Fractures of the Tibia and Fibula

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Anatomy

Incomplete Fractures

Complete Fractures of the Tibia

Fractures of the tibia are common in the dog and may occur at any level. Fibular fractures usually occur with tibial fractures but on occasion can occur by themselves. Young dogs, because of their open physes, are more likely to have physeal fractures. Following physeal closure most fractures are then associated with the diaphysis of the bone.

ANATOMY

BONY ANATOMY OF THE MATURE DOG AND CAT

The tibia is formed proximally by two flat condyles that make up the tibial plateau, which in turn articulates with the femoral condyles. The plateau is a triangular surface that is flat caudally and has a lateral edge and medial edge that converge cranially at the tibial tuberosity. Although the tibial plateau is quite broad, the actual articular surface is relegated to the posterior half of the proximal tibia. The cranial portion of the tibial plateau occupies the area associated with the fat pad. The tibial tuberosity, which serves as an insertion for the quadriceps muscle, is located just distally to the cranial border of the tibial plateau. The tuberosity continues distally as the tibial crest before tapering back to the diaphysis. The proximal tibial metaphysis is relatively flat medially but quite concave both caudally and laterally. All these surfaces blend into the distal tibial diaphysis, which is uniform in diameter but slightly S-shaped. It curves from medial to lateral in the proximal half and then back from lateral to medial in the distal half. When the diaphysis is viewed laterally an S-shape is also apparent, in which the concavity is proximal and caudal and the convexity is distal and caudal. The distal tibia is flared slightly and forms the distal articular surface. The distal epiphysis also forms the medial malleolus, which is the proximal attachment of the medial collateral ligament of the talocrural joint.

The fibula is a very thin bone. Its proximal end is enlarged to form the fibular head, which articulates with the lateral tibial condyle. It also serves as the distal attachment of the lateral collateral ligament of the stifle. The fibular diaphysis is very thin and possesses only a small medullary cavity, if any at all. Distally the diaphysis enlarges to the distal epiphysis, which forms the lateral malleolus, which articulates with the tibial tarsal bone. The malleolus also serves as the proximal attachment of the lateral collateral ligament of the hock(3) (Figs. 31-1 and 31-2). The normal bony anatomy of the tibia and fibula in the cat mimics that of the dog. The marrow cavity in the cat appears to be more uniform in diameter than it does in the dog, but no other important difference exists (Fig. 31-1C).

FIG. 31-1 Line drawings representing two views of a mature normal tibia and fibula in a German shepherd (A), a dachshund (B), and a domestic short-haired cat (C). Figures illustrate comparative anatomy and are not drawn to the same scale.
BONY ANATOMY OF THE IMMATURE DOG AND CAT

The tibia possesses three separate epiphyses of significance: the proximal epiphysis, the tibial tuberosity epiphysis, and the distal epiphysis. The proximal tibial epiphysis is relatively flat and forms the actual articular surface of the tibia. The epiphysis sits on the metaphysis, and the interface between the epiphysis and metaphysis contains two small concavities that help interdigitate the epiphysis to the metaphysis. The associated growth plate is responsible for approximately 40% of the length. Premature closure of the growth plate may result in tibial shortening or bowing if asymmetric closure occurs. At some point in development the proximal epiphysis is attached to the tibial tuberosity epiphysis. The tibial tuberosity epiphysis forms the prominence onto which the patellar ligament inserts. It has a flat interface with the metaphysis. Premature closure of the associated growth plate may cause extreme tibial deformity; that is, growing with a caudal convexity and cranial concavity. This growth plate normally closes relatively late in the development of the dog (Fig. 31-3). The distal tibial epiphysis interfaces the metaphysis via two triangular convexities on the metaphysis and corresponding concavities in the epiphysis. The growth plate is responsible for approximately 60% of the growth, and premature closure may cause tibial shortening. The fibula possesses an epiphysis both proximally and distally. Neither is of significance except for diaphyseal length.

FIG. 31-2 Cranial-caudal (A) and mediolateral (B) radiographic views of a normal tibia and fibula from a Great Dane.

BLOOD SUPPLY TO THE TIBIAL AND FIBULAR DIAPHYSIS

In the mature dog and cat the major diaphyseal artery enters the tibia through the nutrient foramen in the posterior lateral edge of the proximal one-third diaphysis. The nutrient artery is a branch of the caudal tibial artery. Similarly a branch of the caudal tibial artery enters the fibular diaphysis.

INCOMPLETE FRACTURES

Incomplete fractures of the metaphysis and diaphysis of the tibia are common in young growing dogs. Often the presenting signs include lameness although the animal is weight bearing. On physical examination the leg appears to be intact and there is no crepitus evident. There is, however, usually marked exquisite pain over the fracture site. Radiographs in two views will help confirm the diagnosis, and if deformity is not present external immobilization is the treatment of choice. This can easily be accomplished in a cranial half cast or other appropriate splint. If deformity is present, which is uncommon, it may be necessary to complete the fracture to allow adequate reduction of the axis of the tibia. Most deformities of the tibia are associated with valgus deformity of the hind leg, and all attempts at immobilization and treatment should be aimed at preventing valgus deformity.

FIG. 31-3 Lateral radiograph of the proximal tibia of an immature, 9-month-old German shepherd. Note the width of the growth plate distal to the tibial tuberosity. This area is slow to be mineralized and is often mistaken for fracture.

COMPLETE FRACTURES OF THE TIBIA

PHYSEAL FRACTURES

Fractures to the proximal and distal tibial growth plates occur in young dogs prior to the closure of these physes and are most commonly associated with Salter type I and type II fractures. Many of these fractures can be reduced in a closed manner, and, if stable, can be immobilized with external fixation. Sometimes minimal open reductions will be necessary to obtain perfect anatomical reduction with minimal traumatic manipulation. When this occurs, small Kirschner wires can also be used to stabilize the bony epiphysis in place over the metaphysis. Sometimes following open reduction internal fixation may not be necessary, and the resulting reduction is stable. In these cases external fixation can be applied with the use of casts or splints. Proximal tibial physeal fractures, once reduced, can be immobilized adequately in a Schroeder-Thomas splint or lateral
coaptation splint. Distal epiphyseal fractures, once reduced, can be easily maintained in reduction with a cranial half cast. The Salter type II fracture of the proximal tibia may be difficult to reduce and may remain unstable. A buttress plate or multiple pins will usually stabilize this fracture once reduced. Tibial crest avulsions occur commonly and must be treated with open reduction and internal fixation.\(^\text{(55)}\) The method of choice seems to be tension band wiring of the avulsed piece, but care must be taken not to close this physis in very young dogs or cats because of resulting deformity. If such a technique is used in the very young dog, it is necessary to remove the tension band wire within 4 weeks. Older animals may not need to have the devices removed at all. In the very young, simple small Kirschner wire fixation may be all that is necessary, thereby eliminating a second surgery for implant removal.

**DIAPHYSEAL FRACTURES**

Diaphyseal fractures of the tibia are commonly due to vehicular injury. Transverse, short oblique and spinal fractures as well as spiral fractures with butterfly fragments and comminuted fractures are common. Simple fractures, if easily reduced, can be adequately immobilized in a functional below-the-knee cast using the cranial half cast with the caudal element as described in Chapter 16. This cast is especially helpful in severely comminuted fractures in which internal fixation may have considerable shortcomings. In recent years the use of the cast brace system for tibial fractures had decreased our use of internal fixation for fractures of this bone. Many fractures, even in elderly dogs, can be treated adequately with this form of external fixation.

Most short oblique or transverse fractures of the tibia can be easily handled through intramedullary pinning\(^\text{(1,2,4)}\) (Fig. 31-4). Usually one pin is sufficient to stabilize these fractures. Since the medullary canal has an S-shape in two planes, the introduction of a straight pin through this shaft cavity will provide adequate stabilization. To insert a Steinmann pin in the tibia, the pin is placed through the proximal fragment entering just medial and caudal to the tibial tuberosity of the medial side of the patellar ligament. In this position the pin does not impinge upon the joint cavity, which can occur when inserting a pin retrograde into the proximal tibia from a middiaphyseal fracture. Following introduction of the pin in the proximal fragment, the fracture is reduced and the pin is seated normally. Since the tibia does not have very much muscle mass around its cranial and medial aspects, it is often possible to do closed intramedullary pinning. Great effort should not be expended in a closed reduction, however, since there is little added risk to opening the fracture to provide visualization for adequate reduction, provided aseptic technique is used. Following intramedullary pinning most of these fractures are inherently stable and need no external fixation. Sometimes cerclage or hemicerclage wires can be used to provide stability against rotation (Fig. 31-5). Comminuted fractures of the tibia can be handled with intramedullary pins and multiple cerclage wires or hemicerclage wires. When open reduction and internal fixation is undertaken for tibial shaft fractures, the use of bone grafting material should be considered to buttress any defect and provide vascularity to the area. Young animals must be watched closely for the timing of pin removal.

**FIG. 31-4** (A) A midshaft fracture of the tibia in an immature dog. (B,C) Open reduction and internal fixation was accomplished using a single Steinmann pin for fixation (D). The 10-week postoperative films show bone healing. The pin was removed at this time.

**FIG. 31-5** This long spiral fracture of the tibia (A) was fixed with an intramedullary pin and multiple cerclage wires (B). The 3-month follow-up film (C) shows stable internal fixation evidenced by the presence of very little periosteal callus. (Courtesy of T. Lenehan, University of Pennsylvania)

Plate and screw fixation is commonly used for tibial fractures. Plates are used to buttress comminuted fractures of the proximal tibial metaphysis (Fig. 31-6), or for any shape of diaphyseal fracture (Fig. 31-7). They are most amenable for use with comminuted fractures. Plates are placed on the cranial-medial surface of the tibia. Proper contouring to the S-shaped surface is necessary. It is important to make all skin incisions over the cranial or cranial-lateral surface of the crus so that they will not lie directly over the plate following fixation. Reconstruction of comminuted diaphyseal fractures must be near perfect on the lateral surface of the shaft, or metal fatigue and failure can easily occur (Fig. 31-8). This can be prevented best by perfect anatomical reconstruction, when possible, or by cancellous bone grafting.
Half-pin or full-pin external skeletal fixation is used for both open and closed fractures of the tibia. Frame configuration is dependent on the size of the animal and the type of fracture present. The device has been used in conjunction with intramedullary pins and interfragmentary screw fixation. The frame is easily used on the tibia because of the lack of large muscle masses over the point of entry of the pins. The half-pin device is usually placed with the connecting frame on the medial or anterior surface of the tibia, whereas the full frame is placed in a frontal plane.

FRACTURES OF THE MEDIAL OR LATERAL MALLEOLUS

Fractures of the medial or lateral malleolus result in instability of the hock joint. Good consistent end results can be achieved using open reduction and internal fixation for these injuries (Fig. 31-9). Tension band wiring of the medial malleolus fracture works well when two Kirschner wires are used, similar to other tension band wiring procedures. With lateral malleolar fractures (fractures of the distal fibula), it is sometimes necessary to attach the distal fragment to the distal tibia, creating a synostosis using small-Kirschner wires. Larger animals may have the fibular fragment reattached to the proximal fibular fragment by an intramedullary wire if a marrow cavity is present. Additional external fixation can be applied to

FIG. 31-6 This Borzoi hound fractured his leg while racing in the backyard with a littermate. His running into an immovable object created an open comminuted tibial fracture extending into the joint (A,B). Reduction and internal fixation was accomplished using a plate and screws (C,D). Interfragmentary screws as well as a small tension band wire were used to control the cranial fragments. Infection was part of the postoperative course of fracture healing, but films (E,F) document the consolidation of the fracture 3 months postoperatively.

FIG. 31-7 This long spiral fracture of the tibia (A) was treated using interfragmentary compression with screws and a plate (s). The internal fixation devices were removed following fracture healing (c) This type fracture could also be handled in the cast brace system described in the text. (See chapter 16.) (Courtesy of H. Millar, Deal, New Jersey)

FIG. 31-8 Cranial-caudal radiographs of a comminuted midshaft tibial fracture in a dog (A); treatment was with a plate (B). The bones were compressed; however, the lateral buttress was incomplete because a lateral chip had fallen out of the fixation. The plate failed 6 weeks postoperatively (C). A second plating and graft resulted in union.

FIG. 31-9 This bimalleolar fracture (A) was treated with tension band wires both medially and laterally (B).
protect the hock joint if necessary. Here a Robert Jones dressing may provide support while encouraging the increasing range of joint motion associated with wear and tear of the bandage.

**OPEN FRACTURES OF THE TIBIA**

The occurrence of open fractures of the tibia (described in Chapter 36) is quite high. These fractures are usually associated with vehicular trauma and may or may not include the avulsion and abrading fracture of the distal tibia associated with being dragged over asphalt paving. Most severe open fractures of the tibia are treated with local fixation using an external skeletal fixation device such as the Kirschner splint to provide stability. Severe avulsion injuries and abrading injuries associated with the loss of collateral ligaments of the distal tibia can be adequately handled with surgical debridement and external fixation. The closure of open wounds by granulation will result in stability along with some loss of motion of the talocrural joint if adequate external immobilization is used. Functional return of the limb can be expected with some loss of joint motion, a result that in most cases is completely satisfactory.

**REFERENCES**


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