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NOTE

Surgery

Ventral onlay graft urethroplasty using bladder mucosa in a cat with a urethral stricture

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ABSTRACT. A 3-year-old, 4.0 kg, intact male domestic shorthair cat presented with postoperative dysuria following urethral resection and anastomosis for urethral rupture. Retrograde urethrography revealed a stricture in the pelvic urethra. Urethroplasty with bladder mucosa was performed following a bilateral pubic-ischial osteotomy. The bladder wall was resected to harvest an appropriately sized bladder mucosa graft. The graft was placed over the urethral defect in patch fashion and stabilized with interrupted sutures. The cat was able to urinate normally with no evidence of lower urinary tract signs 2 year postoperatively. Therefore, urethroplasty with an onlay bladder mucosa graft may be a feasible alternative to prepubic or subpubic urethrostomy for the treatment of pelvic urethral stricture in cats.

KEYWORDS: bladder mucosa, cat, onlay graft, urethroplasty

Urethral stricture can be a sequela of surgical intervention for urethral injury. Although a urethral stricture does not always result in obstruction, treatment is needed if clinical signs of urinary tract obstruction develop. In cats, stricture of the pelvic urethra can be managed by conservative treatment consisting of balloon dilation and urine diversion via a tube cystostomy, with or without an indwelling urinary catheter [2]. However, if a stricture is recurrent and not amenable to such management, resection and anastomosis of the urethra or permanent urinary diversion such as a prepubic or subpubic urethrostomy is generally indicated [2]. Urethral resection and anastomosis is limited by the available urethral tissue length and has an associated risk for stricture formation [2]. Salvage urinary diversion of the pelvic urethra has a high incidence of complications, such as urinary incontinence, urinary tract infections, peristomal dermatitis, stenosis, and subcutaneous urine leakage [4, 5, 16].

Urethroplasty using various autogenous materials has been attempted to augment or replace the urethra. In humans, oral mucosa autografts are successfully used for urethroplasty [22]. In cats, sublingual mucosa has been used as a tubular graft for urethrostomy revision surgery [26]. However, these procedures require additional surgery to harvest the oral mucosa in a different surgical field. In an experimental study in dogs, bladder mucosa as an onlay graft had similar effects to buccal mucosa for reconstructing the urethra [7]. In cats, pelvic urethral surgery requires a caudal laparotomy and pubic osteotomy to access the surgical site [3]. A bladder mucosa graft can be harvested simultaneously with the urethral surgery in the same surgical field.

This report describes the use of free bladder mucosa as a ventral patch graft to reconstruct the urethra in a male cat.

On June 24, 2022, the PubMed and Google Scholar databases were searched with the following keywords: urethroplasty, urethrostomy, bladder mucosa, and feline. In addition, the textbook Veterinary Surgery: Small Animal, 1st ed. [Tobias & Johnston (Ed.)] was consulted. No reports of treating urethral stricture with a ventral onlay graft urethroplasty using free bladder mucosa in cats were found in these searches.

A 3-year-old, 4.0 kg intact male domestic shorthair cat was examined by the referring veterinarian for acute dysuria after a suspected impact by car. The cat was alert and responsive, and the general physical examination failed to reveal any obvious abnormalities. The cat had no previous history of urinary tract disease including urinary tract infection. Blood examination revealed azotemia. Urinalysis was not performed. Retrograde urethrography revealed rupture of the pelvic urethra. A urinary catheter could not be introduced to the bladder. Urethral resection and anastomosis with interrupted 6–0 monofilament absorbable sutures (PDS II; Johnson & Johnson Medical, Tokyo, Japan) following bilateral pubic-ischial osteotomy were performed. The osteotomy sites were stabilized with 22-gauge orthopedic wire. After surgery, an indwelling 3-Fr soft urinary catheter (Atom multi-purpose tube, Atom Medical, Tokyo, Japan) was placed in the bladder through the anastomosed urethra for 5 days. One month later, the cat developed dysuria again. Retrograde

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urethrography revealed stricture formation at the pelvic urethra anastomosis. Revision surgery with balloon dilation of the stricture through a small incision in the bladder was performed. However, complete resolution was not achieved.

The cat was referred to Iwate University Veterinary Teaching Hospital for revision surgery 6 weeks after the second surgery. Retrograde urethrography revealed a stricture in the pelvic urethra at the previous surgical site (Fig. 1). A 3-Fr soft urinary catheter (Atom multi-purpose tube, Atom Medical) could not be advanced to the bladder through the stricture. The complete blood count and serum biochemistry panels were within normal limits. General urinalysis was unremarkable. Urine culture revealed infection with *Enterococcus faecium*, which was confirmed 3 days after surgery.

The cat owner approved of performing urethroplasty with an onlay bladder mucosa graft as the surgical treatment of pelvic urethral stricture.

The cat was premedicated with fentanyl citrate (2 µg/kg intravenously [IV]) and midazolam (0.3 mg/kg IV). Anesthesia was induced with propofol (4 mg/kg IV to effect) and maintained with sevoflurane in oxygen. Fentanyl (3–5 µg/kg/min as a continuous rate infusion IV) was used for perioperative pain control. Lactated Ringer's solution (7 mL/kg/hr) was administered. Cefmetazole sodium (25 mg/kg IV) was administered at anesthetic induction and 2 hr later, and then continued twice daily for 7 days. The caudal abdomen was clipped and prepared for surgery. A 3.5 Fr Tomcat catheter (PP catheter with side hole, Fujihira, Tokyo, Japan) could be introduced to the bladder under anesthesia despite difficulty approximately 1 cm caudal from the cranial edge of the pubis, indicating severe stricture of the pelvic urethra.

With the cat in dorsal recumbency, a caudal ventral midline abdominal incision was made. The pubic symphysis was exposed by subperiosteally elevating the adductor muscles until half of the obturator foramen was exposed. The prepubic tendon was transected along the pubis to the proposed osteotomy site. On both sides of the four previous osteotomy sites, 1.5 mm diameter holes were drilled in the pubis and ischium. The osteotomies for the previous pubic and ischial osteotomy sites were made with an electronic sagittal saw (Colibri, Synthes Vet, Switzerland) and the central bone plate was removed.

The stricture site in the pelvic urethra was confirmed by palpation and a ventral urethrotomy incision of the stricture was made over the catheter at both the proximal and distal ends of the stricture until reaching healthy urethra. The urethral stricture was approximately 2 cm long. A full-thickness spindle-shaped resection of the relatively inflamed bladder was made longitudinally considering the length of the graft to be harvested. The resected region was 2.4 cm long and 0.5 cm wide (Fig. 2A). The donor site was closed with interrupted 3–0 monofilament absorbable sutures (PDS II; Johnson & Johnson Medical). The bladder mucosa graft with submucosal tissue was dissected bluntly and sharply from the muscularis to optimize subsequent vascularization. The graft was placed over the urethral defect as an onlay patch and attached to the urethral margins with interrupted 6–0 monofilament absorbable sutures (PDS II; Johnson & Johnson Medical) under the operative microscope (Fig. 2B). Omentum was placed over the graft to promote angiogenesis. The bony plate was replaced in its original location and stabilized with 2–0 polypropylene sutures (Prolene™; Johnson & Johnson Medical), passed through the previously drilled holes. An indwelling 5-Fr locking-loop cystostomy tube (custom-made 5-Fr locking-loop cyctostomy tube, Okid, Shizuoka, Japan) was used for postoperative monitoring of urination and was connected to a sterile urine collecting bag. An abdominal drain was also placed to avoid fluid accumulation in the abdominal cavity. Closure of the abdomen was routinely performed. The 3.5 Fr Tomcat urinary catheter (PP catheter with side hole, Fujihira) was replaced with a 4 Fr soft urinary catheter (Atom multi-purpose tube, Atom Medical) and was used as a urethral stent, which was secured to the skin with a Chinese finger trap suture.

The cat recovered uneventfully from anesthesia and surgery. The urethral catheter used as a stent and abdominal drain were both removed on postoperative day 7. The cat was discharged with a 3-week course of cephalexin (25 mg/kg, orally, twice a day).

Two weeks after surgery, retrograde urethrography using iohexol as contrast medium showed no leakage or stricture at the urethroplasty site. After removing the cystostomy tube, the cat was able to urinate normally. Six weeks postoperatively, the cat was

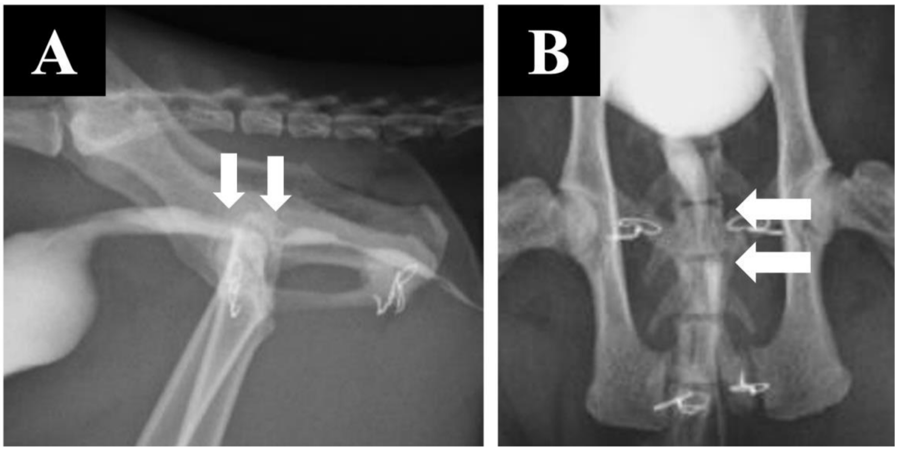

Fig. 1. Retrograde urethrography showed a stricture of the pelvic urethra (arrows). A soft urethral catheter could not be introduced cranially from the stricture site: **A**) lateral and **B**) ventrodorsal views.

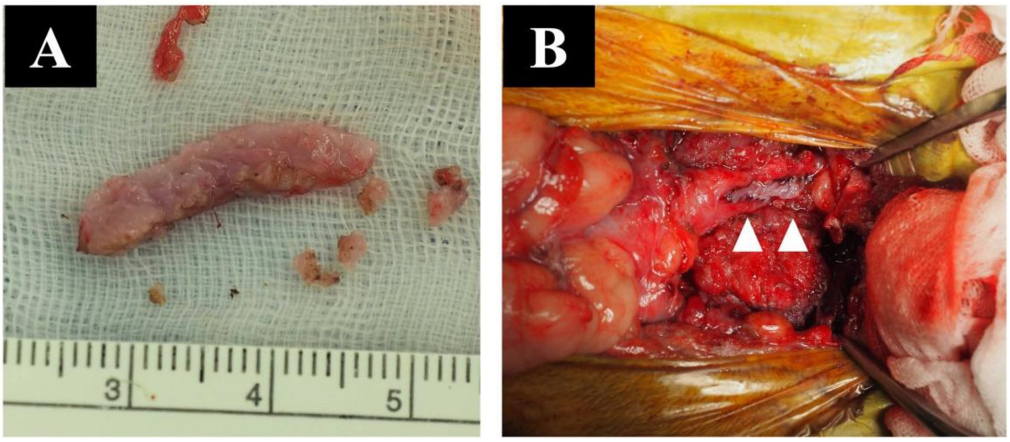

Fig. 2. Intraoperative photographs showing reconstruction of the pelvic urethra using a bladder mucosa onlay graft: **A**) bladder mucosa graft, **B**) onlay grafting with interrupted sutures at the urethral defect (arrowheads).

Fig. 3. Retrograde urethrography 6 months postoperatively. A soft urethral catheter could be introduced to the bladder without difficulty.

able to urinate with no difficulty or signs of discomfort. A bacterial culture of a urine sample obtained by cystocentesis was negative. Six months after surgery, the cat could urinate normally without lower urinary tract signs such as dysuria, stranguria, pollakiuria, and hematuria. Contrast urethrography showed no abnormalities, including no leakage or stricture at the urethroplasty site (Fig. 3). A bacterial culture of a urine sample obtained by cystocentesis was negative again. Two years later, the owner reported that the cat continued to do well with no abnormalities. The owner was very satisfied with the cat's functional outcomes.

The development of substitution urethroplasty techniques highlights the efforts to restore urethral anatomy and function as near to normal as possible. Buccal mucosa graft urethroplasty offers excellent outcomes, success, morbidity and quality of life, independently of previous urethral interventions and stricture length in humans with urethral strictures [22]. However, the cat oral cavity is too small to harvest a sufficiently large buccal mucosa graft. Yippaditr and Roongsitthichai [26] reported the successful use of sublingual mucosa as a tubular graft to connect the urinary bladder and preputial ends in cats. Maarouf *et al*. [15] reported that the success of urethroplasty in humans using sublingual mucosa was comparable to that using buccal mucosa (76.1 vs. 78.2%). However, oral mucosa graft urethroplasty can cause difficulty with tongue movement and mouth opening in the short-term in human patients [24]. The removal of oral mucosa in cats has potential complications such as anorexia and ptyalism. Furthermore, harvesting an oral mucosal graft requires additional surgery. In comparison, bladder mucosa is ideal uroepithelium; it is easy to harvest and hairless, and it closely resembles the urethra and does not suffer from the effects of chronic exposure to urine [17]. It also has high regenerative capacity, which is desirable when multiple previous operations have resulted in excessive scar formation and compromise the blood supply of the recipient bed [17]. In our case, we harvested a 0.5 × 2.4 cm piece of the bladder wall for the mucosa graft. Dogs regained their baseline bladder capacity by 10 months after resection of 35–40% of the bladder wall [13]. Therefore, a bladder mucosa graft may be a feasible alternative to buccal or sublingual mucosa, particularly in feline pelvic urethral surgery.

Unfortunately, bladder mucosal grafts have major disadvantages, such as excessive pliability and a tendency to shrink, which can be important when considering the length and width of the graft [11]. The most common complications are graft shrinkage and stricture formation. Graft shrinkage was 20–40% for bladder mucosa [7]. A bladder mucosa onlay graft may have a lower complication rate, particularly of anastomotic stricture and fistula, compared to tubed grafts [6, 20, 25]. In our case, we increased the graft size 20% at harvest to prevent stricture formation due to postoperative graft shrinkage. The grafted urethra in the cat had an adequate diameter on contrast urethrography 6 months after the surgery and there was no difficulty with urination at 1 year postoperatively. Note, however, that excess size can lead to folding of the graft on itself, compromising its blood supply.

Angiogenesis is a reliable indicator of the viability of engrafted tissue [10, 18, 23]. The best tissue graft for urethral reconstruction is one that induces angiogenesis within areas of ischemia, to improve graft viability [1]. Gardikis *et al*. [9] reported that bladder mucosal grafts had similar angiogenic activity to buccal mucosa grafts, which are considered the gold standard for urethroplasty in humans. In addition, the recipient bed must be able to accept and nourish a graft. In this study, the urethroplasty site was covered by omentum, which has angiogenic properties, promotes wound healing, and stimulates revascularization of ischemic organs and tissues [14, 21]. In our case, the angiogenic activity of the graft itself and the omentum bed may have helped to prevent graft loss.

Long-term placement of a urethral catheter increases the risk for ascending bacterial infection of the urinary tract and stricture formation at injured urethral sites. Catheterization for 10 days is thought to be sufficient to allow uroepithelium to bridge minor wound defects [3]. However, Fairbanks *et al*. [8] developed a rabbit model of bladder mucosa urethroplasty and reported that the graft did not stabilize until 12–14 days postoperatively, although it is not known whether rabbit and feline transitional cell epithelia are identical. In the present study, a urethral catheter was placed as a stent for 7 days after surgery. However, removal of the urethral stent after 2 weeks may be preferable to healing of the grafted site in the urethra.

In this study, a bladder mucosa graft was used for urethroplasty in a cat with preoperative urinary infection. The cat ultimately had a successful outcome without clinical signs of urinary tract infection 2 years postoperatively. However, preoperative urinary tract infection is a risk factor for graft failure [12, 19]. Therefore, bladder mucosa might be avoided for use as a urethroplasty graft in animals with urinary infection.

In conclusion, urethral reconstruction using bladder mucosa as an onlay graft may maintain anatomically normal urination in cats. Future studies on more cases are needed to evaluate the effectiveness of this grafting technique.

CONFLICT OF INTEREST. The authors declare that there are no conflicts of interest.

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