# Sacral Fractures and Sacrococcygeal Injuries in Dogs and Cats

CHARLES A. KUNTZ
*Fort Collins, Colorado*

CVT XIII

Sacral fractures and sacrococcygeal injuries are uncommon but not rare injuries in dogs and cats. Reports of these potentially devastating fractures have been relatively underrepresented in the veterinary literature. Sacral fractures and sacrococcygeal injuries are often missed on conventional radiography; accurate diagnosis requires an increased level of suspicion at initial evaluation of patients with pelvic trauma. Diagnosis is often made based on the presence of characteristic neurologic signs that are due to damage to nervous structures present within or adjacent to the vertebrae. An understanding of the anatomy of the sacrum and related nerves and of the physiology associated with normal micturition and defecation is imperative when attempting diagnosis and prognostication.

## ANATOMY AND PHYSIOLOGY

The sacrum is made up of the fused bodies and processes of the three sacral vertebrae. Sacralization of the first coccygeal vertebral body is a common anatomic variation. The first sacral vertebral body and the cranial portion of the second lie between and articulate with the ilial wings through a partially fibrous and partially synovial joint. The dorsal and ventral sacral foramina lie just lateral to the fused sacral bodies. Lateral to the sacral foramina are the fused transverse processes. Cranially, the transverse processes of S1 and S2 make up the sacral wing. The three fused dorsal spinous processes make up the median sacral crest. The ventral aspect of the sacrum is smooth and is the cranial part of the dorsal boundary of the pelvic canal. The sacrum is the weight-transmitting structure between the hind limbs and the lumbar vertebrae. The sacrum houses a portion of the cauda equina, that is, the sacral and coccygeal nerves. The three sacral nerves exit their respective foramina at S1-2, S2-3, and S3-Cd1.

Innervation of the viscera (urinary bladder, terminal colon, and rectum) is critical for normal voiding of urine and feces. Normal micturition and defecation rely on somatic and autonomic innervation. The spinal cord ends at the level of L6 in dogs and L7 in cats. Caudal to the termination of the spinal cord, the distal continuation of the nerve fibers is the cauda equina. Somatic innervation of the pelvic viscera is through the pudendal nerve, which usually arises from the three sacral nerves. It is directly responsible for voluntary contraction and relaxation of the external urethral sphincter and indirectly responsible for the voluntary contraction and relaxation of the external anal sphincter via the caudal rectal nerve. The perineal nerve, a branch of the pudendal nerve, allows cutaneous sensation in the perineal region. Parasympathetic innervation of the bladder and rectum is via the pelvic nerve, which receives contribution via the three sacral nerves. Parasympathetic innervation is responsible for reflex voiding of urine and feces following stimulation of parasympathetic nerve fibers within the urinary bladder and rectum, respectively. Sympathetic innervation of the pelvic viscera is via the hypogastric nerve, which joins the pelvic nerve to form the pelvic plexus. The hypogastric nerves represent the postganglionic connections between the caudal mesenteric ganglion, which lies just cranial to the bifurcation of the terminal aorta, and the pelvic plexus. Sympathetic stimulation allows bladder filling. S1 and S2 also contribute to the formation of the sciatic nerve.

Normal bladder function can be divided into filling and emptying phases. Filling is facilitated by sympathetic stimulation of the bladder and the internal urethral sphincter. Efferent beta-adrenergic fibers within the bladder wall are inhibitory and result in relaxation of smooth muscle cells allowing storage of urine. Efferent beta-adrenergic fibers present in the internal urethral sphincter are excitatory and prevent emptying. Emptying occurs when, at a threshold, afferent parasympathetic fibers that are stimulated by filling carry nerve impulses back to the terminal spinal cord, where they stimulate efferent parasympathetic nerve fibers, resulting in a detrusor contraction of the urinary bladder. At this point, if urination is inappropriate, voluntary contraction of the external urethral sphincter can prevent voiding. This requires cerebral input and an intact spinal cord. An analogous reflex system is present in the terminal rectum, colon, and internal and external anal sphincters, and is responsible for storage and voiding of feces. Sacral fracture or sacrococcygeal injuries may injure the neurologic structures that control these processes.

## PATIENT EVALUATION

Sacral fractures and sacrococcygeal injuries in dogs and cats almost always result from trauma, which is most often automobile related. Pelvic fractures in dogs and cats are among the most common orthopedic injuries resulting from automobile-related trauma (Kolata et al. 1974). In one study, 20% of cats with pelvic fractures had concurrent sacral fractures. The need for careful physical examination is underscored by the fact that greater than 70% of animals sustaining orthopedic injury have injury of the thoracic structures including pneumothorax, hydrothorax, pulmonary contusion, rib fracture, and traumatic myocarditis. Urinary integrity should be assessed by patient observation, abdominal palpation, and abdominal radiography. Animals should urinate within several hours of fluid administration following trauma. Of 100 dogs sustaining blunt injury resulting in pelvic fractures, 39 had concurrent urinary tract injury including ureteral avulsion, urinary bladder rupture, urethral tear, urinary bladder mucosal irregularities, urinary bladder displacement or herniation, hydroureter, and hydronephrosis (Selcer, 1982). At least three of these dogs with urinary tract injury had documented sacral fractures, and several more had sacroiliac luxations.

Rectal examination should be performed as an initial assessment of the bony integrity of the pelvis. Anal tone can be simultaneously evaluated. A complete *neurologic examination* should then be performed to evaluate the extent of injury, and to aid in prognostication. This should include an assessment of ambulation, myotactic reflexes, perineal sensation, bladder tone, tail voluntary motor ability and sensation, and bladder palpation. The ability to initiate and complete urination should be assessed. If manual expression of the bladder is required, residual urine volume should be measured. Abnormal rectal palpation, the presence of neurologic deficits of the pelvic viscera, and inability to ambulate should increase suspicion of pelvic and sacral fractures.

Dogs and cats with sacral fractures and denervation of the tail almost always have some denervation of the pelvic viscera. Dogs and cats that have intact perineal reflex, anal tone, and perineal sensation but large residual urinary volume likely have intact pudendal nerve fibers, but have damage to the pelvic nerve fibers. This is possible because the pelvic nerve fibers are thought to be more fragile than pudendal nerve fibers. These patients' bladders are usually easily expressible. The inability of the patient to void completely after initiating urination may be due to the lack of a detrusor reflex. These animals may have a better chance of recovery than those who also have diminished perineal sensation and anal tone. Dogs and cats with no anal tone; large, flaccid, and easily expressed urinary bladders; and perineal hypalgesia have severe damage to both pelvic and pudendal nerve fibers, and are less likely to recover function.

In some animals, urinary bladder function may be impossible to evaluate directly because of concurrent urinary tract injury, that is, urinary bladder rupture or urethral injury. However, there is a high degree of correlation between urinary continence and fecal continence because of the common dependence on pudendal and pelvic nerve function. Therefore, if a decrease in anal tone is present, it can be assumed that urinary incontinence will also be present.

Some dogs and cats with sacral fractures have sciatic nerve deficits characterized by conscious proprioceptive deficits and knuckling of the hind limb, and diminished cranial tibial, and gastrocnemius and withdrawal reflexes (Kuntz et al, 1995). It is possible that these deficits may result from injury of the sacral components of the sciatic nerve or be the result of peripheral sciatic nerve injury associated with ipsilateral pelvic fractures that frequently coexist in animals with sacral or sacrococcygeal injuries.

## RADIOLOGIC EVALUATION

Pelvic radiography should be performed whenever physical or neurologic examinations suggest that sacral or sacrococcygeal injuries have occurred. Care should be taken to prevent further damage to neurologic structures during pelvic radiography by careful patient handling and light sedation if necessary. The sensitivity of radiography in the assessment of patients with sacral fractures in dogs and cats has not been adequately evaluated, but, in the author's experience, many patients initially diagnosed with pelvic fractures had sacral fractures that had been missed on initial examination. The most common is the misdiagnosis of a sacroiliac luxation when a sacral fracture is actually present. Conventional radiographs are generally sufficient to make a diagnosis, especially when neurologic deficits are present that would increase one's level of suspicion that these injuries exist. Plain radiography has been shown to be insensitive in the diagnosis of sacral fractures in humans, and computed tomography has greatly improved diagnostic accuracy. Other diagnostic modalities that have been helpful in elucidating the diagnosis of sacral fractures include linear tomography, nuclear scintigraphy, and oblique conventional radiographic views.

A scheme for classification of sacral fractures in dogs has been devised that may be helpful in prognostication. Fractures that are lateral to the sacral foramina are called abaxial (Fig. 1), whereas those which are medial to the sacral foramina are called axial (Fig. 2). Abaxial fractures are similar to sacroiliac fracture-separations relative to clinical signs, prognosis, and surgical treatment. They are unlikely to be associated with urinary or fecal incontinence, and often carry a good prognosis. Axial fractures are almost always associated with neurologic deficits of the pelvic viscera (tail, perineum), and carry a less favorable prognosis. A similar classification scheme, independently devised in humans, has been useful in predicting the incidence

**Figure 1.** Radiograph showing an abaxial sacral fracture in a dog.

**Figure 2.** Radiograph showing an axial sacral fracture in a dog.

and severity of neurologic deficits in people with sacral fractures.

## MEDICAL AND SUPPORTIVE CARE

If a patient has urine retention, the bladder must be intermittently emptied to prevent the development of an atonic bladder through excessive or persistent stretching of tight junctions. This may be done manually or by use of a urinary catheter. Use of an indwelling closed urinary catheter system is often beneficial in a recumbent patient in that it allows complete urine evacuation, avoids painful bladder expression, and helps prevent urine scalding. Urine scalding can result in patient discomfort, infection of surgical sites, progression of pressure sores, and owner dissatisfaction. Urine scalding must be avoided at all costs even if daily bathing is required. This is usually well tolerated and can be performed with minimal assistance. Petrolatum in the perivulvar or peripreputial region can also be used to help prevent minor urine scalding. The use of antibiotic therapy in patients with indwelling urinary catheters is controversial, but is generally not recommended because it can result in the development of resistant bacterial strains. Patients should be closely monitored for the development of urinary tract infection by frequent urinalysis and culture. If systemic illness or pyelonephritis develops, appropriate antibiotic therapy based on sensitivity should be administered. Pyelonephritis may be initially characterized by fever, pain, and leukocytosis, but signs are often limited to those of recurrent lower urinary tract infection. Pyelonephritis is diagnosed by urine sediment examination and culture. Confirmation is made with contrast dye studies of the renal pelvis or ultrasonography. Urinary culture and sensitivity should be performed 1 week after removal of urinary catheters.

Urethral spasm due to unopposed alpha-adrenergic innervation may be alleviated by the use of phenoxybenzamine, an alpha-antagonist (Dibenzyline, Smith, Kline and French) (1 mg/kg t.i.d.). This should not be used in hypotensive patients because it can cause further hypotension. Complete bladder emptying may be assisted by the use of bethanechol (Urecholine, Merck, Sharpe and Dohme) (1 to 2 mg/kg orally b.i.d. or t.i.d.), a parasympathomimetic. Bethanecol should not be used in patients with markedly increased urethral tone because urinary bladder rupture may result. These drugs may take several days to begin working, so early administration should be attempted when the need is anticipated. Striated muscle relaxants (diazepam, 1.25 to 2.5 mg/kg) can also be used to reduce external urethral sphincter spasm, and may have the advantage of a more rapid onset of effect. Diazepam should not be used in cats for this purpose due to the recent recognition of fatal hepatocellular necrosis in some cats receiving this drug (p. 241). Fecal retention in patients with neurologic injuries does not frequently occur. If associated pelvic fractures are causing fecal retention, stool softeners may be used.

## TREATMENT OF SACRAL FRACTURES

Surgical decompression of sacral nerve roots using dorsal laminectomy of the sacrum has been recommended in dogs and cats with axial sacral fractures (Taylor, 1981). Results were similar to those seen in the author's study, where no decompression of nerve roots was performed (Kuntz et al, 1995). The primary difficulty is in identifying which patients have nerve root compression. Animals that have evidence of excessive pain without neurologic deficits may warrant the use of decompressive and exploratory surgery. Surgical stabilization of abaxial fractures resembling sacroiliac fracture-separations is recommended following guidelines used for the repair of the other pelvic fractures. Indications for pelvic fracture repair include presence of articular fractures, disruption of major weightbearing structures, evidence of nerve compression and marked displacement of fracture fragments resulting in collapse of the pelvic canal. Surgical repair is similar to that of sacroiliac fracture-separations using one or two screws placed in lag fashion from the lateral aspect of the ilial wing to the sacral body using previously described guidelines (DeCamp and Braden, 1985). Surgical anatomy is disrupted, and screw placement can be difficult.

In dogs with abaxial sacral fractures, the prognosis for complete return to function is excellent. The prognosis in dogs with axial sacral fractures is good, in that most dogs that are not euthanized during the immediate post-trauma period make nearly complete recoveries even though they may have significant neurologic dysfunction (Kuntz et al, 1995). It is important to note that dogs made significant neurologic recovery only after release from the hospital, and that many dogs with complete urinary and fecal incontinence later become continent. Dogs should not be euthanized during the initial hospital stay despite a lack of early neurologic recovery. A prolonged opportunity for recovery should be allowed, and owners should be warned that although complete neurologic recovery frequently occurs, in some cases, it does not.

## SACROCOCCYGEAL INJURIES IN CATS

Sacrococcygeal (SC) separations in cats comprise a distinct clinical syndrome that is markedly different from sacral fractures in dogs and cats (Smeak and Olmstead, 1985). Sacrococcygeal separations result when the tail of a cat is forcefully and abruptly pulled away from the body, whereas sacral fractures result from blunt trauma to the pelvis. Sacrococcygeal separations can occur when the tail is caught under the tire of a moving vehicle or in a closing door. Denervation of the tail, pelvic viscera, and hind limbs results from "tethering" of the cauda equina and laceration of nerve roots or their avulsion from the distal tip of the spinal cord. The salient anatomy is similar to that of the dog.

Clinical signs are related to the degree of the neurologic injury and to the presence of other orthopedic and soft tissue trauma. Hyperesthesia at the base of the tail is common. Some cats may have paraparesis; this almost always resolves during the weeks following the initial injury. Most cats with SC separations have some degree of analgesia and diminished motor function of the tail. This may, in some cats, be the only deficit (group 1). Some cats have residual urine and tail denervation with normal anal tone, perineal sensation, and a maintained ability to posture to urinate (group 2). Cats with decreased anal tone and decreased perineal sensation who do not posture to urinate have damage to both pudendal and pelvic nerve fibers or segmental damage to the spinal cord (group 3). Cats with no anal tone and no perineal sensation have complete urinary and fecal incontinence (group 4). The prognosis for cats in groups 1 and 2 is excellent. All cats will recover tail function, and most cats in group 2 will recover urinary function. Cats in group 3 have a reasonably good prognosis with appropriate medical management. Approximately 75% of these cats will recover completely. Cats in group 4 have a guarded prognosis, but as many as 50% of these cats may make a complete recovery. It is generally accepted that most of the neurologic recovery will occur within the first month after the initial trauma, and that if recovery does not occur by this point, it is unlikely to occur at all. Surgical decompression of nerve roots in cats with sacrococcygeal separations is controversial, but is generally not recommended because injury is generally not compressive but avulsive. Tail amputation should not be performed at initial diagnosis. Indications for tail amputation include ischemic necrosis, frequent soiling with feces and urine, and persistent pain.

### References and Suggested Reading

DeCamp CE, Braden TD: The surgical anatomy of the canine sacrum for lag screw fixation of the sacroiliac joint. Vet Surg 14:131, 1985.
*Describes salient surgical anatomy relative to the placement of lag screws used to repair sacroiliac luxations.*

Kolata RJ, Kraut NH, Johnston DE: Patterns of trauma in urban dogs and cats: A study of 1000 cases. J Am Vet Med Assoc 164:499, 1974.
*Describes clinical findings in dogs and cats sustaining trauma in urban areas.*

Kuntz CA, Waldron D, Martin RA, et al: Sacral fractures in dogs: A review of 32 cases. J Am Anim Hosp Assoc 31:142, 1995.
*Describes clinical findings and classification scheme for dogs with sacral fractures.*

Selcer BA: Urinary tract trauma associated with pelvic trauma. J Am Anim Hosp Assoc 19:785, 1982.
*Evaluates urinary tract trauma in 100 dogs with pelvic fractures.*

Smeak DD, Olmstead ML: Fracture/luxations of the sacrococcygeal area in the cat. Vet Surg 14:319, 1985.
*Describes neurologic deficits and other clinical signs seen with sacrococcygeal separations in cats.*

Taylor RA: Treatment of fractures of the sacrum and sacrococcygeal region. Vet Surg 10:119, 1981.
*Describes decompression of sacral nerve roots in eleven dogs and cats with sacrococcygeal fractures.*

# Diagnosis and Management of Pelvic Fractures and Dislocation of the Sacroiliac Joint

STEVEN C. SCHRADER
*Columbus, Ohio*

Pelvic fractures and sacroiliac dislocation are common injuries in dogs and cats; pelvic fractures account for 20 to 30% of fractures diagnosed in dogs and cats (Brinker et al, 1990). Pelvic fractures and sacroiliac dislocation are frequently found concurrently and are almost always the result of blunt trauma.

There are several issues concerning treatment that should be considered once the diagnosis has been made. Because the incidence of injuries to adjacent soft tissues (abdominal wall, urinary bladder, urethra, lumbosacral trunk, or sciatic nerve) and bony structures (lumbar, sacral, coccygeal vertebrae) is quite high, successful management ized during the initial hospital stay despite a lack of early neurologic recovery. A prolonged opportunity for recovery should be allowed, and owners should be warned that although complete neurologic recovery frequently occurs, in some cases, it does not.

## SACROCOCCYGEAL INJURIES IN CATS

Sacrococcygeal (SC) separations in cats comprise a distinct clinical syndrome that is markedly different from sacral fractures in dogs and cats (Smeak and Olmstead, 1985). Sacrococcygeal separations result when the tail of a cat is forcefully and abruptly pulled away from the body, whereas sacral fractures result from blunt trauma to the pelvis. Sacrococcygeal separations can occur when the tail is caught under the tire of a moving vehicle or in a closing door. Denervation of the tail, pelvic viscera, and hind limbs results from "tethering" of the cauda equina and laceration of nerve roots or their avulsion from the distal tip of the spinal cord. The salient anatomy is similar to that of the dog.

Clinical signs are related to the degree of the neurologic injury and to the presence of other orthopedic and soft tissue trauma. Hyperesthesia at the base of the tail is common. Some cats may have paraparesis; this almost always resolves during the weeks following the initial injury. Most cats with SC separations have some degree of analgesia and diminished motor function of the tail. This may, in some cats, be the only deficit (group 1). Some cats have residual urine and tail denervation with normal anal tone, perineal sensation, and a maintained ability to posture to urinate (group 2). Cats with decreased anal tone and decreased perineal sensation who do not posture to urinate have damage to both pudendal and pelvic nerve fibers or segmental damage to the spinal cord (group 3). Cats with no anal tone and no perineal sensation have complete urinary and fecal incontinence (group 4). The prognosis for cats in groups 1 and 2 is excellent. All cats will recover tail function, and most cats in group 2 will recover urinary function. Cats in group 3 have a reasonably good prognosis with appropriate medical management. Approximately 75% of these cats will recover completely. Cats in group 4 have a guarded prognosis, but as many as 50% of these cats may make a complete recovery. It is generally accepted that most of the neurologic recovery will occur within the first month after the initial trauma, and that if recovery does not occur by this point, it is unlikely to occur at all. Surgical decompression of nerve roots in cats with sacrococcygeal separations is controversial, but is generally not recommended because injury is generally not compressive but avulsive. Tail amputation should not be performed at initial diagnosis. Indications for tail amputation include ischemic necrosis, frequent soiling with feces and urine, and persistent pain.

### References and Suggested Reading


DeCamp CE, Braden TD: The surgical anatomy of the canine sacrum for lag screw fixation of the sacroiliac joint. Vet Surg 14:131, 1985.
*Describes salient surgical anatomy relative to the placement of lag screws used to repair sacroiliac luxations.*

Kolata RJ, Kraut NH, Johnston DE: Patterns of trauma in urban dogs and cats: A study of 1000 cases. J Am Vet Med Assoc 164:499, 1974.
*Describes clinical findings in dogs and cats sustaining trauma in urban areas.*

Kuntz CA, Waldron D, Martin RA, et al: Sacral fractures in dogs: A review of 32 cases. J Am Anim Hosp Assoc 31:142, 1995.
*Describes clinical findings and classification scheme for dogs with sacral fractures.*

Selcer BA: Urinary tract trauma associated with pelvic trauma. J Am Anim Hosp Assoc 19:785, 1982.
*Evaluates urinary tract trauma in 100 dogs with pelvic fractures.*

Smeak DD, Olmstead ML: Fracture/luxations of the sacrococcygeal area in the cat. Vet Surg 14:319, 1985.
*Describes neurologic deficits and other clinical signs seen with sacrococcygeal separations in cats.*

Taylor RA: Treatment of fractures of the sacrum and sacrococcygeal region. Vet Surg 10:119, 1981.
*Describes decompression of sacral nerve roots in eleven dogs and cats with sacrococcygeal fractures.*


# Diagnosis and Management of Pelvic Fractures and Dislocation of the Sacroiliac Joint


STEVEN C. SCHRADER
*Columbus, Ohio*


Pelvic fractures and sacroiliac dislocation are common injuries in dogs and cats; pelvic fractures account for 20 to 30% of fractures diagnosed in dogs and cats (Brinker et al, 1990). Pelvic fractures and sacroiliac dislocation are frequently found concurrently and are almost always the result of blunt trauma.

There are several issues concerning treatment that should be considered once the diagnosis has been made. Because the incidence of injuries to adjacent soft tissues (abdominal wall, urinary bladder, urethra, lumbosacral trunk, or sciatic nerve) and bony structures (lumbar, sacral, coccygeal vertebrae) is quite high, successful management

**Figure 1.** A male Schnauzer 5 months following blunt trauma that caused multiple pelvic fractures, right sacroiliac dislocation, and ventral abdominal hernia. Only the hernia had been repaired. The dog had no detectable alteration of gait or signs of constipation and little external evidence of previous injury at the time this photograph was taken.

of the patient with pelvic fractures and sacroiliac dislocation often depends on timely identification and appropriate management of these injuries as well (see also the previous article, "Sacral Fractures and Sacrococcygeal Injuries in Dogs and Cats"). A significant degree of malalignment of the pelvis can be present without long-term functional disability (gait disturbance, constipation) or altering the outward appearance of the animal (Figs. 1 and 2). Most pelvic fractures will heal without reduction or fixation. However, even a small degree of malalignment of acetabular fractures will lead to degenerative joint disease and perhaps to its clinical sequelae; a large degree of medial displacement of the ilium or acetabulum may interfere with defecation or parturition. Narrowing of the pelvic canal is of greatest clinical significance in cats and very small dogs.

**Figure 2.** Ventrodorsal radiograph of the pelvis of the dog in Figure 1.

## DIAGNOSIS

### Physical Examination

The high incidence of concurrent injuries in animals that have sustained pelvic fractures and sacroiliac dislocation underscores the importance of a complete physical examination. Careful examination of the caudal abdominal wall for hernias and the urinary bladder and urethra for rupture is imperative. Urethral trauma associated with pelvic fractures is much more common in males than in females. The sensory status of the tail, anus, and perineum should be determined. Anal tone and the status of the anal reflex should be evaluated. Fractures of the lumbar, sacral, and caudal (coccygeal) vertebrae may alter sensory and motor function of these structures; in such cases, a painful response can usually be elicited by manipulation of the base of the tail or by application of digital pressure at the level of the fracture (see also the previous article "Sacral Fractures and Sacrococcygeal Injuries in Dogs and Cats").

The neurologic status of the limbs should be evaluated in all animals that have sustained trauma to the pelvic region. The intimate relationship between the lumbosacral trunk-sciatic nerve and adjacent bony structures (sacrum, sacroiliac joint, and ilium) predispose them to injury. In one study, approximately 11% of dogs and cats with pelvic fractures and sacroiliac dislocation had evidence of peripheral nerve injury (Jacobson and Schrader, 1987). Injury to the lumbosacral trunk or sciatic nerve may result in various degrees of proprioceptive deficit (knuckling of the paw) and diminished sensory status over the dorsal, lateral, and plantar aspects of the paw. Accurate assessment of proprioceptive, sensory, and motor status can sometimes be difficult. Animals with pelvic fractures and sacroiliac injuries may be unwilling to bear weight on the limb, may be less willing to respond to a noxious stimulus because movement of the limb is painful, and may have soft tissue bruising and swelling that alters voluntary movement or sensory perception. Severe avulsive, crushing, or lacerative injuries of the lumbosacral trunk and sciatic nerve will result in diminished or absent withdrawal reflex, loss of voluntary motor function distal to the stifle region, and slight to moderate hyperflexion of the tarsus with weightbearing. Complete denervation of the muscles that extend the tarsus does not result in marked tarsal hyperflexion and a plantigrade stance because the animal's ability to extend the stifle will reciprocally extend the tarsus. There may be hyperextension of the stifle and exaggerated patellar tendon reflexes with denervation of the biceps femoris, semitendinosus, and semimembranosus muscles (loss of antagonists). Entrapment of peripheral nerves often evokes a painful response; entrapment of the lumbosacral trunk or sciatic nerve must be considered whenever the animal appears to have intractable pain or has a marked response to manipu-

**Figure 3.** Ventrodorsal radiographs of common pelvic injuries. Craniodorsal displacement of the ilium is commonly associated with disruption of the sacroiliac joint *(left)*. Fractures of the ilium *(center)* and acetabulum *(right)* usually result in medial displacement of bone fragments and the femur. Lumbosacral trunk or sciatic nerve injuries are most commonly associated with sacroiliac dislocation *(left)* or ilial fractures that allow craniomedial displacement of the ilium *(center)*.

lation of the limb. It is common for animals with pelvic fractures to allow manipulation without marked painful response.

The physical findings associated with pelvic fractures and sacroiliac dislocation can be predicted with knowledge of the pathology created by the trauma. Bone is usually displaced away from the site of direct impact. Cranial displacement of the ilium occurs with sacroiliac dislocation, and bone is usually displaced in a medial direction with ilial and acetabular fractures (Fig. 3). The sacrum, sacroiliac joint, ilium, ischium, pubis, and pelvic symphysis form a continuous structure ("pelvic ring"). Disruption of one portion of this structure is almost always accompanied by disruption at another site. Therefore, isolated (single) fracture of the pelvis or sacroiliac dislocation is highly unlikely. Although gross inspection would lead one to believe that the pelvis is somewhat fragile, its shape and the protection afforded by surrounding muscles make it less vulnerable to fracture. A significant amount of kinetic energy is needed to disrupt the "pelvic ring." This would explain the prevalence of associated bony and soft tissue injuries. Soft tissue disruption may be severe; the extent of soft tissue injury, as defined by swelling and bruising, is often not fully apparent until 3 to 4 days have elapsed.

Animals with pelvic fractures and sacroiliac dislocation have a variable degree of functional disability. Some animals are unable or unwilling to rise and walk on the affected limb; others can rise and walk with little or no assistance. Functional abilities often improve, sometimes dramatically, during the first 48 to 72 hours.

Crepitus can usually be detected in the pelvic region when the limb (hip) is manipulated. Doing a rectal examination at the time of such manipulation may facilitate detection of crepitus or movement of bone fragments. Rectal examination allows simultaneous evaluation of anal tone and reflex, the rectum, and the size and shape of the pelvic canal. Rectal examination is much more accurate than radiographic evaluation for determining the extent of narrowing or adequacy of the pelvic canal. The intrapelvic portions of the sciatic nerve and urethra can sometimes be identified by rectal examination.

In animals having craniodorsal dislocation of the sacroiliac joint (see Fig. 3), the area about the iliac crest may appear swollen or the iliac crest will be more prominent or easier to palpate than on the unaffected side. The greater trochanter may seem less prominent or be more difficult to palpate in animals having medially displaced fractures of the ilium or acetabulum (see Fig. 3).

## Radiographic Examination

Standard ventrodorsal and lateral views of the pelvis usually suffice for the diagnosis of pelvic fractures and sacroiliac dislocation. Animals with these injuries seem to tolerate positioning for the dorsoventral "frog-leg" view (Fig. 4) better than ventrodorsal "hip-extended" view (Fig. 5); however, dorsoventral views are generally more difficult to evaluate (compare Fig. 4 and Fig. 5). The ventrodorsal view is particularly helpful in the diagnosis of sacral fracture and sacroiliac injuries. Because even slight rotational malpositioning may cause the width of the two sacroiliac joints to appear different, sacroiliac dislocation is not usually diagnosed unless there is unequivocal widening of the joint or cranial displacement of the ilium (Fig. 6).

Making standard ventrodorsal and lateral views of the pelvis also allows radiographic evaluation of the proximal portion of the femur, the last 2 to 3 lumbar vertebrae, the sacral and caudal vertebrae, and the caudal abdomen (urinary bladder, abdominal wall). Each of the above structures should be carefully examined when evaluating radiographs of animals that have sustained pelvic trauma. Thoracic radiography is recommended in all animals that have sustained blunt trauma; concurrent thoracic injuries are com-

**Figure 4.** Dorsoventral "frog-leg" radiograph of the pelvis of a dog having multiple pelvic fractures and right sacroiliac dislocation.

**Figure 5.** Ventrodorsal "hip-extended" radiograph of the pelvis of the dog in Figure 4. Although dogs and cats are more likely to resist or struggle during positioning for this view, it is preferred over dorsoventral views because the bony injuries are more clearly defined.

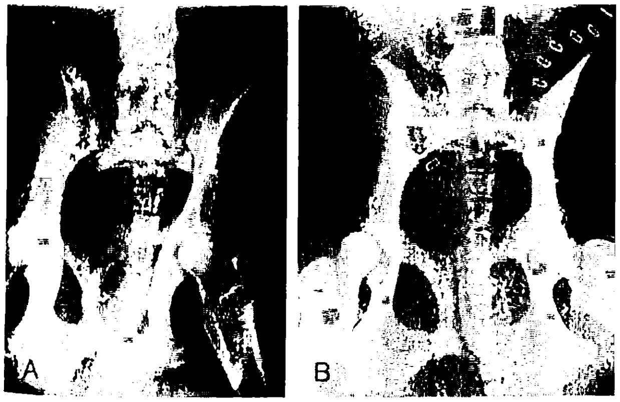


**Figure 6.** Preoperative *(A)* and postoperative *(B)* ventrodorsal radiographs of the pelvis of a dog having bilateral sacroiliac dislocation and fracture of the pelvic symphysis. The normally confluent bony margin created by union of the medial portion of the ilium and the sacral body has been disrupted on both sides *(dotted line arrows,* right joint); this disruption confirms that sacroiliac dislocation has occurred. Following reduction *(B)* confluence has been re-established on the right side *(dotted line arrows).* The left dislocation has been slightly over-reduced; that is, the ilium has been moved slightly caudal to its normal position *(solid arrowheads).*

mon and such injuries may not be detected by physical examination methods.

The radiographic findings associated with pelvic fracture and sacroiliac dislocation are limited predictors of concurrent soft tissue injury, severity of limb dysfunction, and degree of pelvic narrowing. As such, therapeutic decisions concerning such injuries should be based on both radiographic and physical findings with emphasis on the latter.

## INDICATIONS FOR SURGICAL INTERVENTION

### Concurrent Soft Tissue Injuries

The presence of an abdominal hernia, a ruptured bladder or urethra, or suspected peripheral nerve injury warrants serious consideration. Management of these injuries usually takes precedence over treatment of the associated fracture or dislocation.

In the case of peripheral nerve injury, surgical treatment usually includes reduction and repair of the bone or joint injury. Injury to the lumbosacral trunk or sciatic nerve is most commonly associated with craniodorsal sacroiliac dislocation and with fractures of the ilium where there is medial or craniomedial displacement of the caudal fragment (see Fig. 3). Surgical exploration is usually warranted when the animal has neurologic deficits, appears especially painful, or is experiencing intractable pain concurrent with radiographic evidence that bone fragments may be causing persistent attenuation of the lumbosacral trunk or the sciatic nerve (see earlier). Exploration may be warranted even when the neurologic examination suggests that nerve injury is severe or complete. In one study (Jacobson and Schrader, 1987), limb function was regained in six of eight dogs and cats that were found to have moderate to severe attenuation, fraying, or stretching of the lumbosacral trunk or sciatic nerve at the time of surgical exploration. Surgery should be performed as soon as possible so that nerve entrapment can be relieved, further nerve damage can be avoided, and prognosis can be determined. If the peripheral nerve is partially intact, the ilial fracture or sacroiliac dislocation should be reduced and fixed. Amputation or tendon relocation techniques (Lesser, 1990) are surgical options when laceration is complete. Nerve anastomosis is impractical because the nerve ends are often badly damaged, adequate exposure is difficult to achieve, and, even under ideal circumstances, reinnervation of the limb will be prolonged or incomplete.

### Limb Dysfunction (Pain)

There is a variable degree of limb dysfunction associated with all pelvic fractures and sacroiliac dislocations. Limb dysfunction is the result of soft tissue disruption, bone instability, and the pain associated with each. The degree of dysfunction helps the veterinarian decide whether or not reduction and fixation are warranted.

Regardless of radiographic findings, dogs and cats with pelvic fractures and sacroiliac dislocation that are able or willing to rise and walk without assistance do not usually require surgery (see exceptions below). These animals will recover more slowly than those having open reduction and internal fixation but the end or long-term result is often the same. Although animals with fracture of the acetabulum are often willing to bear weight on the affected limb, early open reduction and internal fixation is recommended because persistent joint incongruence and instability will lead to degenerative joint disease (see Acetabular Fractures).

Assuming that there are no other injuries that require immediate surgical intervention, serial evaluation over a 2- to 3-day period is the best way to evaluate the degree of limb dysfunction. Many animals that initially are unwilling or unable to walk, that is, appear to be surgical candidates, will be able to walk by the third day. Conversely, the decision to surgically intervene should not be delayed too long (more than 3 to 4 days) because, as time passes, reduction becomes more difficult.

### Excessively Narrowed Pelvic Canal

Excessive narrowing of the pelvic canal may interfere with defecation and parturition. Excessive narrowing is usually the aftermath of medial displacement of bone following fracture of the ilium or acetabulum. Less commonly, bilateral craniodorsal sacroiliac dislocation allows craniodorsal displacement of the pubic bones and symphysis which decreases the dorsoventral dimension of the pelvic inlet.

The extent of pelvic canal narrowing is best determined by careful rectal examination. Even severe distortion (30 to 40% narrowing) of the pelvic canal is rarely sufficient to cause persistent signs of constipation or obstipation in dogs weighing more than 10 kg. However, a relatively small degree of pelvic narrowing (15 to 25%) may lead to these signs in cats. Attempting to widen the pelvic canal by per-rectum digital manipulation is potentially dangerous and rarely successful. In cats, signs of constipation or obstipation may not become evident until weeks or months have passed, that is, after the fractures have healed. Chronic partial rectal obstruction leads to chronic distention of the colon (megacolon). In cats, widening the pelvic canal via pelvic osteotomy or ostectomy is usually ineffective in diminishing signs of obstruction once megacolon has developed (Schrader, 1992). Subtotal colectomy, with or without a widening procedure, is often helpful in such situations (Matthiesen et al, 1991). It would seem prudent that open reduction and internal fixation be employed whenever there is doubt about the adequacy of the pelvic canal or as soon as there is any sign of obstruction in those cats having pelvic narrowing associated with pelvic fractures. Likewise, surgery should be performed whenever there is narrowing of the canal in a breeding female of either species, especially if the individual is prone to dystocia (brachycephalic breeds).

### Acetabular Fractures

Physical examination findings are the primary basis for determining if there is peripheral nerve entrapment, significant limb dysfunction (pain), or excessive narrowing of the pelvic canal in animals with pelvic fractures or sacroiliac dislocation. Although physical examination is useful in the diagnosis of acetabular fracture, radiographic examination is required to confirm the diagnosis and provide an insight to the method of treatment and prognosis.

Surgical intervention is usually recommended in dogs and cats with acetabular fractures. Anatomic reduction and rigid fixation help to avoid the sequelae of joint incongruity and instability (degenerative joint disease) and any restriction of motion associated with medial displacement. Careful evaluation of the radiographs allows the veterinarian to determine the shape, size, number, and location of fragments, that is, whether anatomic reconstruction and fixation are possible. Comminuted fractures of the acetabulum are especially difficult to repair.

Femoral head and neck excisional arthroplasty is warranted when satisfactory reduction and fixation of acetabular fragments cannot be achieved. In addition, excisional arthroplasty should be considered a reasonable alternative to acetabular reconstruction in light-weight (less than 15 kg) dogs and in cats because a good functional outcome can be expected in these animals. Regardless of whether reconstruction or excisional arthroplasty is planned, surgery should not be delayed in animals having acetabular fractures. Acetabular reconstruction will be more difficult after just a few days and the outcome of excisional arthroplasty becomes progressively less favorable as muscle atrophy and restricted hip motion become more pronounced.

Surgical intervention may not be necessary when the acetabular fracture is nondisplaced, especially in skeletally immature animals that have a high capacity to heal and remodel. Fractures that involve the caudal one fourth to one third of the acetabulum do not usually need to be repaired if the hip is stable and noncrepitant, that is, the bone fragments are not interfering with motion. In such cases, the status of the hip is most accurately determined by palpation of the hip with the dog under general anesthesia. There is evidence to suggest that most dogs with fractures of the caudal acetabulum will have restricted range of pain-free motion and develop degenerative joint disease when nonsurgical methods of management are employed (Boudrieau and Kleine, 1988).

### Presence of Factors That Adversely Influence Convalescence Following Nonsurgical Methods of Treatment

Compared with nonsurgical methods of managing pelvic fractures and sacroiliac dislocation, convalescence is generally shorter and the degree of limb dysfunction is initially milder with open reduction and internal fixation. In many situations, this alone is reason enough to warrant surgical intervention. It may be especially helpful to repair pelvic fractures and sacroiliac dislocation when there are injuries in other limbs. Rigid fixation of the pelvic injuries may hasten return to ambulatory status, thus reducing the likelihood of complications associated with recumbency (pneumonia, decubital sores, urine or fecal soiling). Repair of pelvic fractures or sacroiliac dislocation has a sparing effect on the repair of fractures in other limbs. Convalescence may be significantly reduced by internal fixation in very large, obese, or debilitated animals or animals with preexisting conditions, such as arthritis in other joints, that adversely affect their ability to walk. Some owners may not be willing or able to provide the nursing care that may be necessary when nonsurgical methods are employed.

## SURGICAL CONSIDERATIONS

Specific methods of reduction and internal fixation are described in most surgical textbooks (see References and

Suggested Reading). Although a detailed description of these methods is beyond the scope of this discussion, several points should be considered:

1. Isolated disruption of the "pelvic ring" is uncommon, i.e., if there is one fracture, there is usually another (Fig. 7).
2. Reduction and fixation of one disrupted segment of the "pelvic ring" will often realign or stabilize other disrupted segments as well. Thus, many animals do not need more than one (unilateral) surgery (Fig. 8; see Fig. 7).
3. Fractures involving the pubis, ischium, and pelvic symphysis do not generally need to be repaired; reduction and fixation is usually reserved for acetabular or ilial fractures and sacroiliac dislocation, i.e., to re-establish the bony connection between the hip and the spine (see Figs. 7 and 8).
4. Anatomic reduction of ilial fractures and sacroiliac dislocation is not necessary as long as fixation is stable and the other goals of surgery, such as decompression of nerves and enlargement of the pelvic canal, are achieved.
5. Most ilial fractures can be repaired via a lateral incision (Piermattei and Greeley, 1979); fixation with plate and screws is the most common method but a variety of methods are useful.
6. The cranial ilium and sacroiliac joint can be visualized via a craniodorsal incision (Piermattei and Greeley, 1979); a screw or screws is most commonly employed for fixation of the sacroiliac joint (see Fig. 6); care must be taken to avoid screw placement in the spinal or pelvic canal and the lumbar vertebrae or lumbosacral joint.
7. Gaining exposure to the acetabulum without excessive disruption of the periarticular soft tissues is difficult; widest exposure is usually obtained via trochanteric osteotomy (Piermattei and Greeley, 1979).
8. It is difficult to preserve joint stability, achieve anatomic reduction, and effect rigid fixation of fragments in animals having fracture of the acetabulum; repair of these fractures should be delegated to those having experience with such surgery.

**Figure 7.** Ventrodorsal radiograph of the pelvis of a dog having multiple pelvic fractures. Disruption of the "pelvic ring" at one site almost invariably is accompanied by disruption elsewhere. The linear radiopacity represents a urinary catheter; the dog had a ruptured urethra.

**Figure 8.** Ventrodorsal radiograph of the pelvis of the dog in Figure 7 following reduction and fixation of the left ilial fracture. Repair of the left ilium has re-established a stable connection between the left limb and the spine, re-established the width of the pelvic canal, and realigned the pubic and ischial fractures. Open reduction and internal fixation of pubic and ischial fractures is rarely necessary.

## NONSURGICAL TREATMENT

Nonsurgical treatment of pelvic fractures and sacroiliac dislocation consists of rest, controlled exercise, and use of analgesic medications. Rest and controlled exercise may be the primary treatment or follow open reduction and internal fixation. The animals should be confined to a small space; the floor or sleeping area should be clean, dry, and well padded. No running, jumping, or climbing stairs should be allowed for 3 to 4 weeks; thereafter, restrictions on physical activities are generally not necessary. During the first 10 to 14 days, the animal may seem reluctant to rise and walk; however, it is important to encourage this in order to prevent muscle atrophy and joint stiffness as well as reduce the likelihood of decubital sores and urine or fecal soiling. Limb function seems to improve more rapidly if the animal has been encouraged to rise and walk numerous times during each day. The owner can help the animal rise and walk as well as prevent falls by placing a towel under the caudal abdomen and using it as a sling. The animal should be re-evaluated by a veterinarian at 10- to 14-day intervals to confirm that limb function is improving, to monitor neurologic status, and to reassess the size of the pelvic canal by rectal examination. Radiographic re-evaluation is warranted whenever internal fixation has been employed.

### References and Suggested Reading


Betts CW: Pelvic fractures. In: Slatter D, ed: Textbook of Small Animal Surgery, 2nd ed. Philadelphia: WB Saunders, 1993, p 1769.
*An overview of surgical and nonsurgical treatments of pelvic fractures.*

Boudrieau RJ, Kleine LJ: Nonsurgically managed caudal acetabular fractures in dogs: 15 cases (1979–1984). J Am Vet Med Assoc 193:701, 1988.
*Found that degenerative joint disease and hip pain developed in dogs having caudal acetabular fractures that were not surgically repaired.*

Brinker WO, Piermattei DL, Flo GL: Handbook of Small Animal Orthopedics and Fracture Treatment. Philadelphia: WB Saunders, 1990, p 76.
*Describes various methods of open reduction and internal fixation of pelvic fractures and sacroiliac dislocation.*

Jacobson A, Schrader SC: Peripheral nerve injury associated with fracture or fracture-dislocation of the pelvis in dogs and cats: 34 cases (1978–1982). J Am Vet Med Assoc 190:569, 1987.
*Describes the diagnosis, treatment, and outcome of treatment in 34 animals having peripheral nerve injury due to pelvic trauma.*

Lesser AS: Tendon transfer for treatment of sciatic paralysis. In: Bojrab MJ, ed: Current Techniques in Small Animal Surgery, 3rd ed. Philadelphia: Lea & Febiger, 1990, p 59.
*Describes a method of salvaging limb function following severe sciatic nerve injury.*

Matthiesen DT, Scavelli TD, Whitney WO: Subtotal colectomy for the treatment of obstipation secondary to pelvic fracture malunion in cats. Vet Surg 20:113, 1991.
*Found that subtotal colectomy helped alleviate signs of constipation and obstipation in cats having pelvic narrowing due to pelvic fracture.*

Olmstead ML: Surgical repair of acetabular fractures. In: Bojrab MJ, ed: Current Techniques in Small Animal Surgery, 3rd ed. Philadelphia: Lea & Febiger, 1990, p 656.
*Describes surgical methods for open reduction and internal fixation of acetabular fractures.*

Piermattei DL, Greeley RG: An Atlas of Surgical Approaches to the Bones of the Dog and Cat, 2nd ed. Philadelphia: WB Saunders, 1979.
*Comprehensive guide to the surgical exposure of the bones and joints of dogs and cats.*

Schrader SC: Pelvic osteotomy as a treatment for obstipation in cats with acquired stenosis of the pelvic canal: Six cases (1978–1989). J Am Vet Med Assoc 200:208, 1992.
*Found that procedures used to widen the pelvic canal of cats having signs of constipation and obstipation were not effective in alleviating signs once megacolon had developed (5 to 6 months).*

Tarvin GB, Lenehan TM: Management of sacroiliac dislocations and ilial fractures. In: Bojrab MJ, ed: Current Techniques in Small Animal Surgery, 3rd ed. Philadelphia: Lea & Febiger, 1990, p 649.
*Description of the management of sacroiliac dislocations and ilial fractures, including specific methods of open reduction and internal fixation.*


# Shearing and Degloving Wounds on the Extremities of Dogs and Cats


STEPHANIE L. BEARDSLEY
*Austin, Texas*


Traumatic injuries of the limbs are common in dogs and cats. These injuries are usually the result of automobile-induced trauma and occur most often in young animals of many breeds. The injuries range in severity from simple lacerations to degloving wounds with loss of skin and underlying soft tissues and associated bone and joint injuries. Shearing and degloving wounds are often highly contaminated because bone, joints, and supportive structures are frequently exposed. Disruption of blood supply, direct tissue damage, and contamination may result in infection. Loss of supportive tissues may lead to joint instability, causing gait or conformational abnormalities. Shearing wounds occur most frequently on the distal portions of the limb, the most common site being the medial aspect of the tarsometatarsal region.

## INITIAL ASSESSMENT

Dogs and cats with life-threatening injuries should be stabilized prior to the management of degloving injuries. A thorough physical examination should be performed because as many as 70% of dogs with shearing and degloving injuries have been reported to have concurrent injuries such as skin laceration, fractures, and cardiopulmonary problems (Beardsley and Schrader, 1995). If definitive management of the wound needs to be delayed, the wound should be cleansed as well as possible and a sterile bandage should be applied to prevent further contamination and to provide support. In most cases, sedation or anesthesia is needed to fully assess and manage the wound. The general physical condition of the animal, along with the degree of injury, dictates the degree and form of anesthesia or analgesia necessary. Neuroleptanalgesics such as acepromazine maleate (Acepromazine, Fermenta Animal Health Co.) and butorphanol tartrate (Torbugesic, Fort Dodge Laboratories Inc.) or oxymorphone (Numorphan, DuPont Merck Pharma) with or without local anesthetics typically provide enough pain relief to allow management of the wounds (see p. 57). In more severe wounds and with a stable