A Multi-Institutional Experience With Robotic Ureteroplasty With Buccal Mucosa Graft: An Updated Analysis of Intermediate-Term Outcomes

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OBJECTIVE To update our prior multi-institutional experience with robotic ureteroplasty with buccal mucosa graft and analyze our intermediate-term outcomes. Although our previous multi-institutional report provided significant insight into the safety and efficacy associated with robotic ureteroplasty with buccal mucosa graft, it was limited by small patient numbers.

METHODS We retrospectively reviewed our multi-institutional database to identify all patients who underwent robotic ureteroplasty with buccal mucosa graft between October 2013 and March 2019 with ≥12 months follow up. Indication for surgery was a complex proximal and/or middle ureteral stricture not amenable to primary excision and anastomosis secondary to stricture length or peri-ureteral fibrosis. Surgical success was defined as the absence of obstructive flank pain and ureteral obstruction on functional imaging.

RESULTS Of 54 patients, 43 (79.6 %) patients underwent an onlay, and 11 (20.4%) patients underwent an augmented anastomotic robotic ureteroplasty with buccal mucosa graft. Eighteen of 54 (33.3%) patients previously failed a ureteral reconstruction. The median stricture length was 3.0 (IQR 2.0-4.0, range 1-8) centimeters. There were 3 of 54 (5.6%) major postoperative complications. The median length of stay was 1.0 (IQR 1.0-3.0) day. At a median follow-up of 27.5 (IQR 21.3-38.0) months, 47 of 54 (87.0%) cases were surgically successful. Stricture recurrences were diagnosed ≤2 months postoperatively in 3 of 7 (42.9%) patients, and ≥10 months postoperatively in 4 of 7 (57.1%) patients.

CONCLUSION Robotic ureteroplasty with buccal mucosa graft is associated with low peri-operative morbidity and excellent intermediate-term outcomes. UROLOGY 147: 306−310, 2021.

Naude first described open ureteroplasty with buccal mucosa graft (OU-BMG) in 1999 for management of patients with complex ureteral strictures not amenable to ureteroureterostomy.[1] OU-BMG was proposed as a potentially less morbid and technically demanding option compared to ileal ureter replacement (IUR) and renal autotransplantation (RA), which require bowel and vascular reconstruction, respectively. Buccal mucosa is particularly well-suited for grafting in the urinary tract as it is readily accessible, hairless, compatible with a wet environment, and has a highly vascular lamina propria that facilitates graft take. Furthermore, harvesting buccal mucosa graft (BMG) for urologic reconstruction has been associated with low morbidity.[2]

The robotic platform is useful for reconstruction of complex ureteral strictures.[3,4] Robotic ureteral reconstruction maintains the benefits of minimally invasive surgery such as decreased estimated blood loss, length of hospital stay (LOS), and postoperative pain, and additionally provides magnified 3-dimensional vision, the ability to operate in small anatomic spaces, and wristed instrumentation to allow for precise dissecting and suturing.[5] Additionally, indocyanine green (ICG) may be utilized intraoperatively as a real-time contrast agent to assist with ureteral identification[6,7] and assessment of ureteral perfusion.[8] Since the first reported robotic ureteroplasty with BMG (RU-BMG)

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by Zhao et al. in 2015,[9] the technique has been replicated at multiple centers. We previously published our multi-institutional RU-BMG experience of 19 patients with excellent outcomes.[10]

Despite this, the current literature regarding ureteral reconstruction with BMG is still limited to a handful of small case series and there are < 50 total unique cases reported. As such, assessment of the safety and efficacy associated with the technique is limited. Furthermore, there is a paucity of literature describing the incidence and timing of surgical failures after ureteral reconstruction with BMG. The purpose of the current report was to update our prior multi-institutional RU-BMG experience and analyze our intermediate-term outcomes.

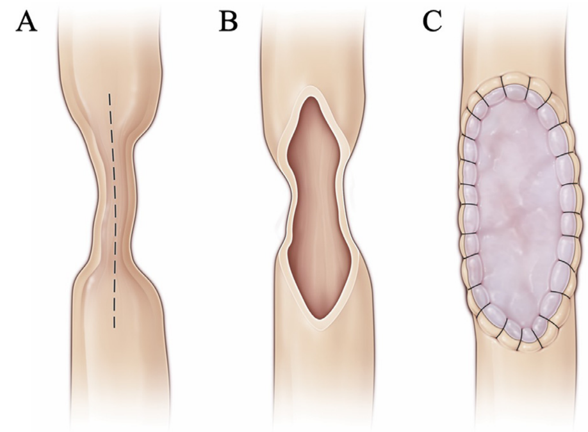

Figure 1. Onlay BMG ureteroplasty for narrowed ureteral stricture. (**A**) dotted line denotes location of longitudinal incision along length of ureteral stricture. (**B**) ureteral defect after longitudinal incision. (**C**) BMG onlayed onto ureteral defect. (Color version available online.)

MATERIALS AND METHODS

We performed a multi-institutional Institutional Review Board approved retrospective review of all patients who underwent RU-BMG at 3 institutions between October 2013 and March 2019 in the collaborative of reconstructive robotic ureteral surgery (COR-RUS) database. Patients with <12 months follow-up were excluded from analysis. All procedures were performed by 3 primary surgeons (LCZ, MDS, and DDE) using the da Vinci Surgical System (Intuitive Surgical, Sunnyvale) with integrated near-infrared fluorescence (NIRF) imaging capability. The indication for RU-BMG was a benign proximal and/or middle ureteral stricture not amenable to primary excision and anastomosis due to stricture length and/or extensive peri-ureteral fibrosis. All strictures were located between the ureteropelvic junction and lower border of the sacroiliac joint.

We analyzed patient characteristics and perioperative outcomes using descriptive statistics. Stricture length was determined by the primary surgeon during RU-BMG. The primary outcomes were ≤30 day major (Clavien >2) postoperative complications, LOS, and surgical success, defined as the absence of obstructive flank pain and ureteral obstruction on radiographic imaging (ie, retrograde pyelography,[11] computerized tomography urography, and/or renal scan).

Surgical Technique

RU-BMG. We previously detailed our approach to RU-BMG.[9-11] After ureterolysis and determination of ureteral stricture length, the BMG is harvested by hydrodissecting with lidocaine and epinephrine, and sharply excising it off of the buccinator muscle. The BMG is prepared by removing submucosal tissue, and fashioning it to appropriate dimensions. Graft length is determined by measuring the ureteral defect intracorporeally with a ruler, and width is 10-15 millimeters.

We use BMG in 2 ways during ureteral reconstruction. In patients with a narrowed ureteral lumen, we utilize the onlay technique. This involves making a longitudinal incision over the strictured ureter and anastomosing BMG to the defect using running absorbable sutures (Fig. 1A-C). In patients with an obliterated ureteral lumen or a transected ureter, we utilize the augmented anastomotic technique. This involves excising strictured ureter, anastomosing a plate of healthy ureter using a running absorbable suture, and anastomosing a BMG to the remaining defect using running absorbable sutures (Fig. 2A-C). In all cases, a 6-Fr double-J stent is placed after completing half of the anastomosis.

An omental or peri-nephric fat flap is used to wrap the reconstructed ureter to supplement BMG take. Formation of an omental flap involves mobilizing a broad-based pedicle of greater omentum supplied by the right or left gastroepiploic artery. Formation of a peri-nephric fat flap involves incising Gerota's fascia and mobilizing the underlying peri-nephric fat. Although omental flaps may be utilized for proximal and/or middle ureteral repairs, the peri-nephric fat flap is generally only suitable for ureteropelvic junction repairs.

ICG. ICG may be used either intraureterally or intravenously at the discretion of the primary surgeon based on intraoperative findings. Intraureteral ICG involves injecting 10 milliliters of ICG (25 milligrams ICG in 10 milliliters of water) into the ureteral lumen in a retrograde (via ureteral catheter) and/or antegrade (via percutaneous nephrostomy tube) fashion. Under NIRF, nonstrictured ureter fluoresces green, strictured ureter is poorly or un-fluoresced, and background tissue is un-fluoresced. This technique allows for ureteral identification in the setting of altered anatomy or peri-ureteral inflammation, and delineation of ureteral stricture margins.[6,7]

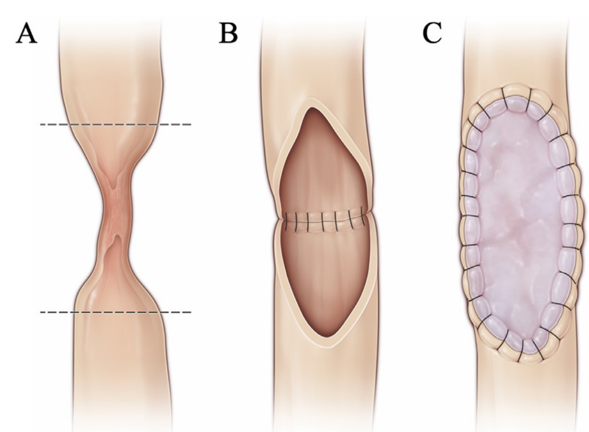

Figure 2. Augmented anastomotic BMG ureteroplasty for obliterated ureteral stricture. (**A**) dotted line denotes location of ureteral excision. (**B**) anastomosis of plate of healthy ureter. (**C**) BMG onlayed onto ureteral defect. (Color version available online.)

Intravenous ICG involves injecting 2 milliliters of ICG. Approximately 30-45 seconds after intravenous administration, ureteral perfusion may be assessed. Under NIRF, healthy ureter fluoresces green, strictured ureter is poorly or un-fluoresced, and background tissue fluoresces green. This technique allows for assessment of healthy (perfused) vs compromised (poorly perfused) ureter.[8] We generally avoid utilization of intravenous ICG when using intraureteral ICG as the fluorescence from intraureteral ICG can confound accurate interpretation of ureteral perfusion.

Postoperative Follow-up. Double-J stents were removed between 4 and 6 weeks postoperatively. Postoperative follow-up and functional imaging were subject to minor variations depending on patient history and surgeon preference. Patients were typically instructed to follow-up once between 2 and 4 months, once or twice between 6 and 12 months, and at least once annually thereafter. Functional imaging in the form of retrograde/antegrade pyelogram,[11] computed tomography urogram, and/or renal scan were generally obtained 2 times during the first postoperative year, and yearly intervals thereafter.

RESULTS

Fifty-four patients underwent RU-BMG for a complex proximal and/or middle ureteral stricture with ≥12 months follow-up. Patient characteristics and perioperative outcomes are summarized in Table 1. Eighteen of 54 (33.3%) patients underwent RU-BMG for a recurrent stricture after a previously failed ureteral reconstruction. The median stricture length was 3.0 (IQR 2.0-4.0, range 1-8) centimeters. Forty-three (79.6 %) patients underwent an onlay, and 11 (20.4%) patients underwent an augmented anastomotic RU-BMG. The reconstructed ureter was wrapped with an omental flap in 52 of 54 (96.3%) and peri-nephric fat flap in 2 of 54 (3.7%) cases. ICG was utilized in 41 of 54 (75.9%) cases, with intraureteral and intravenous ICG being utilized in 13 of 54 (24.1%) and 28 of 54 (51.9%) cases, respectively.

The median operative time was 222.5 (IQR 189.0-283.0) minutes, estimated blood loss was 75.0 (IQR 50.0-100.0) milliliters, and LOS was 1.0 (IQR 1.0-3.0) day. There was 1 of 54 (1.9%) intraoperative complication. A patient with an extensive abdominal surgical history suffered a serosal small bowel injury that was repaired primarily at time of surgery. A major (Clavien >2) postoperative complication occurred in 3 of 54 (5.6%) cases, including 1 patient who developed a port-site hernia requiring operative repair, 1 patient who developed hypercapnia requiring temporary (<24 hours) re-intubation, and 1 patient who developed gluteal compartment syndrome requiring fasciotomy.

At a median follow-up of 27.5 (IQR 21.3-38.0) months, 47 of 54 (87.0%) cases were surgically successful. Stratified by surgical technique, 39 of 43 (90.7%) onlay and 8 of 11 (72.7%) augmented anastomotic RU-BMG were surgically successful. Six of 7 (85.7%) patients who underwent RU-BMG for a ureteral stricture ≥6 centimeters and 12 of 13 (92.3%) patients who underwent RU-BMG for a ureteral stricture ≤2 centimeters were surgically successful. Of 18 patients who underwent RU-BMG after a previously failed ureteral reconstruction, 14 (77.8%) were surgically successful. Stricture recurrences were diagnosed ≤2 months postoperatively in 3 of 7 (42.9%) patients, and ≥10 months postoperatively in 4 of 7 (50.0%) patients. Of 7 patients who failed RU-BMG, 4 patients have been managed with chronic double-J stenting, 1 patient has been serially monitored with renal scans, 1 patient had resolution of the stricture after balloon dilation, and 1 patient underwent nephrectomy.

Table 1.. Patient characteristics and perioperative outcomes (n = 54)

Preoperative variables:	
Median age, years (IQR)	55.0 (IQR 42.0-65.8)
Median body mass index, kilograms/meters2 (IQR)	27.1 (IQR 22.9-34.5)
Stricture location:	
Proximal	39/54 (72.2%)
Middle	8/54 (14.8%)
Proximal and middle	7/54 (13.0%)
History of prior ureteral reconstruction (%)	18/54 (33.3%)
Operative variables:	
Median stricture length, centimeters (IQR, range)	3.0 (IQR 2.0-4.0, range 1-8)
Type of RU-BMG:	
Onlay (%)	43/54 (79.6%)
Augmented anastomotic (%)*	11/54 (20.4%)
Tissue used to wrap reconstructed ureter:	
Omental flap (%)	52/54 (96.3%)
Peri-nephric fat flap (%)	2/54 (3.7%)
ICG utilization:	
Overall (%)	41/54 (75.9%)
Intraureteral (%)	13/54 (24.1%)
Intravenous (%)	28/54 (51.9%)
Median operative time, minutes (IQR)	222.5 (IQR 189.0-283.0)
Median estimated blood loss, milliliters (IQR)	75.0 (IQR 50.0-100.0)
Median length of stay, days (IQR)	1.0 (IQR 1.0-3.0) days
Intraoperative complications (%)	1/54 (1.9%)
Major (Clavien >2) postoperative complications (%)	3/54 (5.6%)
Follow-up variables:	
Median follow-up, months (IQR)	27.5 (IQR 21.3-38.0)
Overall surgical success (%)	47/54 (87.0%)
Onlay RU-BMG surgical success (%)	39/43 (90.7%)
Augmented anastomotic RU-BMG surgical success (%)	8/11 (72.7%)
≤2 centimeter stricture surgical success (%)	12/13 (92.3%)
≥6 centimeter stricture surgical success (%)	6/7 (85.7%)
RU-BMG after previously failed ureteral reconstruction surgical success (%)	14/18 (77.8%)

* Three patients underwent concomitant downward nephropexy.

COMMENT

Naude first reported OU-BMG and omental wrap in 6 patients with complex ureteral strictures.[1] Four patients underwent an onlay repair, 1 patient underwent an augmented anastomotic repair, and 1 patient underwent a tubularized repair. At a median follow-up of 24 months, all patients were surgically successful. Since then, a handful of small OU-BMG series have been reported. Kroepfl et al. described 6 patients who underwent 7 onlay OU-BMG and omental wraps for middle and/or distal ureteral strictures with a median stricture length of 7 centimeters.[12] At a median follow-up of 18 months, 5 of 7 (71.4%) cases were surgically successful. Pandey et al. described 3 patients who underwent onlay OU-BMG with omental/peritoneal wraps for proximal ureteral strictures with a median stricture length of 6 centimeters. At a median follow-up of 34 months, 3 of 3 (100.0%) cases were surgically successful.[13]

The promising outcomes associated with OU-BMG coupled with the increasing prevalence of robotic ureteral reconstruction gave way to RU-BMG.[9-11] We previously reported our initial multi-institutional RU-BMG experience in 19 patients.[10] Onlay and augmented anastomotic repairs were performed in 15 of 19 (78.9%) and 4 of 19 (21.1%) cases, respectively. The reconstructed ureter was wrapped with omentum and peri-nephric fat in 18 of 19 (94.7%) and 1 of 19 (5.3%) cases, respectively. The median stricture length was 4.0 centimeters. There were 2 of 19 (10.5%) major (Clavien >2) postoperative complications. At a median follow-up of 26 months, 17 of 19 (89.5%) cases were surgically successful. Although our initial multi-institutional report provided significant insight into the safety and efficacy associated with RU-BMG, it was limited by small patient numbers.

The current report represents an update of our initial multi-institutional RU-BMG series.[10] Based on our experience, we favor utilization of RU-BMG for proximal and/or middle ureteral strictures not amenable to primary excision and anastomosis due to stricture length and/or extensive peri-ureteral fibrosis. With regards to reconstruction of long-segment strictures, BMG is readily available and can be tailored to fit the precise length of a stricture. In our study, 6 of 7 (85.7%) patients undergoing RU-BMG for a stricture ≥6 centimeters were surgically successful. In the literature, strictures as long as 11 centimeters have been repaired via ureteral reconstruction with BMG.[12] Although the literature suggests that BMG can take during repair of long-segment strictures, further studies assessing efficacy rates in this setting are necessary.

With regards to ureteral reconstruction in the setting of significant peri-ureteral fibrosis, RU-BMG obviates the need for an extensive ureterolysis which may facilitate ureteral dissection and minimize disruption to the ureteral blood supply. Significant peri-ureteral fibrosis may even complicate reconstruction of short-segment ureteral strictures, making ureteroureterostomy difficult. This is particularly true in re-operative ureteral reconstruction, which is often associated with obliterated dissection planes and impaired ureteral blood supply. In patients undergoing an onlay RU-BMG (narrowed stricture), ureterolysis may be focused to the strictured portion as the ureter only needs to be prepared for incision rather than excision and re-anastomosis. In patients undergoing an augmented anastomotic RU-BMG (obliterated stricture), the ureterolysis may be limited as only a tension-free plate of ureter must be anastomosed rather than a circumferential anastomosis. In our study, 12 of 13 (92.3%) of patients who underwent RU-BMG for a ureteral stricture ≤2 centimeters due to significant peri-ureteral fibrosis and 14 of 18 (77.8%) patients who underwent RU-BMG after a previously failed ureteral reconstruction were surgically successful.

The results of our study are notable for 3 main reasons. First, our results suggest that RU-BMG is associated with low morbidity. A major postoperative complication occurred in 3 of 54 (5.6%) patients. We previously described 2 major postoperative complications (port-site hernia requiring operative repair and hypercapnia requiring temporary re-intubation) in our initial series of 19 patients.[10] Over 35 RU-BMG performed since then, only 1 major postoperative complication occurred. A male patient with a body mass index of 39 kilograms/meters^2 and an 8 cm stricture who underwent a 394-minute RU-BMG developed compartment syndrome requiring a fasciotomy. Furthermore, the median LOS was 1.0 (IQR 1.0-3.0) day. Despite the seemingly favorable morbidity profile of RU-BMG, further studies are necessary to elucidate indications for selecting RU-BMG over more traditional options such as IUR and RA. Although we favor RU-BMG in most cases of complex ureteral reconstruction, IUR and RA may be valuable options for pan-ureteral strictures and/or RU-BMG failures.

Second, our results suggest that RU-BMG is associated with excellent intermediate-term outcomes. At a median follow-up of 27.5 months (IQR 21.3-38.0), 47 of 54 (87.0%) patients were surgically successful. Stratified by surgical technique, 39 of 43 (90.7%) onlay and 8 of 11 (72.7%) augmented anastomotic RU-BMG were surgically successful. One possible explanation for the seemingly higher surgical success rate associated with onlay RU-BMG is that patients with a narrowed ureteral lumen undergoing this technique only require a longitudinal incision on the ureter, which may minimize disruption to the ureteral blood supply. In contrast, patients with an obliterated ureteral lumen undergoing an augmented anastomotic RU-BMG require ureteral transection, which may potentially compromise the longitudinal ureteral blood supply and inhibit BMG take. Despite this, we were unable to perform a meaningful statistical comparison between the 2 groups given the low number of augmented anastomotic repairs performed. Future studies assessing the effect of stricture quality (ie, narrowed vs obliterated) on differences in RU-BMG technique and outcomes are necessary.

Third, surgical failures after RU-BMG occurred ≤2 months postoperatively in 3 of 7 (42.9%) patients, and ≥10 months postoperatively in 4 of 7 (57.1%) patients. At a median follow-up of 27.5 months, none of the patients had a stricture recurrence after 13 months postoperatively. These results provide valuable insight into the potential timing of stricture recurrences, especially since only one other study in the literature describes any surgical failures after ureteral reconstruction with BMG (the present study incorporate the results from our prior publications[9-11]).[12] In the aforementioned study by Kroepfl et al., surgical failures were diagnosed at 17 and 39 months postoperatively.[12]

These data have clinical implications on the duration and intensity of surveillance protocols, and highlight the importance of long-term follow-up.

Our study has several limitations. Foremost, although our study represents the largest ureteral reconstruction with BMG experience, the results must be interpreted in the context of its retrospective design. Also, although our follow-up protocols for diagnosing stricture recurrences were similar across institutions, they were not standardized. This could have led to variability in determining the occurrence and timing of stricture recurrences. Currently, multi-institutional efforts are underway to develop standardized follow-up protocols. Lastly, our data are derived from 3 primary surgeons that perform a high-volume of robotic reconstructive procedures, which may limit the generalizability of our findings. As we believe that RU-BMG is indicated for reconstruction of complex proximal and middle ureteral strictures,[10,11] we recommend that RU-BMG only be performed by surgeons with expertise in both urologic reconstruction and robotics.

CONCLUSION

RU-BMG is an effective treatment option for the management of complex proximal and middle ureteral strictures, and is associated with low morbidity and excellent intermediate-term outcomes. Further studies evaluating risk factors for RU-BMG failure are necessary to refine patient selection for utilization of this technique.

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