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Ileal ureter replacement combined with Boari flap-psoas hitch to treat full-length ureteral defects: technique and initial experience

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**Abstract**

**Objectives** To evaluate the feasibility of ileal ureter replacement combined with Boari flap-psoas hitch procedure for the management of full-length ureteral defects (>20 cm).

**Methods** Three patients diagnosed with full-length ureteral defect were treated with our technique performed by a single surgeon between January 2015 to January 2016. All the patients had borderline renal function preoperatively. In each case, the ureteral reconstruction was performed by combining ileal ureter replacement with Boari flap-psoas hitch. Data on indications for surgery, intraoperative and postoperative outcomes, and changes in renal function were collected.

**Results** Surgery was performed successfully with an operation duration between 210
to 250 minutes. The mean estimated blood loss was 230 mL. The mean length of hospital stay was 11 days, and no major complications (grade ≥3) occurred. Postoperative follow-up showed radiologic resolution of hydrenephrosis and improved renal function in all 3 patients.

**Conclusions** Ileal ureter replacement combined with Boari flap-psoas hitch is a feasible option for bridging full-length ureteral defects. This technique minimizes the length of ileal graft required as well as limitations concerning patients selection. Larger series with longer followup to confirm the value of the technique are warranted.

**Introduction**

With the increasing utilization of endoscopic technology in urological diseases, the incidence of iatrogenic ureteral injury has increased significantly. Depending on the extent, position and time of discovery of the ureteral injuries, various management techniques have been introduced. For the short and uncomplicated ureteral injuries, direct ureteroureterostomy, Boari flap, psoas hitch or ureteroneocystostomy can be implemented. For more extensive injuries, the surgical alternatives are more complicated. Transureteroureterostomy, renal autotransplantation and ileal ureter replacement are all recommended interventions for a long ureteral defect. Particularly for full-length defects (>20 cm), ileal ureter replacement is occasionally used as the last resort for ureteral reconstruction.
With regard to the outcomes of ileal ureter substitution, the use of ileal graft may have adverse metabolic consequences and renal deterioration\textsuperscript{5,6}. One of the critical points of the technique is to minimize the length of bowel harvested on the premise of a tension-free anastomosis. Recently, the Yang-Monti ileal ureter reconstruction have been developed to minimize the intestinal absorptive surface\textsuperscript{5,6}. However, greater ischemic and stricture risks may occur due to the use of reconstituted ileal segments. To minimize the length of ileal graft, we present our initial experience of ileal ureter replacement combined with Boari flap-psoas hitch for full-length ureteral defects in this study.

**Patients and Methods**

From January 2015 to January 2016, 3 patients were treated with our combined ileal ureter replacement and Boari flap-psoas hitch technique by the same surgeon in our hospital. The medical history, clinical symptoms, serum creatinine, ultrasound and/or intravenous pyelography (IVP) were used for initial diagnosis of the ureteral defects. Preoperative radiologic evaluations, including antegrade pyelography, retrograde pyelography and computed tomography, were used to delineate the location, length and severity of ureteral stricture. Data on patient demographics, previous urologic procedures, intraoperative variables, surgical complications, and postoperative outcomes were retrospectively collected.
Surgical technique

After induction of general anesthesia, a 25-cm midline incision was made. The colon was mobilized to expose the retroperitoneum. At exploration, multiple segments of the affected ureter were found to be strictured and surrounded by fibrosis. The ureter was isolated at the level of pelvic-ureter junction and the renal pelvis was widely spatulated for later anastomosis. The bladder was completely mobilized and filled with 300ml of saline. A bladder flap, 4 cm wide at the apex and 6–8 cm wide at the base was outlined (Figure 1, A). Stay sutures were then placed at apex of the flap on both sides (Figure 1, B). With the flap in place, a vesico-psoas hitch was performed by suturing the bladder dome to the ipsilateral psoas fascia using interrupted 3-0 Vicryl sutures. After measuring the distance from the incision site of the pelvis to the bladder flap, an appropriate ileal segment 15cm proximal to the ileocecal junction was created. For right-sided ureteral replacement, the ileal graft was placed in the retroperitoneum by lifting the previously mobilized cecum anteriorly and medially. For left-sided ureteral replacement, a 5-cm mesenteric window was created in the descending colon, through which the ileal segment was brought into the retroperitoneal cavity. The bowel continuity was then restored with gastrointestinal stapling devices. Before the anastomosis, a 7-Fr ureteral stent was inserted in the isolated ileal segment. The ureteral stent was fixed to the proximal and distal ends of an ileal graft with 4-0 Vicryl sutures to prevent dislocation. Pyeloileal anastomosis was performed in an end-to-end manner using interrupted 4-0 Vicryl sutures. The flap was tubularized and closed in two layers with a running 3-0 barbed suture for the
submucosa and interrupted 2-0 barbed sutures for the detrusor muscle. Afterwards, an
anti-reflux nipple valve was created before ileocystostomy. The distal ileum with an
anti-reflux nipple was anastomosed to the flap using interrupted 4-0 Vicryl sutures
(Figure 1, C). After refilling the bladder with 300 ml of saline to verify the integrity of
closure, two 20F closed suction drains were placed near the pyeloileal and ileovesical
anastomosis respectively, and a 20F indwelling Foley catheter was inserted into the
bladder.

**Postoperative management**

The criteria for removal of drains included: (1) patients were able to resume diet,
(2) the drainage was less than 50 ml per day, (3) the drainage creatinine was
comparable to serum creatinine. The bladder catheter and suction drains were
removed about 2 weeks after surgery for the maximal drainage. By 8 weeks
postoperatively, outpatient cystoscopy was performed for ureteral stent removal.

All the patients were followed up at 3 and 6 months after surgery, and about once
every six months thereafter. The patients routinely received clinical examination,
blood gas analysis, serum creatinine, abdominal ultrasonography and IVP at each visit.
Cystourethrogramy was performed 3 months after surgery and computed tomography
urography/magnetic resonance urography (CTU/MRU) were repeated at 6 months
after the procedure.

**Results**

6
The patient characteristics and surgical outcomes are summarized in Table 1. All 3 patients were male with a mean age of 35.3 years. Two cases were left-sided defect, and one case was right-sided. All 3 patients had a history of recurrent upper ureteral stones and all underwent ureteroscopic lithotripsy (URSL) for multiple times (n≥2). After the last URSL, the patients presented with fever and recurrent flank pain. The mean serum creatinine increased from 0.9 mg/dl to 3.1 mg/dl. Ultrasound and/or IVP revealed worsening of the hydronephrosis. All the patients underwent percutaneous nephrostomy to temporarily preserve renal function. Preoperative radiologic evaluations confirmed ureteral defects longer than 20 cm (Figure 2, A). On admission, the baseline renal function of the patients ranged from 1.6 to 1.8 mg/dl.

The operations were all successful with surgery durations between 210 to 240 minutes (mean 226.7 minutes). The estimated blood loss for each case was 300, 150, 150 ml, respectively (mean 200 ml). The length of ileum used for replacement in each patient was 7, 10, 12 cm, respectively. The suction drains were removed 6-7 days postoperatively. Postoperative hospitalization varied from 12-15 days. No major complications (grade ≥3) occurred according to the Clavien classification system. Patient 1 developed recurrent urinary tract infection postoperatively and he was managed uneventfully with oral antibiotics. Patient 2 experienced post-operative ileus. His condition was ameliorated with gastrointestinal decompression, antibiotic therapy and fluid electrolyte and acid-base supportive management. The symptoms of patients 1, 2 and 3 resolved at 24-, 14- and 13-month, respectively, and none
experienced metabolic dysfunction. Cystourethrography performed 3 months after surgery did not demonstrate vesicoureteral reflux in any of the 3 patients. Follow-up CTU or MRU (Figure 2, B) 6 months postoperatively revealed excellent drainage with resolution of hydronephrosis in all 3 patients. The renal function of the patients improved, as indicated by the decrease of the average serum creatinine from 1.7 mg/dl preoperative to 1.6 mg/dl 3 months after surgery and 1.4 mg/dl at the last follow-up.

Discussion

For long ureteral defects, ideal management options should restore a non-refluxing and non-obstructive urinary outflow and preserve renal function. When the ureteral injury occurs, ureteral stenting or nephrostomy are commonly used as temporary measures to preserve the renal function. After that, several options have been reported for the reconstruction of long ureteral defects, including transureteroureterostomy\(^2\), renal autotransplantation\(^2\), combined Boari flap-psoas hitch\(^9\) and ileal ureteral replacement\(^4\).

Transureteroureterostomy is a reconstructive option that bypass a diseased distal ureter without compromising the recipient ureter\(^10\). Despite its early introduction in 1934, transureteroureterostomy has not been adopted as the first-line procedure for the anastomotic complications as there is concern for injuring the contralateral ureter\(^2,11\). Renal autotransplantation has been used for high ureteral injury since 1963\(^12\). However, there have always been concerns about the technical complexity, vascular
complications and poor perfusion problems during the procedure.

Though first described by Boari in 1895, Boari flap was first performed to bridge a loss of distal ureteral defect in humans by Ockerblad in 1936\textsuperscript{13,14}. Later published studies have shown encouraging outcomes after using this technique\textsuperscript{15,16}. However, for the long ureteral defects, tension-free anastomosis is difficult to safely execute in a single procedure. Thus, in 1973, Kelami et al.\textsuperscript{17} initially attempted to combined Boari flap and psoas hitch technique to treat long segment ureteral defect. After the psoas hitch was completed, the bladder flap was developed with its base at the psoas hitch. With the use of normal urinary tract, the combined procedure could be performed in renal insufficient patients. In 1986, Olsson et al.\textsuperscript{9} presented 6 patients who underwent this combined treatment, reporting a 100% success rate with no deterioration of renal function. Using this technique, the upper ureteral loss could be repaired, but it remained inapplicable to the replacement of more extensive ureteral defects.

Ileal ureter replacement is a well-established procedure for ureteral reconstruction that bypasses the limitations of defect length. It is occasionally utilized as the last resort for long obstructed ureteral segments. Nevertheless, several investigators have reported a high short-term and long-term morbidity rate after ileal ureteral substitution\textsuperscript{4,6}. The procedure is often associated with renal deterioration, mucous plugging, recurrent urinary tract infection, electrolyte abnormalities and anastomotic stricture. With regard to the metabolic problems, a recently published study revealed
that the overall rate of metabolic hyperchloremic acidosis was as high as 19.5% long
term\textsuperscript{18}. Contemporary series have emphasized the importance of preoperative renal
function in patients with ileal interposition\textsuperscript{5,19}. Verduyckt et al.\textsuperscript{5,19} demonstrated that
patients with worsening preoperative renal function would have increased risks of
metabolic acidosis. Additionally, the contact time and contact area between urine and
intestinal mucosa are also important influencing factors for developing postoperative
metabolic problems. It is generally recognized that the use of an excessive size of ileal
segment during the procedure will lead to metabolic problems, postoperatively.
Accordingly, for patients who present with borderline renal function and require a
complete ureteral reconstruction, measures should be taken to minimize the length of
the ileal graft.

In these 3 cases, all the patients suffered from full-length ureteral injuries with
borderline renal function ranging from 1.6 to 1.8 mg/dl. Both preoperative borderline
renal function and excessive length of ileal graft had deleterious impact on the
surgical outcomes of the ileal ureter replacement. Based on traditional ileal ureteral
replacement and our experience, we integrated ileal ureteral replacement with Boari
flap-psoas hitch to reconstruct the full-length defects. The primary advantage of the
combined procedure is the reduction of the length of the ileal graft for ureteral
reconstruction. With the use of the combined Boari flap and psoas hitch in ileal ureter
replacement, about 10-15 cm ureteral defect could be replaced by normal urinary tract.
As a result, the intestinal mucous secretion and resorption decrease, and subsequently,
the risk of postoperative complications, including renal function deterioration, mucous plugging and metabolic acidosis will be significantly reduced. Moreover, the combined procedure has less limitations concerning patient selection than the stand-alone complete ileal ureter replacement. This technique is more likely to be recommended to patients with preexisting azotemia who are illegible for ileal ureter replacement. With the application of the technique reported here, renal function was preserved for the 3 patients, and no metabolic complications were seen at follow-up (mean of 17 months).

Although reflux is a common issue for ileal ureter replacement, recent data showed that anti-reflux procedure is not always necessary because ileal peristalsis can provide positive effect of buffering the pressure of reflux. Waldnerd et al. recommended the use of ≥15 cm of ileum to prevent the reflux from reaching to the renal pelvic. For our patients, the ileal segment was too short (less than 15 cm) to produce sufficient anterograde peristalsis, Thus, aside from keeping the ileal segment in an isoperistaltic orientation, we created an ileum nipple during ileocystostomy as an anti-reflux mechanism. To date, vesicoureteral reflux has not been reported in any of the 3 patients. Despite the occurrence of potential complications, such as stenosis, desussception, and stone formation secondary to the antireflux technique, the creation of an inverted nipple is recommended for our combined technique.

On the basis of our initial experience, there are some technical considerations
with regard to our combined technique. First, in order to avoid injuries to femoral or genitofemoral nerves, we preferred to place the anchoring sutures on the psoas minor tendon. While in the absence of the psoas minor tendon, sutures should be placed on psoas major muscle superficially and above the level of the common iliac artery bifurcation. Second, the bladder flap was closed in two layers using 3-0(submucosa) and 2-0 (detrusor muscle) barbed sutures. However, the sutures should not comprise any mucosa so as to prevent anastomotic leakage. Third, unlike the classical flap, the base of the flap should be wide enough for subsequent ileocystostomy, and it should be at least 2 cm larger than the apex for a good flap vascularization\textsuperscript{21}. Finally, the ileal segment should be maintained in an isoperistaltic orientation either on left or right side and a distal antireflux procedure should be performed in our technique to prevent postoperative reflux.

The major limitations of the present study are the small sample size and retrospective nature. In addition, the follow-up period is too short to draw a definitive long-term conclusion. Above all, further prospective studies with longer follow-up durations and larger patient cohorts are needed to assess the long-term outcomes of the technique.

**Conclusion**

Several options have been reported for complete ureteral reconstruction but they
each have inherent limitations, respectively. Based on our initial experience, the combined ileal ureter replacement and Boari flap-psoas hitch is a feasible option for bridging full-length ureteral defects, particularly for the patients with borderline renal function. However, more extensive longitudinal studies with larger sample sizes are required to validate this method.

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**Figure 1** Technique of combined ileal ureteral replacement with Boari flap-psoas hitch. (A) Outline of bladder flap with 4 cm wide at apex and 6-8 cm wide at the base; (B) Stay sutures were placed at the apex of the anterior bladder flap on both sides; (C) Completion of anastomosis of the combined ileal ureter replacement with Boari flap-psoas hitch technique.

**Figure 2** Preoperative and postoperative imaging in Patient 3; (A) Antegrade pyelogram and retrograde pyelogram revealed full-length ureteral defect before operation; (B) Magnetic resonance urography (6 months postoperatively) showed the combined ileal ureteral replacement and Boari flap-psoas hitch technique with resolved hydronephrosis.
<table>
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<th>Patient</th>
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<th>Defect length (cm)</th>
<th>Operative time (mins)</th>
<th>Estimated blood loss (ml)</th>
<th>Length of ileal graft (cm)</th>
<th>Length of hospital stay (days)</th>
<th>Surgical complication (Clavien classification)</th>
<th>Creatinine (mg/dl) Preoperative</th>
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<td>14</td>
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<td>29</td>
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<td>12</td>
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<td>Incomplete ileus (Grade 2)</td>
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URSL: ureteroscopic lithotripsy
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