CHAPTER 11
ETIOLOGY, CLASSIFICATION, AND DIAGNOSIS OF FRACTURES

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- Etiology of Fractures
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A fracture is a dissolution of bony continuity with or without displacement of the fragments. It is always accompanied by soft tissue damage of varying degrees, there are torn vessels, bruised muscles, lacerated periosteum, contused nerves. Sometimes there are injured internal organs and lacerated skin. The trauma to soft tissue must always be taken into consideration and is often vitally more important than the fracture itself.(5)

Fractures have been classified by many authorities in the past. (1-4,6-8) This chapter attempts to present a system of nomenclature appropriate for dogs and cats.

ETIOLOGY OF FRACTURES
EXTRINSIC CAUSES
DIRECT VIOLENCE
Trauma is the most common cause of fractures in small animals and is usually due to automobile injury or falling from a height. Since direct trauma is rarely delivered in a calibrated amount to a specific place, the resultant fracture is rarely predictable. The amount and direction of force will vary from accident to accident. Most fractures resulting from violent direct trauma are either comminuted or multiple.

INDIRECT VIOLENCE
Fractures due to indirect trauma are more predictable than those due to direct trauma. Generally a force is transmitted to a bone in a specific fashion and at a "weak link" within the bone, causing a fracture to occur.

BENDING FORCES
Bending fractures occur when force is applied to a specific focal point on a bone to the extent that the traumatic force overcomes the elastic limit of the bone diaphysis. The initial effect of a bending force is a cortical break opposite the site of the trauma. The periosteum will remain intact on the side of the force while tearing over the fracture on the opposite side. With additional force the entire bone snaps, with attendant tearing of vascular and soft tissue structures within or on the diaphysis. Bending fractures are generally oblique or transverse, or they may have a butterfly fragment. (Example: A dog running across a field steps into a gopher hole with the hind limb; the edge of the hole is a fulcrum producing a bending fracture of the midshaft tibia.)

TORSIONAL FORCES
Torsional fractures occur when a twisting force is applied to the long axis of a bone. Usually this is a result of one end of a bone being placed in a fixed position while the other end of the bone is forced to rotate. The resulting fracture will be a very long spiral with sharp points and often sharp edges. It is possible for the sharp points or edges to compromise soft tissues or to cut through the skin and result in an open fracture. Torsional forces generally result in short or long spiral fractures. (Example: A cat jumping from a garage roof to a fence misjudges the distance and catches its hock in the fence. The resulting force of its body twisting against the fixed lower extremity results in a spiral fracture of the tibial diaphysis.)

COMPRESSION FORCES
Compressive forces along the long axis of a bone may force the smaller diaphyseal or metaphyseal portion of a bone to impact into the larger epiphysis: bony substance is thereby crushed. Similarly a compressive force directed along the axis of the spine may result in collapse of a vertebral body. For compressive force to result in fracture, one end of a bone must be in a fixed position while the other end is forced toward the fixed end. Compressive forces result in impacted fractures or compression fractures. (Example: A large breed puppy jumps for a frisbee and in landing forces the hock plantigrade into the ground. The full weight of the dog then crushes the proximal tibial epiphysis over the proximal tibial metaphysis.)

SHEARING FORCES

A shearing fracture is caused by a force transmitted along the axis of a bone, which is then transferred to a portion of the same bone that lies peripheral to the axis or across a joint to other bones that are not protected by the axis of the bone. The force shears off that bony portion unable to continue transmission of the force along the axis. The fracture line in a shear fracture will be parallel to the direction of the applied force. Shearing forces result in the fracture of bony prominences not placed along the direct axis of a diaphysis. (Example: An immature miniature breed dog is dropped from its owner's arms to a hard surface. The force transmitted up the radius and ulna, across the elbow joint and into the distal humerus will shear off the lateral humeral condyle.)

INTRINSIC CAUSES

FRACTURES DUE TO MUSCULAR ACTION

Fractures caused by violent contraction of a muscle are called avulsion fractures. They may occur because of violent isometric contraction but are associated more commonly with trauma that results in forceful muscular shortening. These fractures frequently occur in immature animals while the physeal plate remains open. Such muscular forces are more likely to separate a cartilaginous union than the eventual bony union of mature animals.

Avulsion fractures affecting bony prominences that serve as the major origin or insertion of a muscle are seen routinely. The processes commonly avulsed include the acromion, scapular tuberosity, greater humeral tubercle, olecranon, ischial tuberosity, greater trochanter, tibial tuberosity, and the calcaneus of the fibular tarsal bone.

PATHOLOGIC FRACTURES

Pathologic fractures occur because of underlying bony or systemic disease that causes one, many, or all bones of an animal's skeletal system to be abnormal and thus more susceptible to fracture. Pathologic fractures may occur from any type of trauma: bending force, torsional force, compressive force, or shearing force. Often the only force necessary to cause fracture is the animal's weight; thus, spontaneous fracture occurs without overt trauma.

Pathologic fracture may occur through any of the following types of bony pathology: neoplasia, bone cysts, osteoporotic bone caused by secondary NHPO, nutritional hyperparathyroidism, localized bone infection (osteomyelitis), osteoporotic bone caused by disuse following prolonged external fixation or removal of a rigid internal device(Fig. 11-1).

A pathologic fracture can occur in any bone, in any location within a bone, and take any shape. The diagnosis of underlying pathology is usually of more importance than immediate bone fixation. Once the pathologic basis for the fracture has been diagnosed and specific corrective measures initiated, the fracture or fractures can be treated. Treatment of all pathologic fractures, including those due to neoplasms, can be successful.

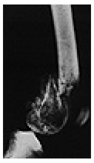

FIG. 11-1 Pathologic fracture. Fibrosarcoma of the distal femoral metaphysis in a dog.

CLASSIFICATION OF FRACTURES BY TYPE

Fractures are classified into many types based on the severity of the fracture, whether it communicates through the skin, the shape of the fracture line, or the anatomical location of the fracture within an individual bone. All systems are compatible and of necessity overlap.

INCOMPLETE FRACTURES

An incomplete fracture implies that a bone has not completely lost continuity; some portion of the bone remains intact. There are several types of incomplete fractures.

GREENSTICK FRACTURE

As the name implies, a greenstick fracture resembles the break that results when a supple green branch of a tree is bent and breaks incompletely. Usually the side opposite the bending force fractures completely, while the side under the force remains intact. In the immature animal with similarly supple elastic bone, a bending force will produce the incomplete fracture. Since a portion of the bone cortex remains intact, this fracture cannot override and result in limb shortening; however, the limb may deform along its axis at the point of the bending force (Fig. 11-2).

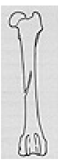

FIG. 11-2 Incomplete fracture of the femoral diaphysis.

FISSURE FRACTURE

Cracks or fissure lines will occur when direct trauma is applied to any long or flat bone. Generally the fissures are formed in one cortex of the bone and are covered by an intact periosteum. Bones may have single or multiple fissure lines of any configuration: transverse, oblique, spiral, longitudinal, or radiating from a central point. Since fissure fractures occur only in a single cortex and represent an incomplete fracture, the fractured bone should maintain its normal shape.

DEPRESSION FRACTURE

Depression fractures represent areas in which multiple fissure fracture lines intersect. With sufficient force, the entire area will depress from the direction of force. This usually occurs in the calvarium, the maxilla, or the frontal bone areas of the head.

COMPLETE FRACTURES

Complete fractures are indicated by the complete loss of bony continuity, allowing overriding and deformation. Complete fractures are far more common than incomplete fractures. They may be classified further by the shape of the fracture line. The following system describes complete fractures.

TRANSVERSE FRACTURE

Tranverse fracture implies a fracture line that is transverse to the long axis of the bone. Transverse fractures may be relatively smooth or may be rough or have deep teeth on the fractured surfaces. Most are caused by bending forces. Roughness simplifies anatomical alignment and increases the likelihood of rotational stability once reduced. Once these fracture fragments have been reduced, fragment override should not occur (Fig. 11-3).

OBLIQUE FRACTURE

Oblique fracture implies a fracture line that is oblique to the long axis of the bone. The two cortices of each fragment are in the same plane without spiraling. The edges of an oblique fracture may be rough but are usually smooth. The cortical edges are flat, rather than sharp. These fractures generally result from bending, with superimposed axial compression. As a result of the obliquity of the fracture line, this fracture tends to override or rotate unless traction is maintained throughout the period of healing (Fig. 11-4).

SPIRAL FRACTURE

Spiral fracture indicates a fracture line that spirals along the long axis of the bone; it is caused by torsional twisting or rotational forces. Spiral fractures tend to have extremely sharp points and edges, which frequently accompany soft tissue trauma or an open fracture. Reduction of spiral fractures is difficult without constant traction or internal fixation, since these fractures tend to override and rotate into deformity (Fig. 11-5).

COMMINUTED FRACTURE

Comminuted fracture implies at least three fracture fragments, the fracture lines of which interconnect. The individual fracture lines that form the comminuted fracture may be transverse, oblique, or spiral. Comminuted fractures are generally caused by high-energy trauma, as typified by automobile accidents, and are a common type of animal fracture (Fig. 11-6). Comminuted fractures are difficult to reduce and fix because they have no inherent stability. Constant external traction and alignment or internal fixation is required.

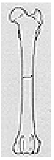

FIG. 11-3 Transverse fracture line. Drawing represents a reduced transverse fracture of the midshaft femoral diaphysis.

FIG. 11-4 Oblique fracture line. Drawing represents a reduced oblique fracture of the midshaft femoral diaphysis.

FIG. 11-5 Spiral fracture line. Drawing represents a reduced spiral fracture of the midshaft femoral diaphysis.

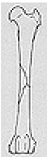

FIG. 11-6 Comminuted fracture lines. Drawing represents a reduced comminuted fracture of the midshaft femoral diaphysis.

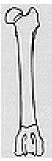

FIG. 11-7 Multiple fractures. Drawing represents a reduced femoral neck fracture and a reduced transverse fracture of the distal femoral metaphysis.

MULTIPLE FRACTURE

Multiple fracture implies three or more fracture fragments in a single bone; however, unlike comminuted fractures, the fracture lines do not interconnect. The individual fracture lines may be of any shape. Typically this term describes two completely independent fractures affecting the same bone, such as an oblique fracture of the proximal femur and an epiphyseal fracture of the distal femur. Neither of these fractures interconnects. Reduction and fixation of a multiple fracture requires two separate reductions and fixations (Fig. 11-7).

IMPACTION FRACTURE

Distinguishing between impaction fracture and compression fracture is difficult; however, because both terms are used routinely in orthopaedic texts, the difference will be clarified. An impacted fracture implies a fracture in which a bony fragment, generally cortical, is forced or impacted into cancellous bone. Typically this occurs at the ends of long bones. Reduction of such fractures requires traction to disengage the fragments and fixation to hold the fragments apart. If, after fracture, malalignment is untreated, bone shortening will occur because one end has impacted into the other. This is an uncommon fracture in small animals.

COMPRESSION FRACTION

Compression fractures are similar to impaction fractures, but the term is used to describe a fracture in which cancellous bone collapses and compresses upon itself. Typically this occurs in vertebral bodies following trauma to the spine. Compression fractures are rarely reduced, since the bone within the fracture area has been destroyed by the crushing. These fractures are stable and heal in place; however, shortening occurs as a result of compression (Fig. 11-8).

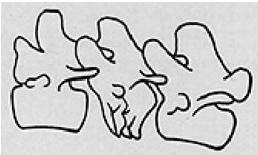

FIG. 11-8 Compression fracture. Drawing represents an unreduced compression fraction of a lumbar vertebral body.

CLOSED FRACTURE

A closed fracture implies a fracture that remains encased within the skin and musculature that surround it. No wound or mucosal membrane overlies the fracture. The fracture does not communicate with the outside environment. Most fractures in animals are closed. A synonym found in older literature is "simple fracture" (Fig. 11-9, A)

OPEN FRACTURE

Unlike a closed fracture, the open fracture communicates with the outside environment. This may occur through a large wound in the soft tissue and skin or through a tiny puncture wound. Regardless of wound size, any fracture that has communicated with the outside is considered an open fracture. Of greatest significance is the potential for contamination of the fracture itself (Fig. 11-9, B). A synonym found in older literature is "compound fracture."

CLASSIFICATION OF FRACTION BY LOCATION

Fractures may be classified by their anatomical location in relation to a specific bone. Identifying a fracture by location does not indicate whether the fracture is open or closed, nor does it indicate the type of fracture: transverse, oblique, spiral, or the like. The systems of classifying by type and classifying by location are compatible and should be used together. FIG. 11-8 Compression fracture. Drawing represents an unreduced compression fracture of a lumbar vertebral body.

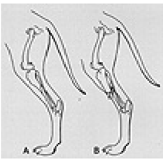

FIG. 11-9 (A) Closed reduced oblique fracture of the midshaft tibial diaphysis. (B) Open unreduced oblique fracture of the midshaft tibial diaphysis.

DIAPHYSEAL FRACTURE

For purposes of description, fractures are termed midshaft if they occur near the axial center of the diaphysis. All other fractures of the diaphysis are referred to by breaking the diaphysis into equal thirds. Therefore, fractures can be proximal third, middle third, or distal third of the diaphysis. A proper description would be closed, transverse fracture of the proximal third diaphysis of the femur. This classification should suggest a fracture within the skin, as well as the shape, anatomical location, and the bone fractured.

METAPHYSEAL FRACTURE

Any fracture within the anatomical metaphysis of a long bone is referred to as a metaphyseal fracture. For a clearer description the terms proximal or distal should be added, such as a closed, oblique fracture of the distal femoral metaphysis. Since most metaphyseal fractures are through cancellous bone, they generally heal rapidly.

FRACTURE OF THE EPIPHYSEAL PLATE

Fracture of the epiphyseal plate occurs in immature animals during the time that the epiphyseal plate remains open and cartilaginous. Fracture occurs through the zone of hypertrophied cartilage cells. Referral to such fractures should specify the proximal or distal epiphyseal plate. In mature animals, such fractures are called physeal fractures or fracture of the physis. Fractures of the epiphyseal plate are classified further to accurately describe their shape and severity of the fracture. The method of Salter- Harris is the standard classification for all species.(7) (See Figs. 34-1 through 34-6.)

Type I-Epiphyseal separation: there is displacement of the epiphysis from the metaphysis at the growth plate.
Type II-A small corner of metaphyseal bone fractures and displaces, with the epiphysis displaced from the metaphysis at the growth plate.
Type III-Fracture is through the epiphysis and part of the growth plate, but the metaphysis is unaffected.
Type IV-Fracture is through the epiphysis, growth plate, and metaphysis. Several fracture lines may be seen.
Type V-Impaction of the epiphyseal plate occurs, with the metaphysis driven into the epiphysis.
With each progressive type, the fracture described becomes increasingly difficult to treat and carries a poorer prognosis for

return to normal function.

EPIPHYSEAL FRACTURE
In the mature animal with closed growth plates, fractures of the epiphysis are termed epiphyseal fractures. They should be classified further by describing them as fractures of the proximal or distal epiphysis.

CONDYLAR FRACTURE
Condylar fractures occur in mature animals and affect the distal ends of the humerus or femur, or the proximal tibia. Since anatomically a condyle is composed of metaphysis, physis, and epiphysis, this descriptive classification system is used instead of the previous three. Condylar fractures are further defined as medial or lateral, depending on the aspect fractured. If both condyles fracture off the shaft as a unit, the fracture is termed supracondylar. Both condyles may fracture from the shaft and from each other. This is a supracondylar/intercondylar fracture and may be classified as a "V," "Y," or "T" fracture to better describe the shape of the fracture lines (Fig. 11-10). Any fracture of a condyle reflects potential problems if fracture of the joint surface has occurred.

ARTICULAR FRACTURE
Articular fracture indicates that the subchondral bone and articular cartilage are involved in a fracture. Such a fracture may be classified further by indicating which bone (proximal or distal) or which specific joint is fractured. Intra-articular fracture of the knee is nonspecific; description must specifically indicate fracture of the femoral or tibial component. Articular fracture is synonymous with intra-articular fracture and means fracture within a joint. The term periarticular fracture is used to refer to fracture close to, but not into, the joint. The term could be replaced by epiphyseal fracture. Articular fracture requires perfect anatomical reduction and fixation to prevent secondary degenerative joint disease.

AVULSION FRACTURE
Avulsion refers to a fracture of intrinsic etiology, generally caused by muscular contraction. The prominences that fracture are usually separate centers of bone formation referred to as apophyses. Avulsion fractures are classified by the prominence that has been avulsed, such as avulsion of the greater trochanter. Avulsion fractures tend to displace in the direction of the muscle pull that caused the fracture. Reduction and fixation is difficult and requires constant traction or internal fixation.

FRACTURE-DISLOCATION
Fracture-dislocation describes joint fractures that produce joint instability sufficient to result in simultaneous subluxation or luxation of the affected joint. This classification is incomplete, since fracture-dislocation of the shoulder indicates dislocation of the shoulder but does not indicate which bone, the scapula or the humerus, is fractured. Therefore, a more descriptive classification of the fracture must be given. Fracture-dislocations can be difficult to treat because they represent intra-articular fracture plus supporting tissue laxity. When fracture and dislocation are found together, the prognosis is poorer than if each problem occurred separately.

DIAGNOSIS OF FRACTURE
In most instances the clinical signs associated with fracture make diagnosis uncomplicated. Although the owner of an animal often will have observed the fractured bone, locating a fracture can at times be difficult. In these instances, the practitioner needs a systematic, logical approach to diagnose the fracture.

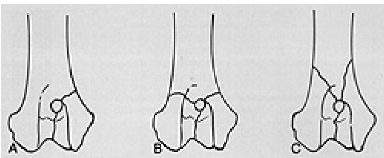

FIG. 11-10 Condylar fractures. (A) Lateral humeral condyle fracture. (B) Intercondylar and supracondylar fractures of the distal humerus (a "T" fracture). (c) Intercondylar and supracondylar fractures of the distal humerus (a "Y~ fracture).

DYSFUNCTION
Dysfunction is most commonly exemplified by lameness. In the orthopaedic examination the focal site of the lameness must be found and the diagnosis pursued. Dysfunction may also include paralysis with spinal fracture, unconsciousness accompanied by cranial fracture, or masticatory dysfunction with mandibular fracture.

Impairment or loss of function is a constant sign of complete fracture and is the result of pain or loss of mechanical support. Only in cases of incomplete or impacted fracture may some weight be borne by the bone. The careful observer will determine the difference between loss of function due to pain alone and that due to inability to bear weight. The smaller the animal, the more difficult it is to make this distinction. Toy Pekingese, Pomeranians, and all cats require considerable care in determining the presence of this sign.

PAIN
Pain over the site of fracture is common. In incomplete fractures this may be the only clinical indication. Direct tenderness can be misleading, since it may be due to a contusion or other soft issue damage caused by a blow. Indirect tenderness is a more accurate sign of fracture. It is produced by pressure in the long axis of the bone exerted at its two extremities. If there is a break in the continuity of the shaft, such pressure will cause pain at the fracture site that is quite distinct from the pain of injured soft tissue parts. If an animal is examined during the state of local tissue shock, that is, within 20 to 30 minutes after the accident, pain may not be a conspicuous sign.

LOCAL TRAUMA
Examination of the area around a fracture may demonstrate swelling, hematoma, contusion, or laceration if the fracture is open. Often because of extreme swelling, the examiner will be unable to palpate crepitation. Local swelling, although

present in many other conditions, is one of the most constant signs of a fracture. Immediately after injury the swelling may be sharply outlined as a result of bleeding from the bone and the soft parts. An indistinctly outlined swelling that occurs later is caused by edematous infiltration. Generally the swelling increases for 24 to 48 hours, then gradually subsides (particularly under treatment). When applying bandages and splints immediately following fracture, it is important to bear in mind that swelling will subside.

ABNORMAL POSTURE OR LIMB POSITIONING

Abnormalities of positioning, when of acute onset associated with trauma, usually reflect a fracture. Deformity, a deviation from the normal anatomical structure, may be caused by displacement of the bony framework as in a fracture or dislocation, but it may also be caused by changes in configuration due to a neoplasm. The displacement of bone fragments that produces deformity in a fracture may be angular, longitudinal, or rotational. Longitudinal displacements may cause shortening, referred to as overriding, or may result in separation of the fragments, termed distraction (e.g., fractures of the olecranon). In most cases the primary displacement is determined by the direction and force of an injury and is maintained and often increased by the contraction of muscles. If in doubt about positioning, comparison with the opposite limb or side of the body part is advised.

CREPITUS

Crepitus is a sign of fracture that is considered pathognomonic. Bony crepitus is the gritting sensation transmitted to the palpating fingers by the contact of the broken bone ends on each other. There are other forms of crepitus (pseudocrepitus) such as occurs in some cases of arthritis, partial luxations of the patella, or luxations of the coxofemoral joint. The absence of crepitus does not necessarily indicate the absence of a fracture. The interposition of a piece of soft tissue between the fragments will prevent crepitus. It is also absent when the ends of the bones are so far apart that they cannot be brought into contact, or when they are impacted. Crepitation should be elicited with the utmost precaution because of the danger of causing further damage to bony fragments and surrounding soft tissue. Vigorous palpation, which may turn a routine closed fracture into a contaminated open one should be avoided.

ABNORMAL MOBILITY

A false point of motion is also pathognomonic. It occurs if there is a complete fracture of the shaft of a long bone; it does not occur in an incomplete or impacted fracture. Mobility near a joint may be difficult to differentiate from normal or abnormal mobility of the joint itself. In order to avoid additional trauma, the same precaution should be taken in eliciting this symptom as in eliciting crepitus.

RADIOGRAPHIC SIGNS

Fracture, either diagnosed or suspected, should be documented by radiography. At least two views including the joints above and below the fracture are needed. Fracture of joints or special anatomical locations may require additional radiographs or special positioning. Radiographs should be read on a well-illuminated flat surface. If questions about anatomical structures exist, the opposite limb or side of the body may be radiographed for comparison. The specific radiographic signs of fracture include those listed below: A break in the continuity of a bone A line of radiolucency when the fragments are distracted A line of radiopacity when the fragments are compressed or superimposed (Fig. 11-11)

OTHER SIGNS

Although all of the above signs do not always occur in all fractures, combinations of these signs are always present. As time elapses between the time of the trauma and the time of treatment, symptoms change in accordance with the changes at the fracture site. Miscellaneous signs associated with fracture include the following:

Fever. Elevated temperatures are seen routinely 24 to 48 hours following a fracture and reflect the response to breakdown of the hematoma.

Anemia. Medullary arteries are high-pressure vessels, and significant hemorrhage can occur with fracture. Large dogs may lose 200 ml to 300 ml of blood into the hematoma. Animals with multiple bone fractures can lose this amount of blood into each hematoma.

Shock. Hypovolemic shock can readily occur with severe fracture or concomitant vascular lacerations. Shock may lead to death following severe blood loss into a fracture site.

Nerve injury. Depending on the location of the fracture or its severity, peripheral nerves can be involved.

Necrosis or gangrene. In instances of fracture and simultaneous vascular laceration or occlusion, necrosis of distal extremities may occur. This usually occurs several days following fracture.

Fat in synovial fluid. This sign may indicate presence of an articular fracture; however, any trauma to a joint may result in fat in the synovial fluid. If fat is found and the animal remains lame, further studies may be needed to pursue the diagnosis of fracture.

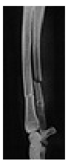

FIG. 11-11 Radiographic signs of fracture. Note both a line of radiolucency where fragments are distracted and two lines of radiopacity where fragments are superimposed.

PATHOLOGY ASSOCIATED WITH FRACTURE

Many specific fracture types have soft tissue injuries associated with them. Pelvic fracture may result in laceration of the bladder, prostate, pelvic urethra, or major vessels and nerves. Fractured ribs routinely accompany hemothorax, pneumothorax, or laceration of the lung parenchyma. Fracture of the axial skeleton can be expected to compromise the brain, brain stem, or spinal cord.

There may also be associated injury to the surrounding soft tissue produced by the trauma that caused the fracture. It is important to remember that skin, muscles, periosteum, tendons, nerves, and vessels over the fracture absorbed the same force as the fractured bone. Any or all of these structures may be severely damaged at the time of impact.

Trauma sufficient to cause fracture may also produce whole body manifestations. While automobile trauma can cause a fractured femur, the entire animal is involved and the likelihood of shock is great. The brain or spinal cord may have contused within its bony case and become edematous. Fat embolization from the fracture site may occur and produce respiratory difficulty. Hemorrhage at the fracture site may be minimal, but a ruptured abdominal organ may result in blood loss sufficient to cause death.

In summary, when examining an animal with a fractured femur, it is important to remember that the entire animal may need treatment, as well as the fracture. Every fracture is part of a functioning animal, and although the fracture may be obvious it is only a small portion of the problems present because of the trauma sustained.

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REFERENCES

1. Brinker WO: Types of fractures and their repair. In Archibald J (ed): Canine Surgery, 2nd ed, pp 957- 960. Santa Barbara, American Veterinary Publications, 1974
2. Denny HR: A Guide to Canine Orthopaedic Surgery. Oxford, Blackwell Scientific Publications, 1980
3. DePalma AF: The Management of Fractures and Dislocations, vol 1 and 2. Philadelphia, WB Saunders, 1959
4. Gartland JJ: Fundamentals of Orthopaedics, Phila- delphia, WB Saunders, 1965
5. JennyJ: Orthopaedic Notes. Unpublished, University of Pennsylvania, 1970
6. Leonard EP: Orthopaedic Surgery of the Dog and Cat, 2nd ed, pp 90-94. Philadelphia, WB Saunders, 1971
7. Salter RB, Harris WR: Injuries involving the epiphy- seal plate. J Bone Joint Surg 45A:587, 1963
8. Whittick WG: Canine Orthopaedics, pp 127-130. Philadelphia, Lea & Febiger, 1974