

1 **Comparison of surgical indications and short- and long-term complications in**
2 **56 cats undergoing perineal, transpelvic or prepubic urethrostomy**

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20 **Key Words**

21 Urethrostomy

22 Feline Idiopathic Cystitis

23 Urolithiasis

24 Urethral Injury

25

26 **Abstract**

27

28 **Objectives:** The aim of this study was to compare indications, complications and
29 mortality rates for perineal urethrostomy (PU), transpelvic urethrostomy (TPU) and
30 prepubic urethrostomy (PPU).

31 **Methods:** A retrospective review and follow-up owner questionnaire of cats
32 undergoing urethrostomy between 2008 and 2018, at a single referral hospital, was
33 performed.

34 **Results:** Fifty-six cats underwent urethrostomy: 37 cats had PU, 8 TPU and 11 PPU.
35 Presenting problem was significantly associated with urethrostomy technique
36 ($p < 0.001$). For PU cats, feline idiopathic cystitis (FIC) (21, 56.7%) was the most
37 common problem, whereas for PPU cats, trauma (9, 81.8%) was most common
38 ($p < 0.001$). Urethrostomy technique was associated with imaging diagnosis ($p < 0.001$)
39 of urethral lesion. Most PU cats had no diagnostic imaging lesion (15, 40.5%) or
40 obstructive calculi or clots (10, 27%) and all PPU cats had urethral rupture. Ten (91%)
41 PPU cats had a pelvic lesion, while 21 (56.7%) PU cats had a penile lesion. TPU cats
42 presented with a range of presenting problems and imaging diagnoses. Short-term
43 and long-term complications were reported in 33/55 (60%) and 11/30 (36.7%) cats
44 respectively. Number of cats with long-term complications was greater amongst
45 PPU cats ($p = 0.02$). Short-term dermatitis ($p = 0.019$) and long-term incontinence
46 ($p = 0.01$) were associated with PPU. Short-term mortality was 5.6% and long-term

47 mortality was 13.3%: both were independent of urethrostomy technique. Quality-of-
48 life post-urethrostomy, across all techniques, was graded as good by 93% of owners.

49 **Conclusions and relevance:** In this study, PU was the most common feline
50 urethrostomy technique indicated for FIC. Short-term urethrostomy complications
51 are common, irrespective of urethrostomy technique. Long-term complications are
52 less frequent, but more common with PPU.

53

54 **Introduction**

55

56 Feline perineal urethrostomy (PU) is a salvage procedure that makes the narrow
57 distal penile urethra redundant, by creating a permanent urethral opening between
58 the wider, more proximal, pelvic urethra and the perineal skin. Its primary indication
59 is for male cats with recurrent urethral obstruction, due to feline idiopathic cystitis
60 (FIC) that cannot be managed by urethral flushing and catheterisation.¹ Reported
61 complication rates are 13-25 and 20-42% in the short and long-term respectively,
62 with mortality rates of up to 24%.²

63

64 Feline prepubic urethrostomy (PPU) has been described as a technique to deal with a
65 failed PU, irreparable injury of the intrapelvic urethra or congenital narrowing of the
66 intrapelvic urethra.³ In this surgery the pelvic urethra is transected as far caudally as
67 possible, but proximal to the site of injury and sutured to the skin of the ventral
68 midline, just cranial to the pubis.³ Complication rates of up to 83.3% and mortality
69 rates of up to 38% are reported, which appear to exceed those of PU.^{4,5}

70

71 Due to the apparently high complication rate associated with PPU compared to PU,
72 transpelvic urethrostomy (TPU) has been described as an alternative technique for
73 cats with failed PU.⁶ In this procedure the caudal intrapelvic urethra is accessed by
74 making a window in the pubis. The urethrostomy is then created between the

75 exposed intrapelvic urethra and overlying skin. A single study of 11 cats reported a
76 complication rate of 36% with no mortality.⁶

77

78 In summary, based on the reported complication and mortality rates for each
79 technique, preservation of the longest length of urethra possible according to the
80 underlying disease process is recommended. Accordingly, PU would be preferred
81 over TPU, which in turn would be preferred over PPU. To the author's knowledge no
82 studies have directly compared the three feline urethrostomy techniques. The
83 purpose of the current study was to perform a retrospective review of feline
84 urethrostomy procedures at a single referral centre, in order to directly compare the
85 indications, complications and mortality rates of PU, PPU and TPU. Our null
86 hypothesis was that when used for the appropriate indication, outcome for each of
87 these techniques would be the same, when outcome was assessed according to
88 complication rates, mortality and owner satisfaction.

89

90 **Materials and Methods**

91

92 Cats undergoing urethrostomy, between January 2008 and November 2018, at a
93 single referral hospital were identified and retrospectively reviewed by searching
94 computerised clinical records. Data recorded for each cat included signalment,
95 history and results of physical examination, clinical pathology and diagnostic
96 imaging. Surgical reports, anaesthesia records and hospitalisation records were

97 reviewed to confirm details of urethrostomy technique, peri-operative treatments
98 and post-operative progress. The variables collected are given in Tables 1 to 7.

99

100 A board-certified specialist surgeon performed all of the surgeries, with or without
101 the assistance of surgical resident. PU, TPU and PPU were performed following the
102 published techniques of Wilson and Harrison¹, Bernard and Viguier⁶ and Bradley³,
103 respectively.

104

105 Outcome of urethrostomy was assessed according to complications, mortality and
106 owner satisfaction. Short term outcome was defined as outcomes recorded in the
107 case records during the first four post-operative weeks. During the study period,
108 suture removal for all urethrostomy surgeries occurred at the referral hospital, 10 to
109 14 days after surgery. Moreover hospitalisation until suture removal was offered to
110 all clients. This allowed detailed monitoring for early complications, which were dealt
111 with by the referral hospital, normally within the first four post-operative weeks.

112 Short-term complications were divided into minor and major complications. Minor
113 complications were defined as those that required no intervention or
114 pharmacological treatments only. Major complications were defined as those that
115 required surgical or other procedural intervention or resulted in death or euthanasia.

116

117 Long term outcome was defined as outcomes arising after the first four post-
118 operative weeks. Long term outcome was therefore less detailed and obtained

119 primarily by means of an owner telephone questionnaire, which was completed at
120 the time this retrospective study was carried out, but also by review of case records.
121 The maximum duration of long-term follow-up was therefore determined by the
122 date of surgery and the date of the telephone questionnaire. The telephone
123 questionnaire is outlined in Table 8. This questionnaire was conducted by telephone,
124 which allowed the interviewer to use appropriate language to ensure understanding
125 of all technical veterinary terms.

126

127 Statistical analysis was performed using IBM SPSS Statistics, Version 25 (IBM
128 Corporation, New York, USA). Cats were divided into three groups according to
129 urethrostomy technique: PU, TPU and PPU. Data for these three groups were
130 compared graphically and statistically. For continuous variables, the Kruskal- Wallis
131 test, followed by the Dunn's pairwise test, were used to explore differences between
132 the 3 groups. For categorical variables, the Pearson X^2 test, followed by the Fisher's
133 Exact test, were used to explore differences between the 3 groups. Statistical
134 significance was set at $p < 0.05$.

135

136 This study was approved by the local social science ethical review board ([URN](#)
137 [SR2017-1506](#)).

138

139 **Results**

140

141 *Signalment*

142 Fifty-seven cats underwent urethrostomy between January 2008 and November 2018
143 at the study hospital. One cat was excluded due to incomplete medical records,
144 leaving 56 study cats. These 56 cats included 37 cats (66.1%) that underwent PU,
145 eight cats (14.3%) that underwent TPU and 11 cats (19.6%) that underwent PPU.
146 Figures 1, 2 and 3 demonstrate each of the urethrostomies. Fifty-four cats (96.4%)
147 were neutered males and two cats (3.6%) were entire males. Fifty-one cats (91.1 %)
148 were Domestic Shorthair (DSH) or Domestic Longhair (DLH) cats and five cats (8.9%)
149 were pure breeds. The median age was 5.9 years (range 6 months to 18 years).
150 Median weight was 4.9 (range 2.5 to 8.2) kg. There was no difference among surgical
151 groups with respect to breed, age or bodyweight.

152

153 *Presenting problem, clinical pathology and diagnostic imaging*

154 The primary presenting problem leading to urethrostomy for the 56 study cats was
155 recurrent urethral obstruction due to FIC in 26 cats (46.4%); urolithiasis in 15 cats
156 (26.8%); major trauma in 13 cats (23.2%); an inflammatory penile mass in one (1.8%)
157 cat and a penile adenocarcinoma in one (1.8 %) cat. Presenting signs are
158 summarised in Table 1. Blood tests results based on those performed on admission
159 to the study hospital or just prior to referral are summarised in Table 2. Out of 56
160 cats, 34 (60.7%) had urine bacterial culture and sensitivity testing performed; 12
161 (21.4%) had a positive culture recorded before or at the time of surgery; and 23

162 (41.1%) were prescribed antibiotics empirically or based on culture and sensitivity.

163 Diagnostic imaging studies and findings are summarised in Tables 3, 4 and 5.

164

165 *Cats presenting with FIC*

166 The 26 cats with FIC had median duration of clinical signs prior to urethrostomy of

167 221.5 (range 8 to 1245) days. Prior to referral, 25 (96.2%) cats underwent urethral

168 catheterisation, a median of 3 (range 1 to 7) times and 21 (80.8%) cats were

169 prescribed medical management for FIC. After referral, procedures performed prior

170 to urethrostomy included: urethral catheterisation in 11 (42.3%) cats; cystostomy

171 tube placement in five (19.2%) cats; bladder rupture repair in one (3.8%) cat; and

172 abdominal drain placement in one (3.8%) cat. In addition, pharmacological

173 treatments for cystitis, including one or more of meloxicam, prazosin and

174 buprenorphine, were initiated in 22 (84.6%) cats. Urethrostomy was performed at a

175 median of 3 days (range 0 to 43) after referral.

176

177 *Cats presenting due to urolithiasis*

178 The 15 cats with urolithiasis had a median duration of clinical signs prior to

179 urethrostomy of 19 (range 0 to 1095) days. Prior to referral, all 15 cats underwent

180 urethral catheterisation, a median of 2 (range 1 to 4) times and 12 (80%) cats were

181 prescribed medical management for FIC. After referral, procedures performed prior

182 to urethrostomy included: urethral catheterisation in three cats (20%); and

183 cystostomy tube placement in four cats (26.7%). In addition, pharmacological

184 treatments for cystitis, including one or more of meloxicam, prazosin and
185 buprenorphine, were initiated in 12 (80%) cats. Urethrostomy was performed at a
186 median of 3 days (range 0 to 74) after referral.

187

188 *Cats presenting due to trauma*

189 For the 13 cats with major trauma urethrostomy was performed a median of 20
190 (range 1 to 44) days after trauma. Concurrent injuries were seen in 11 cats (84.6%),
191 including pelvic fractures, skin wounds, pleural and pericardial fluid and abdominal
192 wall rupture. Treatment prior to urethrostomy included surgical fracture
193 management in two (15.4%), surgical wound management in four (30.8%),
194 cystostomy tube placement in nine (69.2%), urethral catheterisation in five (38.5%),
195 abdominal wall repair plus abdominal drain placement in one (7.7%), and pelvic limb
196 amputation in one (7.7%). Urethrostomy was performed at a median of 13 (range 1
197 to 42) days after referral.

198

199 *Cats presenting due to penile/preputial masses*

200 Two cats presented with a penile/preputial mass. Median duration of clinical signs
201 prior to urethrostomy was 45 (range 30 to 60) days. Neither cat had episodes of prior
202 urethral obstruction or cystitis. Biopsy of the lesions revealed a penile
203 adenocarcinoma in one cat and an inflammatory penile lesion in the other. Thoracic
204 and abdominal staging (CT scan) was performed for the cat with penile

205 adenocarcinoma and no metastatic disease was noted. Surgery was performed 1 and
206 9 days after referral.

207

208

209 *Association between primary presenting problem and urethrostomy technique*

210 A significant association was found between primary presenting problem and
211 urethrostomy technique ($p < 0.001$). Amongst the 37 PU cats, FIC (21, 56.7%) was
212 most common, followed by urolithiasis (12, 32.4%), trauma (2, 5.4%) and penile mass
213 (2, 5.4%). Whereas amongst the 11 PPU cats, trauma (9, 81.8%) was most common,
214 with only two (18.2%) FIC cats. TPU cats included a more even range of FIC (3,
215 37.5%), trauma (3, 37.5%) and urolithiasis (2, 25%).

216

217 *Association between diagnostic imaging findings and urethrostomy technique*

218 A significant association was found between urethrostomy technique and both the
219 nature ($p < 0.001$) and site ($p < 0.001$) of lesion, as determined by plain radiography
220 and positive contrast retrograde urethrocytography and/or normograde
221 cystourethrography. For this analysis, the penile urethra was defined as the portion
222 of the urethra at or distal to the ischial arch and the pelvic urethra was defined as the
223 portion of the urethra within the pelvis. Figures 4-8 exemplify the range of
224 radiographic lesions and sites of urethral injury. Fifteen (40.5%) PU cats had no
225 lesion, 10 (27%) had calculi or clots, eight (21.6%) had stricture and four (10.8%) had
226 rupture. Conversely 100% of PPU cats had rupture, with four (36.4%) also having

227 stricture. The TPU cats included the full range of lesions: stricture (4, 50%), rupture
228 (2, 25%), stricture plus rupture (1, 12.5%) and calculi (1, 12.5%). As expected, all
229 except one (9%) PPU cat had a pelvic lesion. PU cats included one (2.7%) with a
230 pelvic lesion and 21 (56.7%) with a penile lesion. TPU cats included six (75%) with a
231 penile lesion and two (25%) with a pelvic lesion.

232

233

234

235 *Surgery*

236 Median surgical times for PU, TPU and PPU was 85 (range 35 to 235) minutes, 150
237 (range 60 to 200) minutes and 150 (range 85 to 270) minutes, respectively. Surgical
238 time was significantly shorter for PU compared to TPU ($p=0.034$) and PPU ($p=0.019$).

239

240 *Short-term outcome*

241 One TPU cat did not return for suture removal and was lost to follow up. Short-term
242 complications were reported in 33 out of 55 (60%) cats including: 23 out of 37
243 (62.2%) PU cats, 4 out of 7 (57.1%) TPU cats and 8 out of 11 (72.7%) PPU cats. There
244 was no association between number of cats with complications and urethrostomy
245 technique. Short-term complications are given in Table 6. The only complication
246 significantly associated with a particular urethrostomy technique was peristomal
247 dermatitis, which was only seen in 2 (18%) PPU cats ($p=0.019$). No association could

248 be found between incidence of complications and any of the pre-operative and
249 operative variables reported in Tables 1 to 5.

250

251 Sterile cystitis was left untreated in six out of 14 (42.9%) cats as clinical signs were
252 mild or self-resolving. Eight out of 14 (57.1%) cats were treated with a combination
253 of drugs for the management of FIC (meloxicam and/or prazosin). Urinary tract
254 infections (UTI) were treated with antibiotics according to culture and sensitivity with
255 no further follow-up performed. Urinary incontinence was managed by skin care as
256 for peristomal dermatitis below.

257

258 Urethral obstruction was reported in two PU cats and one PPU cat prior to hospital
259 discharge. One PU cat was euthanised as a result and the other two cats were
260 successfully managed with temporary urethral catheterisation. Stoma stricture was
261 seen 2 weeks after urethrostomy in one PU cat and 3 weeks after urethrostomy in
262 one TPU cat and one PPU cat. The PU and PPU cats underwent successful revision
263 surgery: the PU was revised to a TPU and the PPU was revised to create a more
264 cranial stoma. The TPU cat was euthanised. Urine leakage in to the peri-stoma
265 subcutaneous space was successful managed in one PPU, cat by revision surgery and
266 one PU cat by temporary placement of a urethral catheter. Peristomal dermatitis
267 (Figure 9) in two PPU cats was treated successfully by daily care: bathing in water,
268 drying and application of barrier sprays.

269

270 Three out of 55 (5.4%) cats died in the short-term. Short-term mortality was not
271 associated with urethrostomy technique. One PU cat with penile adenocarcinoma
272 suffered respiratory arrest 3 days after urethrostomy, the cause of which was
273 unidentified. One PU and one TPU cat were euthanised due to urethral obstruction
274 and stoma stricture, respectively, as described above.

275

276 Short-term complications were divided into minor and major complications. Minor
277 complications were seen in 32 out of 55 (58.2%) cats overall: 20 out of 37 (54%) PU
278 cats; 4 out of 7 (57.1%) TPU cats; and 8 out of 11 (72.7%) PPU cats. Major
279 complications were seen in 8 out of 55 (14.5%) cats; 4 out of 37 (10.8%) PU cats, 1
280 out of 7 (14.2%) TPU cat and 3 out of 11 (27.2%) PPU cats. There was no association
281 between incidence of minor and major complications and urethrostomy technique.

282

283 *Long-term outcome*

284 The cat that underwent a TPU following stricture of the PU stoma was considered as
285 part of the TPU group for long-term follow-up. Long-term follow-up was available
286 for 30 cats: 14 PU cats; six TPU cats; and 10 PPU cats. Median duration of follow-up
287 was 29.5 (range 1 to 125) months. Long-term complications were reported in two
288 (14.3%) PU cats, two (33.3%) TPU cats and seven (70%) PPU cats and are summarised
289 in Table 7.

290

291 Long term complications were seen in more PPU cats compared to PU and TPU cats
292 ($p=0.02$). The only complication significantly associated with a particular
293 urethrostomy technique was urinary incontinence, which was only seen in 4 (13.3%)
294 PPU cats ($p=0.006$). No association was found between incidence of long-term
295 complications and any of the pre-operative and operative variables reported in
296 Tables 1 to 5. Both cats that underwent stoma revision surgery were included in the
297 long-term follow-up. The cat that underwent revision of a PU to a TPU had no
298 reported long-term complications. The cat with the revised PPU had occasional
299 urinary incontinence.

300

301 Long-term mortality was reported in 4 out of 30 (13.3%) cats. One PPU cat was
302 euthanised due to causes related to urethrostomy. This cat had recurrent episodes of
303 cystitis, urinary incontinence and peristomal dermatitis and was euthanised 9 months
304 post-operatively due to stoma stricture. Three cats died due to reasons unrelated to
305 urethrostomy.

306

307 Of the 30 cats with long-term follow up, 29 owners completed the follow-up
308 questionnaire. Overall, most owners were satisfied with the outcome following
309 surgery, with 28 (96.6%) owners stating they would recommend urethrostomy to
310 other cat owners. Quality of life was rated as good in 27 cats (93.3%), moderate in
311 one cat (3.4%) and poor in one cat (3.4%). All owners of cats in the PU group stated
312 that they would recommend the procedure and reported a good quality of life in

313 their cats. The two cats rated as having a moderate and poor quality of life
314 underwent TPU and PPU respectively.

315

316 Discussion

317

318 To the author's knowledge this is the first study to directly compare the three feline
319 urethrostomy techniques with regards to the surgical indications and short- and
320 long-term outcomes.

321

322 This study shows that cats undergoing PU or TPU were more likely to present due to
323 FIC or urolithiasis, rather than trauma. Conversely, cats undergoing PPU were more
324 likely to present due to trauma. With regards to location of the urethral lesion, cats
325 undergoing PU or TPU were more likely to have a penile urethral lesion, while cats
326 undergoing PPU were more likely to have a pelvic urethral lesion. These results
327 support the current literature which suggests that urethrostomy technique in cats
328 should be based on the location of urethral injury, with preservation of as much of
329 the urethra as possible. Our study further shows that cats undergoing PPU were
330 more likely to have a urethral rupture or stricture compared to cats undergoing PU
331 or TPU.

332

333 Further, this study found no association between duration of clinical signs prior to
334 urethrostomy and outcome. Therefore, we present no evidence to suggest that

335 earlier surgical intervention in these cases results in fewer post-operative
336 complications. To the authors' knowledge, this is the first study reporting duration of
337 clinical signs prior to urethrostomy surgery and its influence on outcome.

338

339 In this study we report short-term complications in 60%, of cats undergoing feline
340 urethrostomy, irrespective of urethrostomy technique, which is higher than that
341 previously reported for PU (13-25%)⁷⁻⁹ and TPU (36%)⁶ and lower than that in some
342 PPU reports (up to 83.3%).⁴ The high short-term complication rate in the current
343 study could be related to the fact that all cats were hospitalised until the time of
344 suture removal or returned to the referral hospital for suture removal and were
345 therefore closely observed, perhaps allowing for detection of more minor
346 complications than in previous reports. Indeed, minor short-term complications
347 were noted in 58.2% and major complications were noted in 14.5%.

348

349 This study reports an overall long-term complication rate of 36.7%, but long-term
350 complication rate was significantly higher in the PPU group (70%) compared to the
351 PU and TPU groups. This agrees with previous reports, which have found a similarly
352 high long-term complication rate of 83.3% for PPU⁵, but a long term complication
353 rate for PU of 25%-31.8%.^{2,8,9}

354

355 This study reports good owner-rated, long-term quality of life following
356 urethrostomy in 93.3% of cats, irrespective of urethrostomy technique, with 96.6%

357 owner satisfaction. These figures are comparable to previous reports of owner-rated
358 quality of life following PU surgery, where 75-88% of cats were judged as having a
359 moderate-good quality of life.^{2,10} However, they are contradicted by another study
360 which reports a satisfaction rate of 33.3% amongst owners of cats undergoing PPU,
361 which was significantly lower than the 81.8% satisfaction amongst owners of cats
362 undergoing PU.⁵ This difference in PPU satisfaction may be due to indication for
363 urethrostomy, rather than surgical technique. In the study by Sousa-Filho et al⁵,
364 primary indication for PPU was feline lower urinary tract disease plus failed PU, but
365 the primary indication for PPU in the current study was pelvic urethra trauma.
366 Urethrostomy does not correct the underlying problem in feline lower urinary tract
367 disease, but cats presenting with urethral trauma (excluding iatrogenic causes) have
368 no underlying urinary tract disease.

369

370 In our study 16.7% of cats had one or more UTI during the long-term follow up
371 period. No difference in the incidence of bacterial UTI at long-term follow up was
372 seen among the surgical groups. This is in contrast to a recent study of 28 cats which
373 reported a higher incidence of UTIs in cats undergoing PPU compared to PU (66.7%
374 vs 22.7%).⁵

375

376 Urethrostomy stricture has been reported in up to 11% of cats in early reports of
377 PU¹¹ but does not feature in all case series. This may be due to early reports
378 identifying the primary cause for stricture as inadequate release of the penile urethra

379 from the pelvis¹¹, which could then have been avoided in later studies. A study by
380 Bass et al reported a 12% incidence of stricture within the first 4 weeks of PU.⁸ A
381 study looking at revision following PU stoma stricture reported that revision was
382 performed at a median of 71 days following initial surgery.¹² In our study, stricture
383 was seen in only one cat (2.9%) that underwent PU. Two previous studies have
384 reported no stricture formation following PPU.^{4,5} Similarly, only 1 out of 9 cats
385 undergoing TPU showed evidence of stricture but showed no associated clinical
386 signs.⁶ In our study, stoma stricture was noted in one PPU cat and one TPU cat
387 within 4 weeks of surgery and in another PPU cat 9 months after surgery. This is a
388 major complication that resulted in euthanasia in two cats and revision surgery for
389 one cat.

390

391 Peristomal dermatitis is another complication reported following urethrostomy. This
392 is uncommonly reported following PU and in a previous PU study, only 1 cat had
393 signs of dermatitis.⁸ Peristomal dermatitis is considered more common following
394 PPU due to the location of the stoma and was reported in 43.7% and 83.3% of PPU
395 cats in two separate studies.^{4,5} In our study, 2 cats, both in the PPU group were
396 successfully treated for peristomal dermatitis in the first 4-weeks after surgery. Two
397 different cats in the PPU group were reported to have peristomal dermatitis in the
398 long-term.

399

400 Urinary incontinence is another reported complication that may result from: nerve
401 (pudendal nerve, sacral spinal cord or pelvic plexus) damage; excessive urethral
402 distension secondary to obstruction; or reduction in urethral length.¹³ In one study
403 of PU cats, incontinence was not noted.⁸ Incontinence has been reported in 12-58%
404 of cats following PPU.¹⁴ In our study, early incontinence was seen in 9 cats (17%)
405 with no difference seen among the surgical groups. However, at long-term follow
406 up, incontinence was significantly more common in the PPU group.

407

408 Limitations of this study include its retrospective design, the low numbers of cats in
409 the TPU and PPU groups and the low number of cats available for long-term follow
410 up. In addition, long-term follow up ranged in duration from 1 to 125 months.
411 Furthermore, the cats lost to follow-up were not evenly distributed between the
412 surgical groups with a higher percentage of PU cats being lost to follow-up
413 compared to TPU and PPU cats. The study was also conducted over a 10-year
414 period. During this period the team of board-certified surgeons was very stable, but
415 nevertheless multiple surgeons were involved and there may have been some
416 unreported variations in case management. In addition, the owner questionnaire
417 may have been exposed to a bias with the satisfied owners being more likely to
418 respond.

419

420 **Conclusions**

421 This study highlights the different surgical indications in terms of reason for
422 presentation, location and type of urethral injury for cats undergoing perineal,
423 transpelvic and prepubic urethrostomies. Whilst we found short-term outcome was
424 not significantly different between the three techniques, our null hypothesis was
425 rejected, as PPU was associated with a higher long-term complication rate of
426 incontinence compared PU and TPU.

427

428 **Conflict of Interest**

429

430 The authors declared no potential conflicts of interest with respect to the research,
431 authorship, and/or publication of this article.

432

433 **Funding**

434

435 The authors received no financial support for the research, authorship, and/or
436 publication of this article.

437

438 **Ethical Approval**

439

440 This work involved the use of non-experimental animals only (including owned or
441 unowned animals and data from prospective or retrospective studies). Established
442 internationally recognised high standards ('best practice') of individual veterinary

443 clinical patient care were followed. Ethical approval from a committee was therefore
444 not necessarily required but was obtained as stated in the manuscript.

445

446 **Informed Consent**

447

448 Informed consent (either verbal or written) was obtained from the owner or legal
449 custodian of all animal(s) described in this work for the procedure(s) undertaken.

450 No animals or humans are identifiable within this publication, and therefore
451 additional informed consent for publication was not required.

452

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489 **Tables**490 **Table 1: Presenting clinical signs demonstrated by 56 cats undergoing**491 **urethrostomy.** Cats are grouped according to presenting problem. Number

492 (percentage) of cats with each clinical sign are given.

Presenting signs	FIC* n=26	Urolithiasis n=15	Trauma n=13	Penile mass n=2
Pelvic limb lameness/weakness or neurological deficits	0 (0.0)	0 (0.0)	11 (84.6)	0 (0.0)
Fluid swelling of ventral abdomen, perineum or pelvic limbs	0 (0.0)	0 (0.0)	10 (76.9)	0 (0.0)
Bruising of skin	0 (0.0)	0 (0.0)	11 (84.6)	0 (0.0)
Open wounds or eschar	0 (0.0)	0 (0.0)	5 (38.5)	0 (0.0)
Blood staining of perineum	1 (3.8)	2 (13.3)	4 (30.8)	0 (0.0)
Anuria for at least 12 hours	23 (88.4)	11 (73.3)	7 (53.8)	0 (0.0)
Larger bladder due to urethral obstruction	20 (76.9)	11 (73.3)	1 (7.7)	0 (0.0)
Stranguria	24 (92.3)	13 (86.7)	2(15.4)	0 (0.0)
Polakiuria	14 (53.8)	9 (60.0)	1 (7.7)	0 (0.0)
Haematuria	6 (23.1)	4 (26.7)	3 (23.1)	1 (0.0)
Periuria	4 (15.4)	7 (46.7)	1 (7.7)	0 (0.0)
Licking Perineum	5 (19.2)	3 (20.0)	1 (7.7)	1 (50.0)
Swollen/bruised penis or prepuce	5 (19.2)	5 (33.3)	0 (0.0)	1 (50.0)

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* FIC Feline idiopathic cystitis

495 **Table 2: Summary of abnormal blood test results demonstrated by cats**
 496 **undergoing urethrostomy.** Cats are grouped according to presenting problem.
 497 Number (percentage) of cats with each abnormality out of the total number of cats,
 498 for which blood tests were available, are given.

Blood test results	FIC* n=26	Urolithiasis n=15	Trauma n=13	Penile mass n=2
Hyperkalaemia (Potassium > 4.6mmol/l)	4/21 (19.0)	3/15 (20.0)	6/11 (54.5)	0/2 (0.0)
Azotaemia (creatinine >140 µmol/l or urea >10mmol/l)	9/23 (39.1)	9/15 (60.0)	8/11 (72.7)	0/2 (0.0)
Hyperlactatemia (lactate >2.5mmol/l)	3/19 (15.8)	0/15 (0.0)	1/11 (9.1)	0/0 (0.0)
Hyperglycaemia (glucose >6.6mmol/l)	7/22 (31.2)	7/15 (46.7)	0/11 (0.0)	0/0 (0.0)
Anaemia (PCV <25%)	1/19 (5.3)	3/12 (25.0)	4/11 (36.4)	0/2 (0.0)

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* FIC Feline idiopathic cystitis

507 **Table 3: Diagnostic imaging studies performed in 56 cats undergoing**
 508 **urethrostomy.** Cats are grouped according to presenting problem. Number
 509 (percentage) of cats undergoing each study are given

Diagnostic imaging study	FIC* n=26	Urolithiasis n=15	Trauma n=13	Penile mass n=2
Abdominal ultrasound	6 (23.1)	3 (20.0)	13 (100)	0 (0.0)
Plain abdominal radiographs without contrast only	0 (0.0)	3 (20.0)	0 (0.0)	0 (0.0)
Plain abdominal radiographs plus intravenous urogram	3 (11.5)	0 (0.0)	1 (7.7)	0 (0.0)
Plain abdominal radiographs plus retrograde or antegrade urethrocytogram	25 (96.2)	11 (73.3)	13 (100)	1 (50.0)

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* FIC Feline idiopathic cystitis

511 **Table 4: Location of urethral lesion seen on diagnostic imaging studies in 56**
512 **cats undergoing urethrostomy.** Cats are grouped according to presenting
513 problem. Number (percentage) of cats undergoing each study are given. P values
514 are given for significant associations between location of urethral lesion and
515 presenting problem

Location of urethral lesion	FIC* n=26	Urolithiasis n=15	Trauma n=13	Penile mass n=2
Penile	10 (38.5)	15 (100.0)	3 (23.1)	0 (0.0)
Pelvic	3 (11.5)	2 (13.3)	10 (76.9)	0 (0.0)
	p=0.001	p<0.001	p<0.001	n.s. [†]

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* FIC Feline idiopathic cystitis

[†] n.s. Not significant

527 **Table 5: Type of urethral lesion seen on diagnostic imaging studies in 56 cats**
 528 **undergoing urethrostomy.** Cats are grouped according to presenting problem.
 529 Number (percentage) of cats with each lesion are given. P values are given for
 530 significant associations between type of urethral lesion and presenting problem

Type of urethral lesion	FIC* n=26	Urolithiasis n=15	Trauma n=13	Penile mass n=2
Rupture	3 (11.5)	2 (13.3)	5 (38.5)	0 (0.0)
Stricture	9 (34.6)	2 (13.3)	1 (7.6)	0 (0.0)
Rupture and stricture	1 (3.8)	0 (0.0)	7 (53.8)	0 (0.0)
Calculi or blood clot	0 (0.0)	11 (84.6)	0 (0.0)	0 (0.0)
No lesion	13 (50.0)	0 (0.0)	0 (0.0)	2 (100.0)
	p<0.001	p<0.001	p<0.001	n.s. [†]

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* FIC Feline idiopathic cystitis

[†] n.s. Not significant

533 **Table 6: Short-term complications in 55 cats undergoing perineal**
534 **urethrostomy (PU), transpelvic urethrostomy (TPU) and prepubic urethrostomy**
535 **(PPU).** Number (percentage) of cats with each complication are given. P values
536 are given for significant associations between complication and urethrostomy
537 technique

Short-term complications	PU* n=37	TPU† n=7	PPU‡ n=11	Total n=55	
Sterile cystitis evidenced by haematuria, pollakiuria and/or stranguria	9 (24.3)	2 (28.6)	3 (27.3)	14 (25.5)	n.s.§
Urinary tract infection confirmed by positive bacterial culture	7 (18.9)	3 (42.9)	3 (27.3)	13 (23.6)	n.s.§
Urinary incontinence	2 (5.4)	2 (28.6)	5 (45.5)	9 (16.4)	n.s.§
Repeat urethral obstruction	2 (5.4)	0 (0.0)	1 (9.1)	3 (5.5)	n.s.§
Urethrostomy stricture	1 (2.7)	1 (2.5)	1 (9.1)	3 (5.5)	n.s.§
Leakage of urine into the peri-stoma subcutaneous space	1 (2.7)	0 (0)	2 (18.2)	3 (5.5)	n.s.§
Peri-stoma dermatitis	0 (0.0)	0 (0)	2 (18.2)	2 (3.6)	p= 0.019

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* PU Perineal urethrostomy

† TPU Transpelvic urethrostomy

‡ PPU Prepubic urethrostomy

§ n.s. Not significant

543 **Table 7: Long-term complications in 30 cats undergoing perineal urethrostomy**
 544 **(PU), transpelvic urethrostomy (TPU) and prepubic urethrostomy (PPU).**

545 Number (percentage) of cats with each complication are given. P values are given
 546 for significant associations between complications and urethrostomy technique

Long-term complications	PU* n=14	TPU† n=6	PPU‡ n=10	Total n= 30	
Sterile cystitis evidenced by haematuria, pollakiuria and/or stranguria	1 (7.1)	2 (33.3)	3 (30.0)	6	n.s. §
Urinary tract infection confirmed by positive bacterial culture	2 (14.3)	1 (16.7)	2 (20.0)	5	n.s. §
Urinary incontinence	0 (0.0)	0 (0.0)	4 (40.0)	4	p= 0.006
Peri-stoma dermatitis	0 (0.0)	0 (0.0)	2 (20.0)	2	n.s. §
Urethrostomy stricture	0 (0.0)	0 (0.0)	1 (0.0)	1	n.s. §

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* PU Perineal urethrostomy

† TPU Transpelvic urethrostomy

‡ PPU Prepubic urethrostomy

§ n.s. Not significant

550 **Table 8: Guide for telephone owner questionnaire used to assess long-term**
 551 **follow up and owner satisfaction**

1. Is your cat still alive?		
a) Yes	b) No	
- How long was your cat alive after surgery/when did you cat die?	Time/Date:	
- Was the main reason for euthanasia urinary related?	Yes/No	
2. After your last visit to the QMHA, did your cat have any recurrent symptoms of a lower urinary tract problem? (haematuria, pain, stranguria, pollakiuria, dermatitis or other)		
a) None	b) Occasional incidents (3 or less mild episodes-resolved with symptomatic treatment)	c) Multiple and/or severe episodes (>3 -did not resolve with simple symptomatic treatment)
3. If recurrence of urinary symptoms occurred, specify the cause:		
a) UTI		
b) Sterile cystitis		
c) Repeat obstruction		
d) Incontinence		
e) Dermatitis		
f) Stricture		
g) Other		
4. What was the quality of life of your cat in your opinion PRIOR to surgery?		
a) Good	b) Moderate	c) Poor
5. What is/was the quality of life of your cat in your opinion AFTER surgery?		
a) Good	b) Moderate	c) Poor
6. After your experience of a urethrostomy procedure, would you recommend urethrostomy to other cat owners?		
a) Yes	b) No	

553 **Figure Legends**

554 **Figure 1:** Photograph of perineal urethrostomy at suture removal. The cat's head is to
555 the left of the photograph

556 **Figure 2:** Photograph of transpelvic urethrostomy stoma immediately post-op. The
557 cat's head is to the left of the photograph

558 **Figure 3:** Photograph of prepubic urethrostomy immediately post-op. A cystostomy
559 tube is also in place. The cat's head is to the left of the photograph

560 **Figure 4:** A normal positive contrast retrograde urethrocytogram highlighting
561 contrast filling the entire urethra and entering the bladder

562 **Figure 5:** A positive antegrade urethrocytogram highlighting contrast filling of the
563 urethra up to the level of the ischial tuberosity where it stops abruptly indicating a
564 penile urethral stricture. This cat underwent a perineal urethrostomy

565 **Figure 6:** A lateral radiograph of the caudal abdomen and pelvis showing a single
566 radiopaque urolith in the penile urethra. This cat underwent a perineal urethrostomy

567 **Figure 7:** A positive contrast retrograde urethrocytogram showing contrast leakage
568 from the intrapelvic urethra at the level of the ischium indicating a urethral rupture at
569 this level. This cat underwent a transpelvic urethrostomy

570 **Figure 8:** A positive contrast retrograde urethrocytogram showing an abrupt stop in
571 contrast filling of the urethra within the pelvis indicating a urethral stricture at this
572 level. This cat underwent a prepubic urethrostomy

573 **Figure 9:** A photo of cat that underwent prepubic urethrostomy 14-days post-
574 operatively. The photo demonstrates peristomal dermatitis and dribbling urinary
575 incontinence.