ORIGINAL ARTICLE

Complications and outcomes of 25 dogs undergoing surgery for intramural ureteral ectopia *via* a minimally invasive modified cystoscopic-guided scissor transection

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Objectives: Ureteral ectopia is a common cause of urinary incontinence in juvenile dogs that is commonly treated with cystoscopic-guided laser ablation due to reduced post-operative pain and hospitalisation time compared with open surgical techniques. However, due to the surgical training and substantial costs relating to laser equipment, this may not always be feasible. This aim of this study was to describe a novel, modified surgical technique for cystoscopic-guided scissor transection of intramural ureteral ectopia detailing the complications and outcomes in dogs.

Materials and Methods: Single-centre retrospective study. Medical records were searched for female dogs treated for ureteral ectopia by cystoscopic-guided scissor transection between 2010 and 2022. Outcome was based on owner questionnaire and dogs were assigned a continence score pre- and post-operatively based on a 5-point scoring system. Descriptive statistics and Wilcoxon signed-rank test were used to analyse the data.

Results: Twenty-five dogs met the inclusion criteria. Median surgical time was 42.5 minutes (20 to 120 minutes) and there were no intraoperative complications. Of the 25 dogs, three (12%) had major complications and two (8%) had minor complications. Of the 18 dogs available for follow-up, 66% of dogs were continent with surgery alone and all dogs' continence scores improved following surgery. Median continence score pre-operatively was 1/5 and post-operatively was 5/5. Surgery had a significant improvement in continence scores when comparing pre- and post-operative values.

Clinical Significance: Cystoscopic-guided scissor transection of intramural ectopic ureters significantly improved continence scores with low complication rates. This method is a successful alternative to the laser alternative.

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INTRODUCTION

Ureteral ectopia (UE) is a congenital anomaly of the distal ureter resulting in urinary incontinence in dogs (Russell, 2023). In dogs, UE can be extramural or intramural with the large majority of UE in dogs (87% to 99%) being the latter (Owen, 1973). Intramural ectopia enter the dorsolateral serosal surface of the bladder in the normal trigonal location but travel submucosally to open ectopically within the urethra or vagina/vestibule (Holt, 1990; Mcloughlin & Chew, 2000). UE is frequently associated with other urogenital developmental abnormalities (Cannizzo et al., 2003) and urethral sphincter mechanism incompetence (USMI) (Owen, 2019). Traditionally, UE is a condition requiring surgical intervention, either by open surgery or minimally invasive techniques (Davidson & Westropp, 2014; Smith et al., 1981) but despite treatment some dogs will remain incontinent following surgery and need additional medical management (Noël et al., 2017).

Previous reports document surgical correction of intramural UE with an exploratory coeliotomy and neoureterocystotomy with exposure of the bladder lumen *via* ventral cystotomy (Holt & Moore, 1995; Mayhew et al., 2006). These surgeries have reported complication rates of 2/35 (6%) to 44% (4/9) with continence rates of 37% (13/35) to 67% (6/9) (Mayhew et al., 2006; Volstad et al., 2014).

Minimally invasive techniques using cystoscopic laser ablation (CLA) of UE have been described with good outcomes and low complication rates. Advantages of a minimally invasive technique are reduced post-operative pain and hospitalisation time (Berent et al., 2012). One prospective case series describes 36 female dogs undergoing endoscopic-guided laser ablation of intramural UE with no complications associated and excellent owner outcomes in 26/30 dogs (Berent et al., 2012). A retrospective study with long-term follow-up reported two major complications in a series of 34 dogs with 64% of dogs reaching continence with surgery alone (Hoey et al., 2021). A 2022 retrospective study comparing UE correction by open surgery or CLA found fewer minor complications and postoperative incidence of incontinence documented after CLA than neoureterostomy (Dekerle et al., 2022).

Laser-assisted procedures require specialist surgical training and substantial costs relating to laser safety and the specialist equipment required (Smith et al., 2010). The potential complications of CLA of UE include ureteral tears, urethral tears, haemorrhage, stricture and recanalisation of the UE (Berent et al., 2008; Dekerle et al., 2022; Hoey et al., 2021). These complications are uncommon, but in the recent abovementioned retrospective study, there were two urethral tears following CLA and one case of urethral stricture following surgery requiring balloon dilatation for resolution (Hoey et al., 2021). Oblique ureteral meatotomy with endoscopic scissors has been described for treatment for benign obstructive pathology of the ureterovesicular junction in humans and had a low index of complications (Arrabal-Martín et al., 2013). A similar technique has been previously reported in one horse with laparoscopic scissors alongside cystoscopy with no associated procedural complication, good short-term and long-term outcomes. Follow-up cystoscopy on this case 7 days following surgery showed minimal inflammation at the transection site (Jones & Ragle, 2018).

There are limited reports of minimally invasive correction of intramural UE without use of laser. One recent case series of eight female dogs reported cystoscopic-guided scissor transection of ectopic ureters (CST-EU) (Jacobson et al., 2022). This paper reported low complication rates with only minor complications (haemorrhage and transient lower urinary tract signs) and a good to excellent outcome in 5/7 dogs with long-term follow-up available. In our clinic, laser therapy was not initially available and so a technique for ablation of ectopic ureters using cystoscopic scissors was developed and used from 2010 to allow minimally invasive correction of UE. The purpose of this study was to describe the method developed, the advantages of the differences to the technique described by Jacobson et al. with a larger case number for the treatment of UE and to document the associated complications and outcomes. We hypothesise that this surgical technique would be successful, have a low complication rate and have similar post-operative outcomes when compared to the current literature.

MATERIALS AND METHODS

Study design and inclusion criteria

Medical records from one referral hospital were searched retrospectively for female dogs treated for intramural UE between 2010 and 2023. Patients were included if medical records were complete and they were diagnosed and treated for intramural UE using cystoscopic-guided scissor cut transection. Patients were excluded if medical records were incomplete or they underwent coeliotomy for neoureterocystostomy. Ethical Approval was obtained for this study from the Royal college of Veterinary Surgeons Ethics Review Panel (reference: 2021-45).

Medical record search and data extracted

Data collected included signalment, weight, neutering status, incontinence history, imaging findings, history of urinary tract infection, cystoscopic and fluoroscopic findings, anaesthesia time, surgeon, surgical time, surgical procedure performed, complications and post-operative medications. Incontinence history gathered included pattern of incontinence, medication at presentation and any response to previous medication. The surgical procedure performed was categorised into unilateral or bilateral UE correction and details on positioning within the urethra; distal third, mid urethra or proximal urethra was documented. Complications were classified as peri- or post-operative. No conflicts of interest have been declared.

Cystoscopic-guided scissor transection procedure

All surgeries were performed by an ECVS diplomate or an ECVS resident directly supervised by an ECVS diplomate. Patients were anaesthetised with individual anaesthetic plans based on assessment by a board-certified anaesthetist (ECVAA). The

surgical technique was developed by one of the authors (Doyle, R.). Patients were aseptically prepared for theatre and positioned in dorsal recumbency. Retrograde vaginourethrocystoscopy was performed using a rigid forward-oblique 30° 2.7 mm cystoscope (Hopkins 64029 BA, Karl Storz, Slough, UK) with a cystoscope-urethroscope sheath (9.5 Fr with a 4 Fr instrument port) (67031E, Karl Storz, Slough, UK) and manually pressurised saline (0.9% NaCL, Aqupharm No.1, Animalcare United Kingdom, York, UK) using a pressure infusor (C-Fusor 1000, Smiths Medical, Dublin, Ohio).

Urethrocystocopy was performed initially to avoid contamination from the vagina, and any abnormalities were noted. All suspected ectopic ureters (EUs) were catheterised using a 4Fr open-end ureteral catheter passed through the instrument port of the cystoscope sheath (70 cm; Cook Medical, Bloomington, USA), and a retrograde ureterogram was performed using <0.5 mg/kg of iohexol (Omnipaque, National Veterinary Services, Stoke-on-Trent, UK) and C-arm fluoroscopy (OEC Fluorostar, 7900 series) to document the presence of an intramural EU. In all cases, an EU was confirmed *via* contrast fluoroscopy (retrograde ureterogram) with the ureteral trajectory ending caudal to the bladder, with iohexol entering the urethra or vagina and no iohexol entering the bladder. Once the EU was confirmed, the ureteral catheter was kept in place and the cystoscope and sheath were removed completely. The cystoscope and sheath were reintroduced following the course of the ureteral catheter as a guide. The cystoscopic scissors (4 Fr, 62501EK, Karl Storz, Slough, UK) were then inserted through the instrument port of the cystoscope sheath until the jaws were visible. The cystoscopic scissors were opened and positioned in between the medial ectopic ureteral/urethral wall and the ureteral catheter (Fig 1). Under direct visualisation *via* the cystoscope, a 'push-cut' technique was used to transect the medial wall of the ectopic ureter by advancing the cystoscope, with the scissors open, to reposition the ureteral orifice of the EU back into a position similar to the contralateral normal ureterovesicular junction in the case of a unilateral EU (Supporting Information Videos S1 and S2). In the case of a bilateral EU, the ureter was transected to an appropriate intravesicular location (past the urethrovesicular junction). Once repositioned, another retrograde ureterocystogram was performed to demonstrate iohexol entering the bladder and adequate location of the re-positioned ureteral orifice (Figs 2 and 3). If iohexol was not visualised entering the bladder, then the ectopic ureter was resected further cranially, and the fluoroscopic study was repeated as described. Bladder location was assessed at this point to determine if it was intra-pelvic.

Vaginoscopy was subsequently performed and other anatomical variants, such as persistent vaginal remnants, were also transected at this point using endoscopic scissors if present. Surgical time was measured from the start of urethrocystoscopy to the end of vaginoscopy and included time spent undertaking fluoroscopy.

Complications were split into intra-operative or post-operative and categorised as catastrophic, major or minor based on Cook et al. (2010). Catastrophic complications resulted in permanent impairment, death or euthanasia, major complications required further surgical or medical treatment, and minor complications resolved without additional intervention.

Post-operative analgesia and medication were determined by the clinician performing the surgery. Time in hospital,

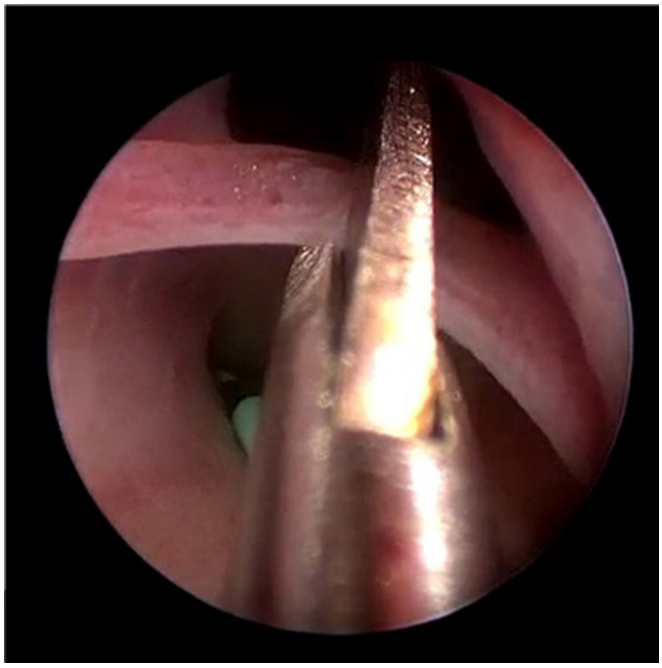

FIG 1. Cystoscopic scissors positioned on the medial wall of the ectopic ureter. Urethrovesicular junction is visible at the top of the screen. The ureteral catheter (3.5 Fr) is positioned within the ectopic ureter at the bottom of the screen.

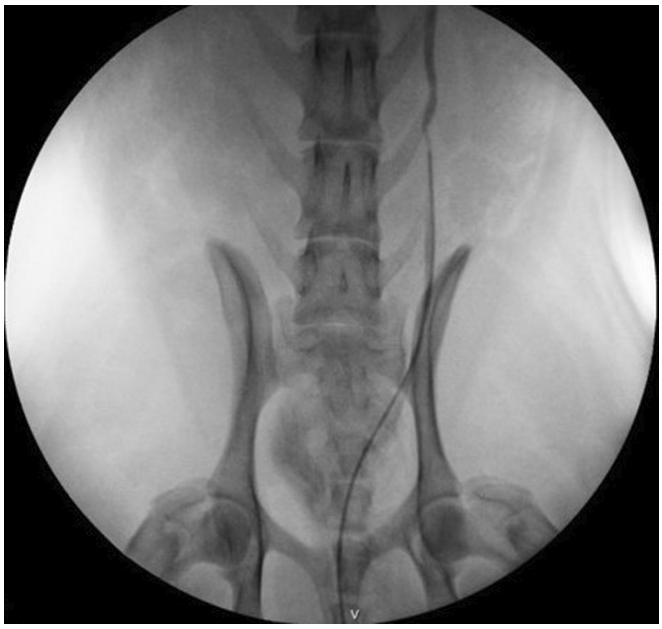

FIG 2. Positive contrast retrograde ureterogram was performed using <0.5 mg/kg of iohexol (Omnipaque, National Veterinary Services, Stoke-on-Trent, UK) and C-arm fluoroscopy (OEC Fluorostar, 7900 series) to document the presence of an EU.

FIG 3. A second positive contrast retrograde ureterogram was performed using <0.5 mg/kg of iohexol (Omnipaque, National Veterinary Services, Stoke-on-Trent, UK) and C-arm fluoroscopy (OEC Fluorostar, 7900 series) to document contrast now entering the bladder and adequate resection of the ectopic ureter.

post-operative complications and post-operative medication were obtained from the clinical records.

Outcome

Medical histories were obtained from the referring veterinarian's medical record and by retrospective follow-up questionnaire with owners between March and December 2022 using a previously validated questionnaire (Byron et al., 2007). Owners were written to initially and then a telephone questionnaire was performed for all cases. Owners were asked to complete the questionnaire describing the nature of their dog's incontinence with respect to frequency, time of day, approximate volume of leakage and other urination-related behaviours. They were then asked to complete the same questions for any clinical signs post-surgical intervention. From these answers, a continence score was assigned (1 to 5) before and after surgery, with a score of 5 representing normal continence (Byron et al., 2007).

Statistical analysis

The data were analysed using descriptive statistics (Excel 2020). Wilcoxon signed-rank test was used to compare continence scores pre and post-surgery (Stata Statistical Software: Release 18).

RESULTS

Patient inclusion and signalment

Forty-seven patients met the initial inclusion criteria; 22 were excluded due to incomplete medical records. Twenty-five female dogs were therefore included in the study. Breeds represented included six golden retrievers, two Labrador retrievers, two Border Collies and two Welsh terriers, one of each of the following; akita, border terrier, bulldog, Cockapoo, cocker spaniel, Dalmatian, English Bull terrier, Labradoodle, miniature schnauzer, French bulldog, a Rhodesian Ridgeback, a Norfolk terrier and a Patterdale terrier. Twenty-three dogs were entire at the time of investigation and CST-EU, with two having undergone ovariohysterectomy prior to referral. Median age at time of procedure was 177 days (range: 106 to 2113 days) and median weight was 11.75 kg (range: 4.3 to 31.7 kg).

All dogs showed clinical signs of urinary incontinence since ownership and the median duration of clinical signs prior to presentation was 77 days (range: 27 to 376 days). Of the two patients that were neutered prior to presentation, both became worse following neutering but one became acutely worse following ovariohysterectomy. The most common clinical sign was urine leakage after being asleep in 96% of dogs (24/25). Constant urine leakage when walking, characterised by a vulval drip, was present in 72% of dogs (18/25). Ten patients received amoxicillin/clavulanic acid prior to referral due to a documented urinary tract infection. Two patients received oestriol alone and two patients received oestriol with concurrent phenylpropanolamine. Continence did not improve in any patient receiving medication. Eleven patients received no medication prior to presentation.

The diagnostic investigation was decided by the attending clinician and all investigations were performed for urinary incontinence. Board certified radiologists (ECVDI) performed all ultrasound scans and CT scans. Ultrasound was performed in 22/25 cases (88%), CT scan was performed in one case and two cases did not undergo any pre-operative imaging. Ultrasound was diagnostic of ectopic ureter in 36% of cases (8/22). CT scan was diagnostic of ectopic ureter in the one case. Twenty-seven per cent of dogs (6/22) were deemed to have an intrapelvic bladder location based on ultrasound. One dog had an abnormal vestigial right kidney. Urine culture was performed in 24/25 dogs (96%).

Thirty-three per cent of dogs (8/24) had evidence of a urinary tract infection, characterised by a positive bacterial culture with appropriate clinical signs that warranted treatment with appropriate antimicrobials, based on culture, prior to surgical correction of the ectopic ureters. The remaining 71% (17/24) of dogs had a negative urinary culture. Cystoscopy and fluoroscopy combined were diagnostic of EU in all cases.

All dogs received a premedication of an opioid (methadone 0.2 to 0.3 mg/kg IM or IV) with or without the addition of medetomidine (5 to 10 mcg/kg IM or IV) or acepromazine (0.01 to 0.02 mg/kg IM or IV) (dosing varied according to individual case and anaesthetic protocol). Induction was performed with propofol (1 to 4 mg/kg IV) or alfaxalone (0.5 to 1.5 mg/kg IV) (dosed to effect according to individual response) and anaesthesia was maintained with isoflurane. Cefuroxime (22 mg/kg) was administered intravenously (IV) pre-operatively in all patients and every 90 minutes throughout the procedure. Cystoscopy, catheterisation of the ectopic ureter with a ureteral catheter and fluoroscopy was performed in all 25 dogs. UE was unilateral in 17 dogs (68%) and bilateral in 8 (32%). Of the unilateral ectopic

ureters, nine were left-sided and eight were right-sided. Vaginal septal remnants were present in six dogs. One dog had a small remnant of a duplicate vagina extending a small distance cranially; no further open surgery was performed for this. Ectopic ureters were successfully repositioned back into the bladder using a push-cut technique and this was confirmed with fluoroscopy in all dogs. If the post-operative positive contrast ureterogram did not confirm contrast entering the bladder, the ectopic ureter was repositioned further and was confirmed in every dog prior to cessation of surgery. Median surgical time was 42.5 minutes (15 to 120 minutes) and median anaesthesia time was 105 minutes (45 to 240 minutes). Vaginal septal remnants were transected using scissor transection using a similar technique to the EUs if present. A total of 27 cystoscopic surgeries were performed on 25 dogs, with two dogs undergoing two surgeries. No dogs were converted to an open surgery at the time of surgery, but one dog had a concurrent exploratory coeliotomy and nephrectomy due to an abnormal contralateral vestigial kidney.

Two dogs required a second cystoscopy due to ongoing incontinence. In one dog with bilateral UE, significant urethral submucosal oedema occurred during transection of the left UE, therefore resulting in reduced visibility and preventing safe transection of the right UE. The right UE was transected at a later date. In the other dog, with bilateral UE, repeat cystoscopy was performed due to ongoing incontinence. This revealed both ureters still inserting in the proximal urethra, either due to recanalisation or inappropriate correction during the first surgery. The ureters were repositioned again past the urethrovesicular junction.

Median hospitalisation time after surgery was 1 day (range: 1 to 5 days).

Complications

No immediate intra-operative complications were recorded. Haemorrhage was experienced in all procedures but did not affect visibility due to the speed of push-cut and high-flow saline. Three major complications were experienced at the time of initial surgery (3/25; 12%). One dog, 24 hours following surgery, developed a uroabdomen. Exploratory coeliotomy was performed which revealed a tear adjacent to the left ureteral opening, which was treated by primary closure of the bladder and omentalisation. This was considered to be secondary to over-filling of the bladder with saline at surgery in a poorly compliant bladder. This did not affect long-term prognosis; this patient was completely continent at follow-up. Two dogs required a repeat surgery due to ongoing incontinence. In one dog, as discussed above, the right UE was not resected in the initial surgery due to sub-mucosal oedema and reduced visibility. In the second dog, repeat cystoscopy revealed that the ureters were seen to be positioned just caudal to the vesiculourethral junction and therefore were repositioned cranially. Two dogs (8%) had minor complications of visible haematuria the following morning.

Follow-up and outcome

Follow-up was available in 18/25 dogs (72%). One dog died due to reasons unrelated to incontinence (suspected neoplastic disease of the liver and spleen). Median follow-up time was 1641 days (31 to 2715 days). All dogs' continence scores improved post-surgery. Median continence score pre-operatively was 1/5 (range: 1 to 3) and median continence score post-operatively was 5/5 (range: 3 to 5). Sixty-six per cent (12/18) of dogs were completely continent at the time of follow-up without medication; two dogs had a continence score of 3 and five dogs had a continence score of 4. There was a significant improvement in median continence score between pre and post-treatment ($P < .001$). Three dogs were receiving long-term medication at follow-up: two on phenylpropanolamine and one on phenylpropanolamine and oestriol. Of these three dogs, only one patient was on phenylpropanolamine pre-operatively and following surgery the dosage of medication required did not change (1.15 mg/kg twice a day PO). All owners reported they would have the surgery again and would recommend it to someone else.

DISCUSSION

This retrospective study demonstrates that cystoscopic scissors transection of intramural ectopic ureters significantly improved continence scores compared to before surgery. Our modified technique is an alternative treatment option for UE with complication rates (12% major and 8% minor) and complete continence rates (66%) comparable to the previous literature (Hooi et al., 2022; Jacobson et al., 2022).

One advantage of cystoscopic laser ablation (CLA) compared to CST is the concurrent haemostasis offered. Haemorrhage and a resultant drop in PCV (44% pre-operative to 38% post-operative) were previously reported (Jacobson et al., 2022). In this study, the addition of a pressure infusion system to deliver high flow rates of saline was used alongside a 'push-cut' technique with the aim of reducing haemorrhage and surgical time. We suspect the additional pressure within the urethra from the high flow rates of saline reduced haemorrhage and also increased clearance of haemorrhage. Combining this with the 'push-cut' technique allowed the cystoscope to be ahead of the haemorrhage, allowing unimpeded visualisation. We suspect the improved visualisation and the 'push-cut' modification helped reduce surgical time as there were fewer delays waiting for haemorrhage to stop and allow visualisation to continue surgery. We found the 'push cut' to be a more efficient way of cutting the tissue without having to reposition the scissors between cuts while waiting for haemorrhage to stop. Surgical time was measured from the start of urethrocystoscopy to the end of vaginoscopy and included time spent undertaking fluoroscopy. This was shorter than the previous report with a median surgical time of 42.5 minutes compared to 105 minutes (Jacobson et al., 2022). The authors believe the reduced surgical time is due to using a push-cut technique rather than a cut and reposition technique. Although haemorrhage was not quantified, in no patient was it deemed severe enough to warrant further investigation (such as PCV). Further prospective studies could explore this further.

Altogether, a 12% major complication rate was found in this study. One of the major complications in this group was suspected to be overfilling of a non-compliant bladder from increased

volumes of saline and a subsequent bladder wall tear with a resultant uroabdomen. This is potentially one of the downfalls of using high flow rates of saline and must be monitored closely during the procedure. In this case, due to the bilateral UE, we suspect the bladder was less compliant than normal and did not distend to a normal volume. This complication became evident 24 hours after the procedure; therefore, monitoring for this complication would seem prudent in patients with bilateral UE who have this procedure. In subsequent cases, additional care was taken to avoid overdistension of the bladder with saline when performing this procedure. This was achieved by palpating bladders frequently during the procedure and monitoring saline inflow and outflow around the cystoscope. If there was a cessation of inflow and outflow and/or the bladder seemed enlarged, it was carefully manually expressed prior to resuming cystoscopy. Uroabdomen has also been reported before with cystoscopic laser ablation of ectopic ureters (Hoey et al., 2021). Injury to the urethra was considered to be associated with the use of laser alongside the lack of fluoroscopy and therefore inadequate understanding of the course of the intramural EU. Although case numbers were small, a prospective case series of laser ablation in dogs with fluoroscopy (Berent et al., 2012) resulted in no urethral injuries resulting in uroabdomen. This could further support the use of fluoroscopy for treatment in future studies.

Two dogs in our study required a second surgery due to ongoing significant urinary incontinence of a similar character. In one patient, appropriate transection of both ectopic ureters was not possible due to significant submucosal oedema, likely from high flow rates of saline, warranting a staged surgery. In the second dog, continued significant incontinence could have been due to improper transection (despite adequate transection being reported on imaging and visually) or potentially recanalisation of the ectopic ureter, as has been previously reported (Smith et al., 2010). Complications in this study were defined and categorised using the criteria set by Cook et al. (2010) to try to standardise reporting of these. Previous studies using this technique do not define the criteria they have used to categorise complications, making it more challenging to draw comparisons relating to severity of complications.

Previous reports have also described a portion of dogs that had not completely improved following surgery. In our study, continence scores improved for all dogs after surgery, with 66% (12/18) judged to be completely continent. In this study, dogs were only considered completely continent with a continence score of 5 post-operatively, which represented normal continence. Previous studies with CLA using a similar continence scoring system have defined continence as a continence score greater than or equal to 4 (Hooi et al., 2022) whereas Dekerle et al. (2022) used a separate subjective scoring system (1 to 10) to quantify incontinence. Future studies would benefit from consistently using a similar continence scoring system to allow easier comparison of results. Persistent incontinence following surgery occurs in a proportion of dogs is common. Urodynamic studies have documented decreased bladder capacity, instability and a low urethral pressure profile (Lane et al., 1995). Recanalisation of ectopic ureters has also been reported and therefore repeat cystoscopy and fluoroscopy in some dogs may be necessary to reassess appropriate transection despite the use of fluoroscopy, especially if clinical signs remain the same. One case in our study fell into this category, showing no improvement after surgery and therefore repeat transection was performed which improved continence markedly (from a continence score of 1 to 5).

This study has some limitations due to its retrospective nature and the small sample size that could potentially lead to a type II statistical error. Follow-up was only performed by retrospective owner questionnaire, and this has its inherent limitations due to the long time to follow-up in some cases and potential bias associated with this.

Complication rates in this larger cohort corroborate the findings from Jacobson et al. (2022), suggesting repeatability of these findings across a larger number of cases and across separate centres with no increase in complications when compared to other larger case studies using cystoscopic-guided laser ablation (CLA) for correction of ectopic ureters (Hoey et al., 2021). In this study, the rates of continence after CST-EU alone were similar to previous studies evaluating surgical or cystoscopic techniques to treat EU (Berent et al., 2012; Hooi et al., 2022; Jacobson et al., 2022; Noël et al., 2017; Smith et al., 2010).

This suggests CST-EU is a safe and appropriate alternative to the use of laser ablation for treatment of intramural ectopia.

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Author contributions

A. Krekis and S. Das designed the study, collected, analysed and interpreted the data and wrote the manuscript. H. Badham collected and interpreted the data and revised the manuscript. R. Doyle conceptualised the surgical technique, interpreted the results and contributed to the manuscript. All authors read and approved the final version of the manuscript and are accountable for the work reported.

Conflict of interest

The authors have no conflicts of interest.

Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Supporting Information Video S1: Multiple demonstrations of our method of transection using a "push-cut" technique. High-flow rates of saline keep haemorrhage to a minimum.

Supporting Information Video S2: Demonstration of a push cut technique, transecting the ectopic ureter back to an appropriate location past the vesiculourethral junction.