



Treatment of pelvic fractures in cats with patellar fracture and dental anomaly syndrome

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Journal of Feline Medicine and Surgery
2021, Vol. 23(4) 375–388
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DOI: 10.1177/1098612X20959616
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Abstract

Objectives The aim of this study was to describe the treatment and outcome of acetabular and other pelvic fractures in cats with patellar fracture and dental anomaly syndrome (PADS) and to provide advice on how to manage these cases in practice.

Methods Data were collated on cats with PADS that were reported to have sustained pelvic fractures or had fractures or fissures of the pelvis identified on submitted radiographs. The details of the fractures were recorded, in addition to any treatment and outcome information.

Results Of the 215 cases reported with PADS, 58 cats (27%) were found to have pelvic fractures, none of which were known to have resulted from significant trauma. There were 101 fractures in total and of these 15 were treated with surgery, including 10 acetabular fractures, two ilial, two pubic and one ischial fracture. Screw loosening and loss of fracture reduction was seen in four of the surgically treated fractures (two pubic fractures, one ilial and one acetabular fracture). Fourteen cats were euthanased as a direct result of a fracture occurring. While most pelvic fractures healed uneventfully, some cats remained intermittently lame, but it was not always possible to determine the cause of the lameness from the information available and because all cats had concurrent patellar fractures.

Conclusions and relevance Many of the pelvic fractures healed with conservative management. Fractures involving articular surfaces such as acetabular fractures may benefit from surgical stabilisation as surgery may offer the benefits of articular fracture repair with improved joint congruency and a faster return to normal activity.

Keywords: Patellar fracture; stress insufficiency fracture; persistent deciduous teeth; acetabulum; pelvic

Accepted: 24 August 2020

Introduction

Patellar fracture and dental anomaly syndrome (PADS), formerly known as knees and teeth syndrome, is recognised as a pathological disorder in cats involving insufficiency fractures of the patella and dental abnormalities.¹ Previous studies report that many of these cats develop non-traumatic fractures to other bones, preceding or subsequent to the patellar fractures. Pelvic fractures are the most frequent additional insufficiency fractures in cats suspected to be suffering from PADS.^{1–3}

An insufficiency fracture occurs when physiological muscular forces are applied to abnormal bone.⁴ Surgical treatment for patellar insufficiency fractures has been reported, but it is challenging and often results in failure of the repair, non-union or further fragmentation of the patella.^{1,2} Although surgical treatment for insufficiency

patellar fractures has a poor prognosis, there is evidence that surgical management for insufficiency fractures to other bones in cats affected by PADS is successful,^{2,3}

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and these fractures can heal normally, in a similar manner to a surgically treated traumatic fracture; however, there is insufficient published literature to support this assertion.

This report aims to document the treatment and outcome following preceding and subsequent pelvic fractures in cats with PADS.

Materials and methods

Details on cats with PADS have been collected since 2005, following a letter requesting cases.⁵ Recently, a combined database was established based on information of cases acquired at the University of Bristol (UK) and Exclusively Cats Veterinary Hospital, Michigan (USA). Following the initial letter, publications in the veterinary literature, and a page on Facebook (<https://www.facebook.com/felinepatellafracturestudy>), owners and veterinarians with cats they believed to be affected by this syndrome have continued to make contact. Cats were included in the databases if they had the following clinical features: transverse patellar fracture(s) with or without dental anomalies, including one or all persistent deciduous teeth, unerupted deciduous or adult teeth; and one or more atraumatic fracture(s) to other bones. The PADS database was searched for all cats with pelvic fractures up until June 2020. Owners and veterinarians were contacted by email or telephone to obtain follow-up information. A request was made to complete a questionnaire (see supplementary material) to obtain long-term follow-up. The questionnaire requested information on the cat's current condition and fractures to other bones; radiographs and histories were requested for details on the treatment and outcome.

For this article, radiographs were reviewed for evaluation of treatment and information was recorded from the data submitted regarding postoperative progress and clinical and current status.

The signalment of the affected cat, date or age the fracture occurred, details of unilateral or bilateral patellar fracture, and whether dental anomalies were present, were recorded for each cat. The treatment method and outcome, including complications, clinical outcome and final outcome, of the cats were documented; when the cats were reported to have died the cause of death was noted, if known.

The University of Bristol Ethical Committee approved the use of the acquired information.

Results

Information was obtained and registered for 215 cats with suspected PADS. Of these, 39.1% ($n = 84$) had sustained preceding or subsequent fractures to other bones, and in 58 of these cats, fractures involved the pelvis. In these 58 cats, bilateral (41 cats) or unilateral

(17 cats) patellar fractures were present and 31/58 cats had dental anomalies, mainly persistent deciduous teeth. In these 58 cats there were 101 pelvic fractures of which 47.5% ($n = 48$) were acetabular, 30.7% ($n = 31$) ischial, 7.9% ($n = 8$) ilial, 6.9% ($n = 7$) pubic and 6.9% ($n = 7$) were unspecified pelvic fractures. Twenty-eight (48%) of the 58 cats with pelvic fractures had only one part of the pelvis affected (unilateral acetabular, ischial, ilial or pubic); 23 cats had two fractures, three cats had three fractures, two had four fractures and two cats had five fractures. The details of the numbers of pelvic fractures, patellar fractures and whether there were dental anomalies reported in these 58 cats are summarised in Table 1.

Thirty-four cats had 48 acetabular fractures; of these, 20 were unilateral and 14 were bilateral fractures. Age at which the acetabular fracture occurred was reported for 27 fractures (range 11 months to 7 years 2 months; mean 3 years to 9 months). There was information on the original fracture configuration for 27 fractures (before healing) and exact location; these fractures were all simple fractures with transverse configuration located cranially, centrally or caudally, and with minimal-to-moderate displacement.

Ten of the acetabular fractures were managed surgically (Figures 1 and 2) by stabilisation with a plate and screws and the fracture was not primarily treated, but femoral head and neck ostectomy was performed in three cats. One postoperative complication was reported with screw loosening and loss of fracture reduction in case 80. Fifteen acetabular fractures were reported to have been treated conservatively (cage rest and analgesia; Figure 3), and in 20 cats the treatment method was not known, not reported or not specifically prescribed as the fractures may have been undiagnosed until they were identified incidentally or the cat was euthanased before treatment. There were 26 healed acetabular fractures and two fractures in one cat that developed non-unions. Six cats with acetabular fractures were ultimately euthanased as a direct result of fracturing a bone (either the acetabulum or different bones). A summary of the details of treatment and outcome for acetabular fractures is listed in Table 2.

Details on treatment and outcome of ischial fractures are described in Table 3. Twenty-two cats were reported to have 31 ischial fractures of which 13 were unilateral and nine bilateral. Fracture configuration was similar between cats, being simple transverse or oblique fractures lines through the ischial body. Details on treatment methods were reported for 15 fractures. One cat with bilateral fractures had stabilisation of the left ischial fracture with bone plate and screws; the right side was treated conservatively. Conservative therapy was the most common treatment method for 14 fractures;

Table 1 Summary of the numbers of pelvic and patellar fractures and dental anomalies in cats with patellar fracture and dental anomaly syndrome

Case number	Pelvis*	Acetabulum	Ischium	Ilium	Pubis	Dental anomalies†	Patellar fractures
5			XX	XX	X	X	XX
7				X			X
12			X				XX
17		X	X				XX
22		X					X
23		XX					XX
27		XX				X	XX
28	X						XX
32			X		X		XX
34	X						XX
35			X				XX
37		XX				X	XX
38	X						X
47			XX				XX
52		XX					XX
54		XX				X	XX
55			XX		X		XX
57		X		X		X	XX
59		X				X	X
72		XX					XX
80		XX	XX		X		XX
87		X				X	XX
88			XX			X	XX
89		XX					XX
90			X			X	XX
92		X					X
95		X	XX			X	X
98		XX					XX
103			X				XX
105		X				X	X
112			XX		XX		XX
113		X	X			X	XX
115	X						XX
117	X					X	XX
122		X				X	XX
123		X				X	XX
124		XX				X	XX
126		XX				X	XX
127		XX				X	X
129		X	XX	X		X	XX
139		XX					XX
140			XX				XX
141			X			X	XX
143		X	X		X		XX
146			X			X	X
148		X				X	X
157		X					XX
161			X			X	X
166		X				X	X
171		X				X	XX
174		X				X	XX
182				XX		X	X

(continued)

Table 1 (continued)

Case number	Pelvis*	Acetabulum	Ischium	Ilium	Pubis	Dental anomalies†	Patellar fractures
183		X		X		X	XX
199		XX					X
201	XX						X
206		X				X	X
213			X			X	X
214			X			X	XX
Totals							
58 cats	7	48	31	8	7	31	98

*In these cats, pelvic fractures were described but no further details provided

†Dental anomalies include persistent deciduous teeth or retained or unerupted adult teeth. Dental anomalies were not specifically assessed for in early cases so may have been missed

X = indicates one bone is affected; XX = indicates two bone (bilateral) fractures



Figure 1 Ventrodorsal projection of the pelvis of case 17. A simple acetabular fracture was stabilised with a four-hole 2.0 mm acetabular plate and screws. Healing is complete, with mild degenerative joint disease evident. The surgical approach involved a greater trochanter osteotomy that has been stabilised with pins and a tension band wire. There is a concurrent left ischial fracture, which has not healed. This cat had bilateral partial patellectomy as treatment for the patellar fractures



Figure 2 Ventrodorsal projection of the pelvis of case 23. Bilateral plate and screw fixation using seven-hole 2.0 mm dynamic compression plates for bilateral acetabular fractures. There is some reaction around the greater trochanters bilaterally, associated with gluteal tenotomies that were performed as part of the surgical approach to the acetabular fractures. The cat has a simple transverse right patellar fracture and the left patellar fracture is evident along with periarticular ossification, mineralisation and enthesophytosis

the remainder of the fractures were not treated as they were incidental findings or no treatment method was reported. Regarding the outcome of the ischial fractures,

in the majority of the cats (20 cats) the fractures were reported as healed (Figure 4). Five cats were euthanased later in life because they went on to fracture other bones.

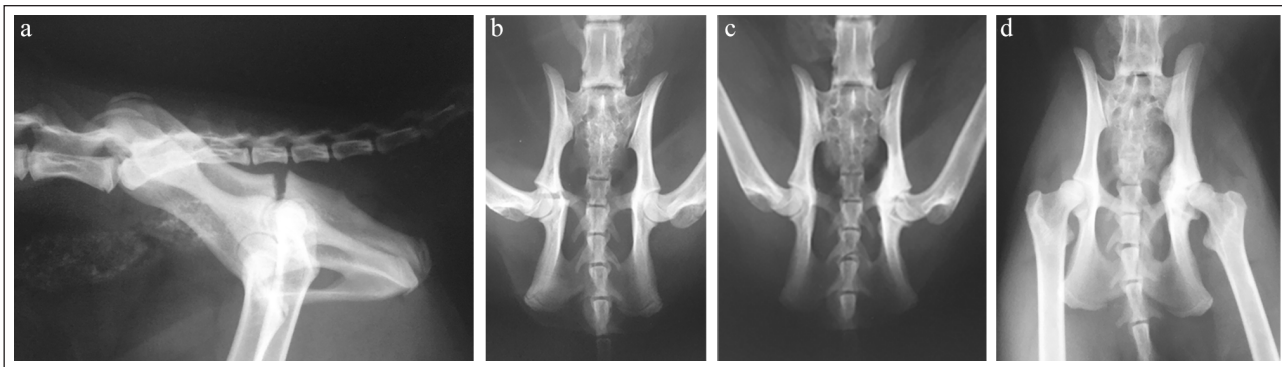


Figure 3 (a) Lateral and (b–d) ventrodorsal projections of the pelvis of case 27. (a,b) At 11 months of age the cat developed a spontaneous cranial right acetabular fracture, which was treated conservatively. (c) At 14 months of age the right acetabular fracture has healed and there is callus around a recent left acetabular fracture. (d) Further callus development and healing of the left acetabular fracture is causing mild pelvic canal narrowing. There is coxofemoral incongruity with mild hip subluxation and very mild periarticular osteophytosis. The right acetabular fracture has healed and remodelled well

Table 2 Details of treatment and outcome in the cats with patellar fracture and dental anomaly syndrome and acetabular fractures

Case number	Age at fracture	Right (R) or left (L) acetabular fracture	Bilateral/unilateral acetabular fractures	Details of fracture from radiographs and descriptions	Treatment	Outcome for fracture	Clinical outcome	Final outcome
17	5 years	R	Unilateral	Transverse central acetabulum	Acetabular plate and screws	Fracture healed uneventfully	Difficult to assess due to multiple fractures	LTFU
22	NR	NR	Unilateral	NR	NR	NR	NR	LTFU
23	2 years 3 months	R	Bilateral – concurrent	Transverse central acetabulum	Plate and screws	Fractures healed uneventfully	Hips painful on rotation and extension 3 years after surgery. No lameness or crepitation	LTFU
	2 years 3 months	L		Transverse central acetabulum	Plate and screws	Fractures healed uneventfully		
27	11 months	R	Bilateral – at different times	Transverse cranial acetabulum	Conservative	Radiographic evidence of complete bone healing	Stiff on hips 13 years after fractures occurred, but difficult to assess lameness origin owing to multiple fractures	LTFU
	1 year 2 months	L		Transverse central acetabulum	Conservative	Radiographic evidence of complete bone healing		
37	NR	R	Bilateral – concurrent	Healed chronic fractures	NT	Radiographic evidence of complete bone healing	Difficult to assess owing to multiple fractures	PTS due to other fractures
	NR	L		Healed chronic fractures	NT	Radiographic evidence of complete bone healing		
52	4 years 6 months	R	Bilateral – concurrent	NR	Conservative	Fractures healed uneventfully	NR	LTFU
	4 years 6 months	L		NR	Conservative	Fractures healed uneventfully		

(continued)

Table 2 (continued)

Case number	Age at fracture	Right (R) or left (L) acetabular fracture	Bilateral/unilateral acetabular fractures	Details of fracture from radiographs and descriptions	Treatment	Outcome for fracture	Clinical outcome	Final outcome
54	5 years	R	Bilateral – concurrent	Transverse central acetabulum	Conservative	Fracture healed uneventfully	Stiff	Alive
	5 years	L		Transverse central acetabulum	FHO	Fracture healed uneventfully		
57	5 years	R	Unilateral	NR	Conservative	Fracture healed uneventfully	Difficult to assess owing to multiple fractures – required intermittent meloxicam	Alive
59	NR	L	Unilateral	Healed chronic fracture	NT	Fracture healed uneventfully	Occasionally lame	Alive
72	2 years	R	Bilateral – concurrent	NR	Plate and screws	NR	Developed subsequent fractures	PTS due to other fractures
	2 years	L		NR	Plate and screws	NR		
80	NR	R	Bilateral – at different times	Transverse central acetabulum	Conservative	NR	Walking normally	Alive
	3 years	L		Transverse central acetabulum	Plate and screws	Radiographic evidence of screw loosening		
87	2 years	R	Unilateral	Transverse central acetabulum	FHO	Fracture healed uneventfully	Slightly abnormal gait	Alive
89	NR	R	Bilateral – concurrent	NR	Plate and screws	NR	Walking normally	Alive
92	NR	L	Unilateral	NR	Plate and screws	NR	NR	LTFU
	2 years	L		Transverse cranial acetabulum	NT	Radiographic evidence of complete bone healing		
95	NR	R	Unilateral	Healed chronic fracture	NT	Radiographic evidence of complete bone healing	NR	PTS due to other fractures
98	NR	R	Bilateral – concurrent	Non-union chronic fractures, transverse central acetabulum	Conservative	Non-unions	Mild narrowing of the pelvic canal	LTFU
	NR	L		Non-union chronic fractures, transverse central acetabulum	Conservative	Non-unions		
105	NR	NR	Unilateral	NR	NR	NR	NR	LTFU
113	2 years	R	Unilateral	Healed chronic fracture	NT	Reported complete bone healing	NR	NR
122	NK	L	Unilateral	Healed chronic fracture	NT	Radiographic evidence of complete bone healing	NR	PTS due to squamous cell carcinoma
123	6 years	L	Unilateral	NR	NR	NR	NR	NR

(continued)

Table 2 (continued)

Case number	Age at fracture	Right (R) or left (L) acetabular fracture	Bilateral/unilateral acetabular fractures	Details of fracture from radiographs and descriptions	Treatment	Outcome for fracture	Clinical outcome	Final outcome
124	7 years 2 months	R	Bilateral – concurrent	Transverse central acetabulum	Conservative	Radiographic evidence of complete bone healing	NR	NR
	7 years 2 months	L		Transverse central acetabulum	Conservative	Radiographic evidence of complete bone healing		
126	NR	R	Bilateral – concurrent	Healed chronic fractures	NT	Radiographic evidence of complete bone healing	NR	NR
	NR	L		Healed chronic fractures	NT	Radiographic evidence of complete bone healing		
127	2 years 6 months	R	Bilateral – concurrent	Transverse cranial acetabulum	NA	NA	NA	PTS due to fractures*
	2 years 6 months	L		Transverse cranial acetabulum	NA	NA		
129	3 years	R	Unilateral	Transverse caudal acetabulum	NR	NR	NR	PTS due to other fractures
139	NR	L	Bilateral – concurrent	Transverse central acetabulum	Plate and screws	NR	NR	NR
	NR	R		Transverse central acetabulum	Plate and screws	NR		
143	7 years	R	Unilateral	Transverse central acetabulum	FHO	Reported complete bone healing	Walked normally after FHO	PTS due to other fractures
148	NR	L	Unilateral	Healed chronic fracture	Conservative	NR	NR	NR
157	NK	R	Unilateral	Healed chronic fracture	NT	Radiographic evidence of complete bone healing	NR	Died – unknown cause
166	1 year 9 months	L	Unilateral	Transverse cranial acetabulum	NR	Reported complete bone healing	NR	NR
171	7 years	R	Unilateral	Transverse central acetabulum	NR	NR	NR	NR
174	NR	L	Unilateral	Transverse caudal acetabulum	NR	NR	NR	LTFU
183	NR	R	Unilateral	Transverse caudal acetabulum	NR	NR	NR	LTFU
199	4 years 4 months	R	Bilateral – concurrent	Transverse central acetabulum	Conservative	NR	NR	LTFU
	4 years 4 months	L		Transverse central acetabulum	Conservative	NR		

(continued)

Table 2 (continued)

Case number	Age at fracture	Right (R) or left (L) acetabular fracture	Bilateral/unilateral acetabular fractures	Details of fracture from radiographs and descriptions	Treatment	Outcome for fracture	Clinical outcome	Final outcome
206	NR	NR	Unilateral	NR	Conservative	NR	Developed subsequent fractures	Alive
Totals (34 cats; 48 fractures)								
	- Mean age at fracture: 3 years 9 months	- R = 24 - L = 21 - NR = 3	- Bilateral = 14 - Unilateral = 20	- Transverse acetabulum = 27 - Healed chronic fracture = 10 - NR = 11	- Plate and screws = 10 - FHO = 3 - Conservative = 15 - NR/NT/NA = 20	- Healed = 26 - Complications = 1 - Non-unions = 2 - NR/NA = 19	- Walking normally = 3 - Pain/stiffness/lameness/difficult to assess specific cause of lameness due to multiple fractures = 9 - Developed more fractures = 2 - NR/NA = 20	- Alive = 7 - PTS due to fractures = 6 - Died/PTS unknown or other = 2 - LTFU/NR = 19

*Euthanased owing to fractures; therefore, outcomes of fracture not reported
 LTFU = lost to follow-up; NR = no report; PTS = put to sleep; FHO = femoral head ostectomy; NT = no treatment; NK = not known; NA = not available

Table 3 Details of treatment and outcome in the cats with patellar fracture and dental anomaly syndrome and ischial fractures

Case number	Age at fracture	Right or left ischial fracture	Bilateral/unilateral ischial fracture	Details of fracture from radiographs and descriptions	Treatment	Outcome for fracture	Clinical outcome	Final outcome
5	NR	R	Bilateral – concurrent	Transverse ischial body and ischial arch	NR	NR	LTFU	LTFU
	NR	L		Transverse ischial body and ischial arch	NR	NR		
12	7 years	NR	Unilateral	NR	NR	NR	NR	PTS, reason unknown
17	5 years	L	Unilateral	Transverse ischial body	Conservative	Healed uneventfully	Stiff, but difficult to assess owing to multiple fractures	LTFU
32	3 years 4 months	R	Unilateral	Short oblique ischial body	Conservative	Healed uneventfully	Stiff, but difficult to assess owing to multiple fractures	Died – acute GI episode

(continued)

Table 3 (continued)

Case number	Age at fracture	Right or left ischial fracture	Bilateral/unilateral ischial fracture	Details of fracture from radiographs and descriptions	Treatment	Outcome for fracture	Clinical outcome	Final outcome
35	NR	L	Unilateral	Transverse ischial body	Conservative	Healed uneventfully	NR	PTS due to other fractures
47	4 years	L	Bilateral – at different times	Transverse ischial body	Conservative	Non-union	Stiff	Alive
	5 years 8 months	R		Transverse ischial body	Conservative	NR		
55	9 years	R	Bilateral – concurrent	Transverse ischial body	NR	Healed uneventfully	Slightly stiff	PTS due to other fractures
	9 years	L		Transverse ischial body	NR	Healed uneventfully		
80	NK	R	Bilateral – concurrent	Transverse ischial body	Conservative	Healed uneventfully	Walking normally	Alive
	NK	L		Transverse ischial body	Conservative	Healed uneventfully		
88	5 months	R	Bilateral – at different times	NR	NR	Healed uneventfully	NR	Died unknown cause
	8 months	L		NR	NR	NR		
90	3 years	R	Unilateral	Short oblique ischial body	NR	Healed uneventfully	Stiff	Alive
95	NR	R	Bilateral – concurrent	Healed chronic fractures	NT	Healed uneventfully	NR	PTS owing to other fractures
	NR	L		Healed chronic fractures	NT	Healed uneventfully		
103	NR	L	Unilateral	NR	NR	NR	NR	NR
112	12 years	R	Bilateral – concurrent	Transverse ischial body	Conservative	Healed uneventfully	Stiff and limps, but difficult to assess owing to multiple fractures	Alive
	12 years	L		Transverse ischial body	Plate and screws	Healed uneventfully		
113	NR	R	Unilateral	Short oblique ischial body	NR	NR	Intermittent lameness	NR
129	6 years	L	Bilateral – at different times	NR	NR	NR	NR	PTS owing to other fractures
	7 years	R		NR	NR	NR		
140	NR	R	Bilateral – concurrent	NR	Conservative	Radiographic evidence of bone healing	NR	PTS, reason unknown
	NR	L		NR	Conservative	Radiographic evidence of bone healing		
141	11 months	L	Unilateral	Oblique ischial body	NR	Healed uneventfully	NR	NR
143	7 years 4 months	R	Unilateral	Fracture line from the right ischial arch to the obturator foramen	NR	Healed uneventfully	NR	PTS owing to other fractures
146	5 years	R	Unilateral	Transverse ischial body	Conservative	Healed uneventfully	NR	NR
161	NR	R	Unilateral	Transverse ischial body	Conservative	Healed uneventfully	NR	NR

(continued)

Table 3 (continued)

Case number	Age at fracture	Right or left ischial fracture	Bilateral/unilateral ischial fracture	Details of fracture from radiographs and descriptions	Treatment	Outcome for fracture	Clinical outcome	Final outcome
213	NK	R	Unilateral	Transverse ischial body	Conservative	Healed uneventfully	NR	Alive
214	NR	L	Unilateral	Transverse ischial body	Conservative	Non-union (CT)	NR	PTS reason unknown
Totals (22 cats; 31 fractures)								
	- Mean age at fracture: 5 years 4 months	- R = 16 - L = 14 - NR = 1	- Bilateral = 9 - Unilateral = 13	- Ischial body = 20 - Other = 3 - NR = 8	- Plate and screws = 1 - Conservative = 14 - NR/NT = 16	- Healed uneventfully = 20 - Non-union = 2 - NR = 10	- Walking normally = 1 - Stiff/lame/difficult to assess owing to multiple fractures = 7 - LTFU/NR = 14	- Alive = 5 - PTS due to fractures = 5 - PTS/died unknown = 5 - LTFU/NR = 7
	- Age range: 5 months to 12 years							
	- NR/NK = 14							

NR = no report; R = right; L = left; LTFU = lost to follow-up; CT = computed tomography; PTS = put to sleep; GI = gastrointestinal; NK = not known; NT = no treatment



Figure 4 Ventrodorsal projection of the pelvis of case 95. Bilateral healed ischial fractures with smooth callus formation. There is callus associated with the cranial aspect of the right acetabulum suggestive, but not conclusive, of a prior fracture in this region

Six cats were reported to have eight ilial fractures; information on the configuration of the fracture was available for seven fractures (five cats), with a transverse or short oblique fracture line through the ilial body being the most frequent. Only two cats (one ilial fracture each) had information on treatment methods, one had stabilisation with plate and screws, which failed and the outcome was a non-union, and the other fracture was stabilised with pins and figure-of-eight wire. The outcome for these fractures was reported as healed in one cat and complications and a non-union in one other cat. The clinical outcome was not reported in three cats; two cats were reported to be stiff or constantly lame. One cat was euthanased owing to multiple fractures. Details on the treatment and outcome of cats with ilial fractures are summarised in Table 4.

Information on treatment for pubic fractures was recorded for six cats with seven fractures. Three of these fractures had conservative treatment and two fractures in one cat were managed surgically by stabilisation with a plate and screws. This cat suffered postoperative complications, with infection and screw loosening, and loss of fracture reduction. Outcome information was available for five cats, all fractures healed but two cats were euthanased later owing to other fractures, one died from unrelated causes, three were stiff and lame, and two were walking normally. Table 5 describes the information on the treatment and outcome in cats with pubic fractures.

Table 4 Details of treatment and outcome in the cats with patellar fracture and dental anomaly syndrome and ilial fractures

Case number	Age at fracture	Right or left ilial fracture	Bilateral/unilateral ilial fracture	Details of fracture from radiographs and descriptions	Treatment	Outcome for fracture	Clinical outcome	Final outcome
5	NR	R	Bilateral – concurrent	Transverse ilial body	NR	NR	LTFU	LTFU
	NR	L		Transverse ilial body	NR	NR		
7	NR	R	Unilateral	Chronic fracture	Plate and screws	Complications and non-union	Constant lameness	LTFU
57	8 years 3 months	R	Unilateral	Transverse ilial body	Pins and figure-of-eight wire	Healed uneventfully	Stiff, but difficult to assess owing to multiple fractures	Rehomed LTFU
129	8 years	NR	Unilateral	Short oblique ilial body	NT	NA*	NA*	PTS owing to fractures
182	1 year 9 months	R	Bilateral – concurrent	Short oblique ilial body	NR	NR	NR	NR
	1 year 9 months	L		Short oblique ilial body	NR	NR		
183	NR	R	Unilateral	Transverse ilial body	NR	NR	NR	NR
Totals (6 cats; 8 fractures)								
	– Mean age at fracture: 4 years 11 months	– R = 5 – L = 2 – NR = 1	– Bilateral = 2 – Unilateral = 4	– Ilial body = 7 – Chronic fracture = 1	– Surgery = 2 – NR/NT = 6	– Healed = 1 – Complications and non-union = 1 – NR/NA = 6	– Stiff/lame = 2 – LTFU/NR = 3 – NA* = 1	– PTS owing to fractures = 1 – LTFU/NR = 5
	– Age range: 1 year 9 months to 8 years 3 months							
	– NR = 4							

*Euthanased owing to fractures; therefore, outcome of fracture not reported
 NR = no report; R = right; LTFU = lost to follow-up; L = left; NA = not available; NT = no treatment; PTS = put to sleep

Table 5 Details of treatment and outcome in the cats with patellar fracture and dental anomaly syndrome and pubic fractures

Case number	Age at fracture	Right or left pubic fracture	Bilateral/unilateral pubic fracture	Details of fracture from radiographs and descriptions	Treatment	Outcome for fracture	Clinical outcome	Final outcome
5	NR	R	Unilateral	Transverse through the pubic body	NR	NR	LTFU	LTFU
32	3 years 4 months	L	Unilateral	Transverse through the pubic body	Conservative	Healed uneventfully	Stiff, but difficult to assess owing to multiple fractures	Died – acute GI episode
55	9 years	NR	Unilateral	Transverse through the pubic body	Conservative	Healed uneventfully	Slightly stiff	PTS owing to other fractures

(continued)

Table 5 (continued)

Case number	Age at fracture	Right or left pubic fracture	Bilateral/unilateral pubic fracture	Details of fracture from radiographs and descriptions	Treatment	Outcome for fracture	Clinical outcome	Final outcome
80	NR	L	Unilateral	Pubic ramus	Conservative	NR	Walking normally	Alive
112	12 years	R	Bilateral – concurrent	Pubic ramus	Plate and screws	Complications – screw loosening and infection	Stiff and limps, but difficult to assess owing to multiple fractures	Alive
	12 years	L		Pubic ramus	Plate and screws	Complications – screw loosening and infection		
143	7 years	NR	Unilateral	Transverse through the pubic body	NR	NR	Walking normally	PTS owing to other fractures
Totals (6 cats; 7 fractures)								
	– Mean age at fracture: 8 years 6 months	– R = 2 – L = 3 – NR = 2	– Bilateral = 1 – Unilateral = 5	– Pubic body = 4 – Pubic ramus = 3	– Plate and screws = 2 – Conservative treatment = 3 – NR = 2	– Healed = 2 – Complications = 2 – NR = 3	– Walking normally = 2 – Stiff/lame/difficult to assess = 3 – LTFU/NR = 2	– Alive = 2 – PTS owing to fractures = 2 – Died unknown/other = 1 – LTFU = 1

NR = no report; R = right; L = left; LTFU = lost to follow-up; GI = gastrointestinal; PTS = put to sleep

Discussion

Fractures of the pelvis are the commonest fracture seen in cats with PADS in addition to the patellar fracture(s). The majority of the non-articular pelvic fractures healed with conservative management. Iliac and pubic fractures were the least common fracture type, with only four fractures treated surgically, and conclusions could not be drawn from such a small number of cases. Surgical stabilisation was most commonly employed for the acetabular fractures with good outcomes, when follow-up was available. Conservative management for acetabular fractures was also successful in terms of bone healing, albeit the bones healed with malunions and mild joint incongruity.

Comparative aspects on concurrent diseases

Pelvic insufficiency fractures are common in geriatric humans with osteoporotic bones and other predisposing factors such as rheumatoid arthritis, metabolic bone disease, neurological disorders, prior irradiation, corticosteroid therapy and bisphosphonate therapy have also been described.^{4,6} Cats affected by PADS do not appear to have osteoporotic bones or history of other predisposing factors; on the contrary, some of them had increased bone density,³ which has also been reported as a predisposing factor for insufficiency fractures in humans.⁷ Results of a

variety of blood tests on PADS cats, including analysis of calcium and vitamin D levels, have not shown consistent or significant abnormalities. Histopathological analysis is presently being performed on bone from cats with PADS that have died, and the results of this analysis will be published in a future article.

Aetiology

Pelvic fractures in cats occur frequently as a result of major trauma such as road traffic accident or falls from a height, and comprise 20–32% of all fractures seen in cats.^{8,9} The fractures in the cats in the present study were usually sustained under circumstances of normal activity and were often missed owing to mild insidious onset lameness or because the lameness was attributed to the patellar fractures, hence, frequently identified late as an incidental finding. Some insufficiency fractures in humans may be asymptomatic and discovered accidentally,¹⁰ and are the result of a low energy mechanism.¹¹

In humans, multiple stress fractures are rare.^{12,13} Approximately 50% of the cats with PADS in this study with pelvic fractures only had single pelvic fractures. It is highly unusual in cats with traumatic pelvic fractures to only have one fracture line as multiple fractures usually occur.⁸

Incidence

The acetabulum was the most commonly affected part of the pelvis affected in the cats with PADS, followed by the ischium, ilium and pubis. In traumatic feline pelvic fractures, the pelvic floor is the most commonly affected with 72% pubic fractures and 51% suffering ischial fractures, ilial fractures accounted for 51% and the least commonly affected bone was the acetabulum (26%).⁸ So the fractures seen in cats with PADS do not concur with the types of fractures usually seen after trauma.

General treatment of insufficiency fractures

Treatment for insufficiency fractures will depend on the location, fracture extent and displacement, functional status of the patient and concomitant diseases. Historically, feline pelvic fractures have been treated conservatively;^{14,15} however, in recent years, several studies have shown the importance of surgical management of selected pelvis fractures.^{9,16–18} Indications for surgery have included pelvic canal narrowing, disruption of the weightbearing 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.¹⁸ In humans, traumatic pelvic fractures are usually treated surgically and it has been demonstrated that outcome of conservative therapy for either traumatic or insufficiency fractures is poor, with loss of social and physical independence and autonomy.¹⁹ In cats, complications associated with pelvic fractures have been associated with narrowing of the pelvic canal as a risk factor for obstipation/constipation.²⁰ In humans, reported complications with surgical treatment are associated with osteopenia, with poor bone stock compromising internal fixation and screw purchase, and increasing the risk of non-union.²¹ In the pelvic fractures in the cats with PADS treated surgically, and reported on in this paper, there were just a few cases of screw loosening, which did not appear to affect outcome. The majority of the pelvic fractures, where information was available, were reported to have healed, with only five reported as non-unions. In many cats follow-up radiographs were not taken so these figures may not be an accurate representation.

Acetabular fractures

Acetabular fractures in cats comprise 17.5–26% of pelvic fractures,^{15,17} and are usually unilateral and frequently contain two fragments.⁸ Meeson and Geddes⁹ published a survey of 43 cats with traumatic pelvic fractures of which the acetabulum was the least commonly affected bone ($n = 12/43$) and all of the acetabular fractures were unilateral. In that publication, seven fractures occurred along the caudal acetabular rim, or were comminuted and were managed conservatively; of these, two had concurrent femoral head and neck excision. Only five

acetabular fractures were managed surgically, and the outcome in the cats with these acetabular fractures was not specifically reported.⁹ Haine et al²² reported 16 cats with 17 acetabular fractures, all associated with concurrent orthopaedic injuries and all managed surgically. Of the 16 cats, three were judged from client history to regain full function and 13 had acceptable function after treatment.²² Of the acetabular fractures in the cats with PADS approximately a quarter of the cats were managed directly with surgery to reduce and stabilise the fracture, or indirectly by femoral head ostectomy. Unfortunately, because of concurrent patellar fractures, it was difficult to ascertain whether surgical management made a difference in outcome in the cats in the present study, but evidence from other studies is supportive of the benefits of surgical stabilisation of articular fractures with a quicker return to function and improved joint congruency.²²

Outcome

Some of the cats were reported to be lame, but the cause of lameness could not be determined, whether from the pelvic fracture or the patellar fracture. Meeson and Geddes⁹ reported that of 43 cats with treated pelvic fractures, 36 showed no sign of lameness and seven had some degree of permanent lameness.⁹ Approximately 20% of the cats with PADS reported on in this study were euthanased as a direct result of either the pelvic fractures or fractures in other bones.

Limitations of the study

In a retrospective study such as the present, gathering data is complex and complete information for many of the cats was not available. Surgical procedures were performed by different surgeons and follow-up times were different for each case. However, this is the first paper that describes the treatment of the most common coincidental fractures in cats with PADS with enough data to give a prognosis on the likelihood of healing following treatment.

Conclusions

Many of the pelvic fractures showed radiographic evidence of bone healing regardless of the treatment method; hence, our conclusion is that many pelvic fractures in cats with PADS, with the exception of the acetabulum (and the ilium), do not require stabilisation surgery. Acetabular fractures may heal with conservative management, but surgical stabilisation should be considered as it may give a quicker return to function and improve outcome. There were insufficient ilial fractures to be able to draw definitive conclusions on the optimal treatment method, but the authors would suggest that, similar to traumatic ilial fractures, the option of surgical stabilisation of these fractures in cats with PADS should be given careful consideration.

Acknowledgements The authors would like to thank Mark Longley for assisting in the collection of data on the cats and all the veterinarians and owners who both treated and provided details, including histories, images and radiographs, concerning these cases and without whom this study would not be possible.

Supplementary material The following file is available online:

Knees and teeth syndrome (KaTS) follow-up survey
<https://svs.onlinesurveys.ac.uk/feline-patella-fracture-survey-follow-up>

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

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

Ethical approval This work involved the use of non-experimental animals only (including owned or unowned animals and data from prospective or retrospective studies). Established internationally recognised high standards ('best practice') of individual veterinary clinical patient care were followed. Ethical approval was therefore not specifically required for publication in *JFMS*.

Informed consent Informed consent (either verbal or written) was obtained from the owner or legal custodian of all animal(s) described in this work (either experimental or non-experimental animals) for the procedure(s) undertaken (either prospective or retrospective studies). No animals or humans are identifiable within this publication, and therefore additional informed consent for publication was not required.

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