Fixation of pelvic floor fractures in cats

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Keywords
Pelvic floor fracture, internal fixation, ventral approach, cat

Summary
Objectives: To retrospectively evaluate the outcome of internal fixation of trauma-related pelvic floor fractures using a ventral abdominal approach in cats.
Methods: Clinical examination and radiographic findings at presentation, after surgery, and at follow-up were assessed. Information gathered included concurrent injuries, surgical technique used, lameness and pain scores, and radiographic signs of implant stability.
Results: Ten European shorthair cats were included in the study. Pelvic floor fractures were stabilised using locking plates in nine cats, and symphyseal separation was fixated using hemicerclage wire in one cat. Additional procedures included reduction of sacroiliac luxation in nine cats with positional screws placed in six cats, and plate stabilisation of sacral fractures in one cat.
All cats were able to walk within five days of surgery. No orthopaedic or neurological deficits were observed in seven cats at follow-up. Neurological deficits were observed in one cat. Signs of pain at implant sites due to inadequate surgical technique were noted in two cats. Anatomical reduction of the pelvic floor was achieved in eight cats.
Clinical significance: Stabilisation of the pelvic floor and repair of sacroiliac luxation and other injuries by a ventral abdominal approach in cats led to an overall successful outcome. Fixation of the pelvic floor in cats with intact acetabular and ilial bones should be considered in patients with multiple pelvic fractures in combination with sacroiliac joint luxation or sacral fracture, pelvic canal narrowing, traumatic abdominal hernia, and other abdominal injuries.

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Introduction

Fracture of the pelvis is a common injury in cats and dogs, accounting for 20 to 30% of all trauma-induced fractures (1, 2). The majority occur in healthy animals under three years of age (3, 4). The box-like configuration of the pelvis ensures that any trauma sufficient to produce a fracture will always cause additional pelvic trauma (5).

In cats, the most common pelvic fracture involves the pelvic floor, occurring in 90% of cases in one study (6). Pelvic floor fractures may be classified as symphyseal separations, or as unilateral or bilateral fractures of the pubic body and ramus or ischial body (7). In addition, concurrent unilateral or bilateral sacroiliac luxations or unilateral ilial fractures occurred in more than 50% of cats (6). Other concurrent injuries may involve all body systems (8).

Indications for the surgical management of pelvic fractures in cats are not well defined, although guidelines are available for dogs (1, 9). Surgical stabilisation of these fractures may be necessary if there is marked instability or marked displacement and pain. In addition, surgical fixation may improve long-term functional outcome. Open fixation of pelvic ring fractures by internal fixation is recommended in humans if the abdomen is already open or if reduction of sacroiliac luxation cannot be achieved by closed reduction (10). A ventral open approach allows stabilisation of both sacroiliac joints, as well as assessment and treatment of injuries to the caudal portion of the abdominal wall and organs in the caudal portion of the abdomen (11).

The purpose of this retrospective study was to evaluate the complications and outcome associated with internal fixation of pelvic floor fractures using a ventral abdominal approach in cats.

Material and methods

The medical record database was searched for feline pelvic floor fractures or separations treated surgically at the Clinic for Small Animal Surgery, University of Zurich, from July 2006 to March 2009. The medical records and associated radiographs were reviewed. Cats were included in the study if clinical examination findings and standard pelvic radiographs (lateral and ventrodorsal views) were available from presentation, as well as postoperatively and at least one follow-up examination six to eight weeks after surgery. Information collected included the signalment, type of fracture, concurrent injuries documented by initial clinical, neurological, and radiographic examination, details of the surgical technique used, and findings of clinical and radiographic postoperative and follow-up examinations. All radiographs were reviewed by board-certified radiologists. Lameness and signs of pain noted by clinicians were based on hospital standard scoring systems (▶Table 1). The clinical outcome at six to eight weeks after surgery was graded as excellent (no orthopaedic or neurologic deficits), good (minor orthopaedic or neurologic deficits), fair

Scoring criteria	Score
Pain scoring system	
No signs of pain during manipulation	0
Signs of mild pain (e.g. animal turns head toward manipulated site)	1
Signs of moderate pain (e.g. animal pulls limb away during manipulation)	2
Signs of severe pain (e.g. animal vocalises or is aggressive during manipulation)	3
Lameness scoring system	
Normal weight bearing at rest and ambulation	1
Normal weight bearing at rest; partial weight bearing in ambulation	2
Normal weight bearing at rest; intermittent weight bearing in ambulation	3
Partial weight bearing at rest and in ambulation	4
No weight bearing at rest and in ambulation	5

Table 1 Lameness and pain scoring system used to assess cats with trauma-related pelvic injuries.

(moderate orthopaedic or neurologic deficits), or poor (severe orthopaedic or neurologic deficits) (▶Table 2). The radiographic outcome at six to eight weeks after surgery was graded as excellent (implants intact with reduced sacroiliac luxation), good (signs of implant loosening with reduced sacroiliac luxation), fair (implant bent or signs of loosening and minimal sacroiliac displacement), or poor (implant broken or signs of loosening and sacroiliac displacement).

Results

Ten cats with trauma-related pelvic floor fractures or separation were included in the study. These were all European shorthair cats with outdoor access (age: mean = 4.3 years; range = 1 – 8 years). There were seven neutered males, two spayed females, and one intact female (▶Supplementary Table 1, available online at www.vcot-online.com).

At initial examination, six of the 10 cats had a lameness score of 5, two of 10 cats had a score of 4, and two of 10 cats had a score of 3. Nine cats had fractures of the pubic ramus and one cat had a symphyseal separation. Concurrent injuries included ischial fractures (5 cats), sacral fractures (1 cat), sacroiliac luxations (9 cats), and pelvic narrowing (5 cats) (▶Table 3). Neurological deficits were noted in five cats due to trauma to the sciatic nerve (3 cats), pudendal nerve (1 cat), or coccygeal nerve (1 cat) (▶Supplementary Table 1). Additional injuries included metatarsal fractures (1 cat), tarsal instability (1 cat), urethral rupture (1 cat), pneumothorax (1 cat), and abdominal hernia (1 cat) (▶Supplementary Table 1).

Grading criteria	Grade
No orthopaedic or neurological deficits (pain score 0 and lameness score 1)	Excellent
Minor orthopaedic or neurological deficits (pain score 1 or lameness score 2)	Good
Moderate orthopaedic or neurological deficits (pain score 2, lameness score 3, loss of skin sensitivity, or reduced proprioception)	Fair
Severe orthopaedic or neurological deficits (pain score 3, lameness score 4-5, loss of proprioception, or loss of deep pain)	Poor

Table 2 Grading system for clinical outcome in cats treated surgically for trauma-related pelvic floor fracture or separation.

Surgery was performed either on that day or within three days following presentation by one of four different surgeons. The surgical approach consisted of a midline incision cranial to the pubis through the linea alba, and continued through the pecten pubis to the perineal surface. A sharp division of the gracilis and adductor muscles was performed and the muscles were partially elevated from the pubic symphysis to expose the pelvic floor. The semimembranosus muscle was partially incised and retracted to approach the ischiatic arch, if necessary. A finger Hohmann retractor placed in the obturator foramen was used to retract the adductor longus muscle, taking care to avoid trapping the obturator nerve between the retractor and the ipsilateral hemipelvis or the acetabular branch of the pubic bone (5). Reduction of the pelvic floor was achieved by stabilisation of ischial or pubic fractures prior to correction of sacroiliac luxations using a ventro-abdominal approach or, in one case, prior to fixation of sacral fractures (11). Nine pelvic floor fractures were fixated with titanium locking plate and screw reconstruction systems functioning as internal fixators; the pubic separation was repaired using a hemicerclage wire. Locking plates used were a 2.0 ComPact Unilock[a] system in eight cases, and a 6.5 Advance Locking Plate[b] system in one case. Screw holes were drilled in an oscillating fashion, avoiding damage to underlying structures. Stability was achieved by locking the screws to the plate. Reconstruction plates were precontoured and used to fixate the pubis in six cats (▶Fig. 1), the pubis and ischium in one cat, and the ischium in two cats (▶Fig. 2). In one cat, a hemicerclage wire of 0.8 mm diameter was used to fixate the symphyseal separation (▶Fig. 3). Closure was performed by joining the gracilis and

[a] Compact unilock 2.0 plates, screws and instruments: Synthes, Solothurn, Switzerland

[b] ALPS plates, screws and instruments: Kyon AG, Zurich, Switzerland

adductor muscles bilaterally at the symphysis using sutures. Any disruption at the insertion of the prepubic tendon was sutured. Excessive abduction of the hindlimbs was prevented for several days by loosely hobbling the legs above the tarsus. Sacroiliac luxations were reduced after pelvic floor stabilisation, as this facilitates reduction and avoids pelvic canal narrowing. Six of the 10 cats were treated with at least one 2.4 mm cortical titanium self-tapping screw[c] of adequate length in a positional fashion to reduce the sacroiliac luxation. All positional screws were placed via a ventral abdominal approach (11, 12). A locking bone plate[a] was used to stabilise the sacral fracture in one cat.

Postoperative radiographs revealed that pelvic floor reduction was achieved in all but two cats. In these animals, trauma-induced pelvic injury had occurred 13 and 20 days prior to presentation, respectively. Anatomical reduction was found to be difficult due to fibrosis and early callus formation. In both cats, the main surgical goal of pelvic fracture fixation was to reduce pelvic ring narrowing. Implants in all cats were positioned correctly with all screws locked to the plates, avoiding penetration of the hip joints.

All cats were able to walk between one and five days after surgery (median = 2 days) and were released from the hospital as soon as they were able to walk and urinate without difficulty. There were not any wound complications, such as seroma formation, infection, or dehiscence observed.

Follow-up examinations were performed in all cats between six and eight weeks after surgery. In addition, a second follow-up examination was performed in five cats between 16 and 18 weeks after surgery. Muscular atrophy in one hindlimb was observed in two cats. In one of these, signs of pain on palpation of the left sacroiliac region was noted at the site of the screw in the left iliosacral region (▶Supplementary Table 1, cat number 1). The second cat was observed by the owner to have difficulty jumping. In this cat, pain was noted on passive extension of the right hip (▶Supplementary Table 1, cat number 9). Evidence of hip osteoarthritis and penetration of the hip joint by a screw were noted on follow-up radiographs. Subsequently, a femoral head and neck ostectomy was performed, where the tip of a screw was observed in the hip joint. Neurological deficits with absence of conscious proprioception required 18 weeks for full recovery in one cat (▶Supplementary Table 1, cat number 6). The remaining seven cats were considered clinically normal six to eight weeks after surgery. Overall clinical outcome at six to eight weeks was graded as excellent in seven cats, good in two cats, and fair in one cat (▶Supplementary Table 1). In the latter case, the suboptimal outcome was associated with persistent ischial nerve deficits, a screw penetrating the hip joint surface, and pain over the sacroiliac region.

Implant complications were observed in two cases. One occurred in the cat with a screw penetrating the hip joint. In the second case, slight rotation and shifting of the plates on the ischial and sacral bone were observed on follow-up radiographs although no clinical consequence was noted (▶Fig. 4). In this case, the ischial fracture had been fixated with only one screw per bone fragment (▶Fig. 4). Radiographic outcome was excellent in five cases, good in three cases, and fair in two cases at six to eight weeks.

Table 3 Preoperative injuries in cats undergoing surgical stabilisation of trauma-related pelvic floor fractures or separation.

Condition	Number of cats affected
Pelvic floor fracture	9
Symphyseal separation	1
Ilial fracture	0
Acetabular fracture	0
Sacral fracture	1
Unilateral sacroiliac luxation	2
Bilateral sacroiliac luxation	7
Abdominal injuries	2
Neurological deficits	4
Pelvic outlet narrowing	5
Other injuries	4

Discussion

Fig. 1 Ventrodorsal radiographs of the pelvis in a three-year-old neutered male cat showing left sacroiliac luxation with cranial displacement of the left hemipelvis, right pubic and ischial fractures, and moderate pelvic narrowing prior to surgery **(A)**, and follow-up radiograph **(B)** eight weeks postoperative showing the reduction of the sacroiliac joint with screw fixation and stabilisation of the os pubis with a locking plate. We recommend more bending of the plate, or to leave one additional empty hole to place the lateral screw at a greater distance from the acetabulum.

[c] 2.4 mm cortical, self-tapping, titanium screws: Synthes, Solothurn, Switzerland

Fig. 2 Ventrodorsal radiographs of the pelvis in a two-year-old, spayed female cat showing bilateral sacroiliac luxation with moderate pelvic narrowing, pelvic floor separation at the symphysis of the os ischii and right pubic fracture **(A)**. The follow-up radiograph taken eight weeks postoperative shows all implants in position, the reduction of the ischium fixated with a six-hole locking plate, and reduction of the sacroiliac joint using screw fixation **(B)**.

All cats included in this study were outdoor cats, and were susceptible to road traffic and other accidents. The amount of energy absorbed during the accident and the size of the animal may lead to injuries disparate from those observed in dogs. Results of this study are therefore only pertinent to cats with trauma-related pelvic floor fractures. Indeed, such fractures are rarely surgically repaired in dogs at our clinic, suggesting a difference in the clinical presentation of these cases. Pelvic fractures were frequently associated with sacroiliac luxation, similar to findings in previous reports (18). Sacral fracture is uncommonly reported in association with road traffic accidents and is generally associated with other injuries, as was the case in one cat in the present study (16, 17).

Fig. 3 Ventrodorsal radiographs of the pelvis in a three-year-old, spayed female cat showing bilateral sacroiliac luxation with separation of the symphysis pubis and marked displacement of the left hemipelvis towards the midline **(A)**, and follow-up radiographs taken seven weeks postoperative with intact fixation, reduction of the sacroiliac luxations using two screws and stabilisation of the symphysis using hemicerclage wire **(B)**.

Most affected animals were unable to stand at time of initial presentation. This was probably due to an inability to adduct the hindlimbs as a result of the pelvic floor fractures being associated with sacroiliac disruption. Stabilisation of sacroiliac luxation and other concurrent injuries affecting the weight-bearing part of the pelvic ring may result in sufficient stability without reduction of pelvic floor fractures, and allow spontaneous healing of the pelvic floor. However, surgical stabilisation of the pelvic ring may be advantageous in some cases. Bilateral sacroiliac luxations or sacroiliac luxation with contralateral ilial fracture renders both hemipelves unstable when associated with pelvic floor fractures. In such cases, surgical repair of simple pelvic floor fractures may re-establish or enhance the stability of the pelvic ring and may make reduction of sacroiliac luxation easier, preventing collapse of the pelvic ring canal (10). Pelvic ring reduction also allows adequate rotational realignment of both hemipelves, which is not guaranteed with a single screw, and may avoid entrapment of soft tissue between the bone fragments (13). In addition, it may also lessen the risk of loosening of sacroiliac screws.

Stabilisation of the pelvic floor may also reduce pain during recovery and lead to early weight bearing. In this study, all cats showed a significant reduction in lameness and pain scores by six to eight weeks after surgery, and only three cats had pain scores above zero at this time. Of these, signs of pain in two cats were related to suboptimal surgical technique. Other advantages of pelvic floor stabilisation are correction of pelvic canal narrowing to avert subsequent coprostasis or dystocia, and prevention of damage to the urethra or pelvic nerves by sharp fracture ends or entrapment by sacroiliac luxation (13).

The ventral approach used to treat pubic and ischial fractures offers easy access, allowing not only fixation of pelvic fractures, but also placement of cortical screws from the ventral surface of the sacral wing for reduction of sacroiliac luxation, repair of sacral fractures and abdominal wall injuries. In addition, access is gained for the

treatment of abdominal injuries, in particular urethral injury that is frequently observed in cats, and even diaphragmatic tears (6). The use of an internal fixator offers greater stability than standard reconstruction plates without locking screws, especially when only two screws are placed in each bone fragment with limited thickness (14, 15). Repair of the pelvic floor, particularly ischial fractures, prior to reduction of any other fractures or of sacroiliac luxation also appears advantageous. Ischial fragments are easily reconstructed and the ischiatic arch area offers a quantity of bone to anchor screws in its thick border. The box of the pelvis is thus reconstructed in a simple way. The pubic fractures guide the reduction, and iliosacral luxations are then easier to reduce if the ilium is intact. The self tapping screws of small size hold well in the pubic branches, even with interfragmentary function over the fractured area. However, penetration of the hip joint is a risk while plating the branches of the pubic bone. To avoid this, plates should be longer, bypassing on the ventral aspect of the acetabulum, and leaving one plate hole empty there. Screws hold better on the caudal part of the body of the ilium, and their placement is without risk. Additional intraoperative fluorscopy or oblique postoperative radiographs may also help to judge the precise location of screws near the hip joints. Screw holes are drilled in an oscillating mode to preserve soft tissue structures, such as the urethra, nerves and rectum. In one case, an ischial fracture was fixated with only one locking screw per bone fragment, leading to cranial rotation of the ischial fragment with loss of anatomical reduction. For this reason, we recommend that at least two screws per bone fragment should be used.

The overall successful clinical outcome of surgery in the cats in this study is likely due to both fixation of the pelvic floor and repair of sacroiliac luxations, sacral fractures, and other injuries. Fixation of the pelvic floor in cats with intact acetabular and ilial bones should be considered in patients with multiple pelvic fractures in combination with sacroiliac luxation or sacral fracture, traumatic abdominal hernias, or other abdominal injuries.

Fig. 4 Ventrodorsal radiographs of the pelvis in a five-year-old neutered male cat showing fixation of a sacroiliac luxation using a single screw, and fixation of a sacral wing fracture and ischial fractures using locking plates immediately after surgery. Only one screw was applied in each ischial segment **(A)**. As a result of the insufficient ischial stabilisation, slight cranial dislocation of the left hemipelvis with shifting of the locking plates occurred six weeks after surgery **(B)**.

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