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Objectives: Evaluate the management and long-term outcome of cats with pelvic fractures.

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Results: Forty-three cats met the criteria; mean follow-up of 24 months (range 6-45). The majority (93%) had more than one orthopaedic pelvic injury, with sacro-iliac fracture-luxations seen most commonly. 23% had pre-surgical neurological deficits. Most cats (74%) were managed surgically; 60% of sacroiliac fracture-luxations, 82% ilial fractures, and 50% acetabular fractures received surgery. The complication rate was 22%, most commonly sciatic neuropraxia, (13%). 79% of all neurological deficits resolved and the remainder improved. Mean pelvic canal narrowing after trauma was -15% in surgical and -16% in conservatively managed cats. Canal width was improved postoperatively (-8%), but mildly narrowed further by follow-up (-12%); however these changes were not significant. 19% of cats had had constipation post-surgery; none developed megacolon. There was no clear correlation between the degree of narrowing of the pelvic canal up to -50%, or whether conservative treatment was opted for, and the development of constipation. Long-term mobility was not impaired in 86%, and 84% did not have any lameness detectable.

Conclusion and Relevance: The majority were managed surgically, with a 22% complication rate; the most common being transient sciatic neuropraxia. Long-term outcome was generally excellent and most had a full recovery. Constipation/obstipation was very uncommon and no clear relationship to pelvic canal narrowing could be found when considering narrowing of up to 50% in both surgical and conservative groups. As no cats in this cohort had narrowing >50%, the current recommendation of surgery to improve the canal width if narrowing is greater than 45-50% should remain.

Title Page

Management and Long-term Outcome of Pelvic Fractures – A Retrospective of Forty-Three Cats

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recommendation of surgery to improve the canal width if narrowing is greater than 45-50% should remain.

Introduction

Pelvic fractures are common, accounting for 20%-32% of cat fractures[1-3]. In a large retrospective from the early 1990s of 103 cats with pelvic fractures, 90% of cats had pelvic floor fractures, 60% had suffered a sacroiliac luxation and 48.5% had ilial fractures[2]. Historically, feline pelvic fractures were commonly managed conservatively[1,4], however there has been a shift to surgical management in recent years, borrowing criteria from canine pelvic fracture management[5]. Indications for surgery have included pelvic canal narrowing, disruption of the weight bearing axis (acetabular, ilial body or sacroiliac luxations), nerve impingement, intractable pain, inability to ambulate within a few days of injury, and bilateral/concomitant orthopaedic injuries[5]. Associated non-orthopaedic injuries are also common, including urinary tract trauma and neurological deficits being reported in 59-72% of cases[2,3]. Various techniques have been used to stabilise pelvic fractures in dogs[6-14] and cats[5,15-20]. Several complications are typically associated with pelvic fractures. Persistent or subsequent narrowing to the pelvic canal of greater than 45% has been suggested to be a risk factor for obstipation/constipation[17]. If left unattended, it may progress to megacolon requiring life long medical treatment or surgical alternatives such as subtotal colectomy and/or pelvic osteotomy[21-24]. This degree of narrowing therefore has been taken to be an indicator for surgical intervention in cats[5]. Peripheral nerve damage has also noted to be associated with pelvic fractures, especially ilial fractures, due to the proximity of the sciatic nerve[3,5,25]. A degree of lameness or decrease in mobility is also commonly cited post pelvic fracture, however there is sparse evidence to support this.

Currently, there are only limited reports on management of feline pelvic fractures that include surgical management, and very limited data on their long term outcomes. This study aims to evaluate the management of feline pelvic fractures, the occurrence of complications, whether

there is an association with pelvic canal size and constipation, and what the subsequent long term outcome is for cats with pelvic fractures.

Materialsand methods

Medical records (January 2010 to January 2014) of cats admitted with pelvic fractures were reviewed. Inclusion criteria were presence of any of the following; acetabular, ilial, ischial, pubic fractures and sacroiliac fracture-luxation, managed either conservatively or surgically, with pre-operative radiographs available. Surgically managed cats had to have post-operative and follow-up radiographs. Cats were excluded if follow-up with an owner assessed questionnaire of greater than six months post fracture was not available. Retrieved data included signalment, fracture configuration, pre-operative neurological assessment, method of management, post-operative neurological assessment, and complications. Cats were determined to have cauda-equina signs when there was a diagnosis recording of the following: 'tail-pull', 'cauda-equina', 'sacrococcygeal nerve impairment', or the clinical notes recorded a flaccid bladder requiring expression/catheterization/tube cystostomy; a lack of tail sensation/movement; reduced or absent anal tone or an absent or decreased perineal reflex. Sciatic neuropraxia was attributed when sciatic nerve damage was recorded as a diagnosis, or from the clinical notes where a reduced withdrawal reflex was noted with lack of flexion at the hock, and/or reduced or absent deep pain sensation at the paw, or knuckling was noted in the absence of other hind limb pathology.

Radiographic evaluation included assessment of both lateral and ventrodorsal view radiographs to determine the fracture configuration, pelvic canal narrowing pre-surgery, post-surgery and at follow-up using the sacral index (SI)[17]. All measurements were performed in triplicate and the degree of narrowing was categorised as mild (<10%), moderate (10-30%) and severe (>30%)[17]. A negative value indicated narrowing and a positive value indicated widening of the canal above the predicted normal width based on the SI measurement. All radiographic

evaluation was performed using DICOM imaging software. (Osirix version 4.1 64-bit open-source DICOM viewer: Osirix Imaging Software, http:// www.osirix-viewer.com/OsiriX-64bit.html).

Short-term clinical outcome (<3months) and complications were determined from the patient records at follow-up appointments. Long-term follow-up (>6months) was by postal or telephone questionnaire to owners using a previously published feline questionnaire[15,17]. Mobility and lameness were graded from 0-5 with descriptors for each group described to the owners. Information regarding specific signs of neurological deficits (knuckling, plantigrade stance, low tail carriage, ataxia) were also requested. Specific questions regarding urination and defecation were made. Data was gathered, analysed (Microsoft Excel, Microsoft Corp and SPSS v 19.0 IBM Corp), and assessed for normality and descriptive statistics performed as appropriate. Association of pelvic narrowing to constipation/obstipation was assessed by Mann-Whitney-U. A P value of <0.05 was considered significant.

Results

Cats with pelvic fractures

Forty-three cats (mean age 71 months, range 7-219), met the inclusion criteria. Twenty-five cats were female (23 neutered, two entire), 18 cats were male (17 neutered one entire). Twenty-eight cats were domestic short hair (65%), seven were domestic long hair (16%), and eight were other breeds (19%). Fracture configurations and frequency is outlined in Table 1, and sub-classification of ilial fractures are outlined in Table 2. In summary, when considering bilateral sacroiliac luxation as more than one fracture, 40/43 (93%) of cats had more than one pelvic injury (fractures/luxations). Sacroiliac fracture-luxations were most common, being seen in 40/43 (93%); unilateral or bilateral pubic fractures were present in 31/43 (72%); unilateral or bilateral ischial fractures were seen in 22/43 (51%) as were ilial fractures, 22/43 (51%). No bilateral ilial fractures were identified. Acetabular fractures were least common and again were only seen unilaterally, in 11/43 cats (26%).

Management of fractures

The majority of cats (74% 32 cats) underwent surgical stabilisation of their fractures with the remainder (26% 11 cats) being conservatively managed. More than one surgical repair/stabilisation was performed in 19/32 cats. Management of fractures were as follows:

- Sacroiliac fracture-luxations were surgically managed in 24/40 (60%), most commonly using a unilateral or bilateral 2.0mm or 2.7mm lag screw. Two cats were managed with a screw and transilial pin, one had a transilial pin alone.
- Ilial fractures were generally managed surgically in 18/22 (82%) fractures, most commonly with a single laterally placed 2.0mm DCP, some with a 1.5/2.0 VCP, two cats

were double plated, one had a reconstruction plate with K-wires, one had a human radial 2.4mm locking plate, and two were reconstructed using K-wires and lag screws alone.

- Acetabular fractures were managed conservatively in 58% (7/12); notably these fractures tended to be along the caudal acetabular rim or were comminuted, and were combined with femoral head and neck excision in two cats. Of the surgically managed cats, two had acetabular plates, one had pins with wire and two were plated using locking or reconstruction plates.
- Pubic fractures were almost exclusively managed conservatively (30/31) other than one cat who had a pelvic symphyeal separation which had caused bilateral ventroversion of the hip joints and was managed by pubic symphyseal wiring.
- No ischial fractures were managed surgically.

The post-operative complication rate was 22%, (7/32). Two cats suffered implant complications (wire breakage, screw loosening), which did not require any further management; one cat developed a surgical site swelling suspected to be infection, and the remainder had post-operative neurological deficits.

Neurological injuries

Neurological deficits were present in 10/43 cats (23%) on presentation. Sciatic neuropraxia was most common (7/10), and the remainder (3/10) had cauda-equina signs. No increase in neurological deficits was seen in the short term in conservatively managed cats, however four cats surgically managed developed further deficits (sciatic neuropraxia) post surgery (13%). Resolution of pre-surgical deficits was seen in five cats by follow-up at six to eight weeks, and in the long term (>6 months), neurological deficits from the trauma or surgery had resolved in 11/14 (79%) of cats,

and had improved in a further three. One conservatively managed cat had no detectable abnormalities at presentation, but went on to develop an unsteady/wobbly gait three months post fracture.

Pelvic canal diameter

Mean pre-operative % canal width was not significantly different between surgically managed cats; -15% (range -43 to +30%) and conservatively managed cats -16% (range -42 to +4%). Post-surgery, mean canal width had widened to a mean of -8% (range -37 to +26%), however this increase was not statistically significant. At the six to eight week follow-up, the pelvic canal had slightly narrowed to -12% (range -51 to + 19%), with an average of increased narrowing by 4%, again not significant. See Table 3 for categorisation of severity of narrowing. Constipation post fracture was seen in eight cats (19%). Two had problems at least monthly, one only twice a year and five were very intermittent suffering less than once every year. Half of the cats with constipation had visited the vet, and 2/8 were medically managed, and 2/8 had no treatment. Cats that developed constipation had a pelvic canal size range of -27 to +5%. "Severe narrowing" of the canal of (> 30%)[13,17] was present in six cats managed surgically and conservatively, with a range from -31 to -51%, however none of these cats developed constipation. Only one cat in this study had narrowing >45% which has been suggested to be the cut off for increased risk of defecation problems[17], however it did not develop any such problems. No cats from this series were reported to develop megacolon or require any surgical intervention for problems relating to constipation/obstipation.

Long term clinical outcome

The mean long term follow-up was 24 months (range 6-45 months). The majority of cats (36/42, 84%) showed no signs of lameness, with only seven (16%) having some degree of permanent lameness, (see Table 4). The majority of cats were felt to be mobile by their owners, with 86% 'as expected' to 'very agile for their age'. Only 14% of cats were considered to have impaired mobility (Table 4).

Discussion

This is the largest group of cats with pelvic fractures that have long-term follow-up of at least six months post surgery. This cohort was older than previous reports, with a mean age of 71 months, compared with a mean age of under 17months[3]. The change in demographic may relate to the increase in motor vehicle traffic since those other cohorts were reviewed or the geographic effect of living in a metropolitan area.

Compared with the largest previously published study[2], there were significantly higher levels of sacroiliac fracture-luxations at 93% compared with 60%, and a similar level of ilial body fractures 51% vs 48.5%. Acetabular fractures were the least common (26% of cats), however this was still higher than previous reports[2]. The higher levels of individual fracture types, or diagnosis of them may be attributable to the use of high detail digital radiographs, which were not present when the previous study was conducted. Furthermore, radiographs were evaluated by board certified surgical and radiology specialists, potentially increasing the likelihood of detection. Although not unsurprising, as 93% of pelvic fractures had at least two pelvic orthopaedic injuries careful evaluation of radiographs needs to be performed if only one fracture is initially identified.

Although fixation of the pelvic floor has been described in the literature[26] , this was not performed routinely in this cohort and did not appear to negatively impact on outcome. Ilial body fractures are usually an indication for surgical repair[5,15,17], and surgical stabilisation was performed in the vast majority. Some combination of lateral plating was most common, usually with a single DCP plate, and no implant complications were seen other than one cat with screw pull out in the ilial wing. This cat had a comminuted ilial fracture which was not fully reconstructed, and there was a conservatively managed sacroiliac luxation which may have contributed to the loads placed upon the relatively thin cranial ilial wing[15]. Greater consideration may be necessary to stabilising

246 concurrent injuries if there is any compromise in the primarily stabilised fracture. Sacroiliac
247 fracture luxations were managed surgically in 60% of cats. Several factors are considered when
248 determining whether to surgically manage these fractures, including whether they are bilateral,
249 degree of displacement, discomfort and mobility considerations and concurrent injuries[5,18,27].
250 Placement of a single or bilateral lag screw[18] remains a popular and successful technique, being
251 used in most cats here (21/24). Placement of a transilial pin[5,20] in conjunction with a lag screw was
252 used in two cats that had bilateral sacroiliac luxations, and was also used as sole fixation in one cat.
253 The transilial pin is a potentially easier technique to perform, and may have particular use for when
254 sacral wing landmarks are lost, however there are currently no guidelines on placement of
255 transilial pins in cats. Acetabular fractures were only surgically managed in 50%. This is surprising
256 as articular fractures are typically treated with reduction and rigid internal fixation, and the
257 historic opinion that fractures in the caudal 1/3 of the acetabulum did not require surgical
258 management has been disproved[28]. However, most of the conservatively managed acetabular
259 fractures in this series had fracture lines which were along the caudal perimeter of the articular
260 acetabulum and therefore the cost to benefit assessment may have laid in favour of conservative
261 treatment. The other conservatively managed fractures had degrees of comminution leading to
262 salvage with a femoral head and neck excision.

263 Neurological deficits were seen in 23% of cats, and therefore careful neurological
264 evaluation is essential in pelvic fracture cats. Fractures with proximity to other structures, will
265 inevitably increase the risk of concurrent injuries. The high frequency of sacroiliac fracture-
266 luxation and ilial fractures seen, could have resulted in damage to the lumbosacral plexus, being
267 ventral to the sacrum, and feasibly result in a degree of traction or avulsion secondary to sacroiliac
268 fracture-luxations[29]. Likewise the position of the sciatic nerve medial to the ilial body and then

passing over the cranial ischium clearly puts it at risk, and therefore the anatomic proximity would explain high levels of concurrent neurological impairment. These intimate relationships also explain the risk of surgically induced nerve impairment[25,30]. During surgery great care is taken to avoid trapping or stretching nerves, especially the sciatic, however 13% of cats did have post-operative sciatic neuropraxia. Positively, all of the traumatic and surgically induced neurological deficits improved, with 79% of cats having complete resolution and the remainder having some residual impairment, implying that the damage is likely a neuropraxia or axontemesis at worst and not neurotemesis. Therefore the prognosis for cats with pelvic fractures and hind limb neurological deficits appears generally good. Only one cat in this cohort developed neurological deficits not present from the trauma or surgery. This cat was conservatively managed, had bilateral mild sacroiliac luxations and no neurological deficits on presentation. Although callus healing of bone fragments have also been suggested to place nerves at risk[3], the cause of the subsequent weakness in this cat remains unclear.

Post-operative complications occurred in around 1/5 cats, with the majority being post-surgical sciatic neuropraxia and therefore particular attention should be given to post-operative neurological deficits when discussing surgical management with owners. Acquired megacolon secondary to constipation/obstipation is often cited as a potential complication of pelvic fractures, due to persistent canal narrowing, and is said to account for 25% of megacolon cases.[24,31,32] Pelvic canal narrowing has become a criteria for surgical management, with narrowing of greater than 45-50% being reported to increase the risk of megacolon[17] and hence the cut off for surgery. However there are other causes of megacolon including neurological injury, sacral spinal cord deformity and most commonly idiopathic[24,31]. This study had a mean follow up of 24months with a minimum of six months, which was important as clinical signs usually begin shortly after pelvic injury but could

take longer than five months[23]. In this follow-up period, only eight cats were reported to have constipation (19%). No cats were reported to develop megacolon. The cats that developed any issues with constipation had a pelvic canal size range of -27 to +5%. Severe narrowing of the canal, when defined as narrowing of greater than 30%[13,17] was present in six cats managed surgically and conservatively, with a range from -31 to -51%, however none of these cats developed constipation. Only one cat in this study had narrowing >45% which has been suggested to be the cut off for increased risk of defecation problems[17]. From the data presented here, it appears that narrowing of up to 50% does not cause constipation. As no cats in this study had narrowing greater than 50%, the current recommendation of surgical intervention if the pelvic canal is >45-50% narrowed should remain, until a cohort of cats with narrowing of greater than 50% has been fully evaluated.

Although, it is reassuring to know that the long term outcome of cats with pelvic fractures is generally excellent, even in those with neurological deficits, there is likely to be some bias in this population. It is possible that some cats presenting with pelvic fractures may well have had such severe trauma, including neurological deficits, such as absence of anal tone, perineal reflex, or bladder function that they may have been euthanatised due to the guarded prognosis given. This study is also unable to determine whether surgical management is superior or not to conservative management. On the face of it, the outcomes were largely similar, and the pre-operative pelvic canal narrowing was also similar. However conservative management vs surgical was not randomly assigned, and usually related to the combinations and configurations of fractures seen. These populations of cats are therefore not the same. In spite of this, this study shows that cats that received surgery and those that were intentionally conservatively managed based on current recommendations[5] can have excellent outcomes.

Conclusions

Current management criteria for feline pelvic fractures appears to work well, with excellent long term outcomes. Surgical complications are infrequent but are most commonly varying degrees of sciatic impairment. Positively, neurological deficits from the trauma or surgery resolve in most and improve in the remainder. No cats developed megacolon however a few did have intermittent issues with constipation, although the relationship to pelvic injuries is unclear. On balance it appears that narrowing of up to 45-50% is not a direct risk factor for development of constipation and megacolon, however narrowing of greater than 50% could potentially still be a risk and therefore should remain as an indication for surgical intervention.

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The Authors declare that there is no conflict of interest.

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Table 1: Fracture classifications, indicating numbers of cats with each fracture type, followed by percentage.

	Acetabular	Ilial	Ischial	Pubic	Sacroiliac
Left	3 (7%)	12 (28%)	9 (21%)	12 (28%)	9 (21%)
Right	8 (18%)	10 (23%)	8 (19%)	13 (30%)	15 (35%)
Bilateral	0 (0%)	0 (0%)	5 (11%)	6 (14%)	16 (37%)
Total	11 (26%)	22 (51%)	22 (51%)	31(72%)	40 (93%)

Table 2: Sub-classification of Ilial fractures, showing ilial fracture configurations and percentage representation. All percentages rounded to nearest whole number.

	Number of Cats	% of ilial fractures
Left comminuted	5	23
Right comminuted	1	5
Total	6	27
Right oblique	4	18
Left oblique	6	27
Total	10	45
Left transverse	1	5
Right transverse	5	23
Total	6	27

Table 3: Classification of pelvic canal narrowing. Widening is pelvic canal diameter greater than the sacral index width. Mild narrowing = 0-10% narrowed, Moderate narrowing = 10-30% and Severe = >30% narrowing.

	Widened	Mild Narrowing	Moderate Narrowing	Severe Narrowing
% Conservative cats	18	9	55	18
% Surgical cats post surgery	22	22	66	0
% Surgical cats follow up	26	30	26	18

Table 4: Lameness and Mobility outcomes from questionnaire. For lameness, grade 0 indicates complete absence of lameness, I indicates barely noticeable lameness, Grade V indicates the lameness could not be worse, and grades II-IV are grades of severity between. For mobility, grade I indicates very agile, grade III indicates mobility consistent with age, grade V indicates poor mobility. Numbers of cats and % out of totals are represented.

Grade	Lameness	Mobility
None	36 (84%)	NA
I	3 (7%)	17 (40%)
II	1 (2%)	7 (16%)
III	2 (5%)	13 (30%)
IV	1 (25%)	6 (14%)
V	0 (0%)	0 (0%)