MAG3 renal scans, although one patient's results were inconclusive due to pre-existing renal dysfunction for which the reconstruction was performed in an attempt to salvage the renal unit.Ventral Buccal Mucosal Graft (BMG) onlay technique was universally employed, with backing provided by an omental flap in nine cases and the posterior colonic mesentery in one case. Median operating time was 301 (range 210-378) minutes, with estimated blood loss ranging from 20 to 50 cc. The median stricture length was 3.0 (range 2.5-4.0) cm; length of stay was 1 (range 0-2) day. Patient demographics reflected a median age of 46 (range 34-70) years and a median body mass index of 28.1 (range 19.1-46.4).Indocyanine green was utilized in 20% of cases, and the median length of hospital stay was one day. issues or complications related to buccal harvest sites. Half of the patients in the series were current tobacco smokers, while 30% had never smoked, and 20% were former smokers. One patient developed a postoperative urinar Postoperative ureteral stent removal occurred at a median of 38 days, and complications were minimal, with no significant intraoperative y tract infection necessitating antibiotic therapy, while two experienced displacement of ureteral stents requiring repositioning.

Discussion

Complex ureteral stricture disease presents a significant challenge to reconstructive urologists. While procedures such as ileal ureter interposition and renal autotransplantation offer durable preservation of renal function, they are complex and associated with substantial comorbidity [5]. Conversely, chronic use of ureteral stents or nephrostomy tubes, while temporarily relieving obstruction, leads to decreased quality of life, frequent surgical interventions, increased costs, psychological distress, and infectious complications [8]. Robotic buccal mucosa graft ureteroplasty provides a less invasive alternative with minimal comorbidity, as demonstrated in this case series, making it feasible for urologists experienced in robotic urologic surgery. BMG has gained popularity in reconstructive urology due to its favorable properties. The oral mucosa, resembling urothelium, is adapted to constant minor trauma and heals rapidly, owing to a robust epithelial layer, thin lamina propria, and extensive vascular plexus optimal for rapid imbibition and inosculation. The oral cavity is easily accessible, and the graft harvest is performed with minimal morbidity. Closure of the graft site is optional and given the robust

regenerative properties of the oral mucosa, repeat grafts can be harvested from the same site given adequate healing time [9]. BMG urethroplasty has shown consistently favorable outcomes, establishing it as a "new gold standard" in urethral reconstruction [10]. This success has generated optimism for its application in ureteral reconstruction.The use of BMG in ureteroplasty dates back to 1999, with early successes reported in open procedures with successful graft patency reported by antegrade nephrostogram, retrograde pyelography, or excretory urography [1]. These early successes were replicated in a series of six patients [11]. Badawy also reported similar success [12].

The evolution of minimally invasive techniques led to the adoption of the Da Vinci robotic platform in RBMGU, demonstrating clinical success in repairing iatrogenic ureteral injuries [2]. The patency of these repaired ureters was confirmed by radiologic evaluation via serial ultrasound and renal scan. At a median follow-up of 5 months, all repairs remained radiologically patent, and no patients had residual flank pain. Further studies comparing BMG ureteroplasty to ureteral stenting alone have shown superior outcomes with BMG grafting, validating its utility. In 2021, Yang conducted a two-phase study comparing BMG ureteroplasty to ureteral stenting alone [13]. Prior to definitive repair, patients underwent 6 months of ureteral stenting for their stricture.

Glomerular Filtration Rate (GFR), estimated GFR, and Quality Of Life (QOL) outcomes were evaluated in a paired setting between the conclusion of phase 1 (ureteral stenting) and phase 2 (definitive ureteral repair). Across all three parameters, definitive buccal mucosal grafting outperformed extended ureteral stenting. Remarkably, at the 12-month follow-up, no patients experienced a recurrence of their stricture. This study provides a pragmatic comparison of BMG ureteroplasty versus ureteral stenting alone and furnishes relatively long-term follow-up data affirming the efficacy of the approach. The CORRUS database provides long-term follow-up data on patients undergoing BMG ureteroplasty, revealing an overall success rate of 87% [3]. The CORRUS database presents the most extensive follow-up data to date, encompassing 54 patients who underwent BMG ureteroplasty from 2013 to 2019 [3]. Strictures were predominantly located proximally (72%) or in the middle (15%) of the ureter, with 33% of patients having previously undergone unsuccessful ureteral reconstruction.

The median stricture length was 3.0 cm (range 2.0–8.0), and the median follow-up duration was 27 months. The overall success rate, defined as resolution of hydronephrosis and clinical improvement, stood at 87%. Notably, among patients experiencing stricture recurrence, three out of seven were diagnosed within two months postoperatively, while the remaining four were diagnosed more than ten months after surgery. This underscores the progressive nature of stricture disease, which can manifest as a long-term complication despite initial intervention.However, tobacco use is considered a relative contraindication due to decreased success rates and increased morbidity from the harvest site [14]. In conclusion, RBMGU offers a promising solution for CUSD, providing a less invasive alternative with favorable outcomes and minimal comorbidity. Ongoing research and collaborative efforts contribute to further refining this technique and expanding its applicability in ureteral reconstruction.

Conclusion

Despite our lower case volume compared to other academic institutions, our incidence of post-operative and short-term complications remains minimal. This highlights the potential applicability of this technique to community urologists. Considering the relative rarity of CUSD, ongoing multi-institutional collaboration is essential to comprehensively ascertain both short and long-term efficacy.

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