Fractures and luxations of the tarsus are common injuries following automobile trauma. While trauma certainly is responsible for most of such injuries, systemic diseases such as rheumatoid arthritis and systemic lupus erythematosus often result in subluxation of the tarsus as well.

ANATOMY

The tarsus is formed by seven major bones (Figs. 32-1 through 32-3). The tibial tarsal bone possesses a trochlea and is the primary articulating surface of the tarsus. It articulates with the distal surface of the tibia. The companion bone, articulating with the tibial tarsal bone, is the fibular tarsal bone. This bone possesses a large prominence, the calcaneal tuber. The tibial tarsal bone is connected to the tibia by the medial (tibial) collateral ligament, while the fibular tarsal bone is attached to the fibular malleolus by the lateral (fibular) collateral ligament. The central tarsal bone is located distal to the tibial tarsal bone and articulates with tarsal bones II, III, and IV.

The remaining tarsal bones are numbered. Tarsal bone I is a small bone that articulates with the central tarsal bone, tarsal bone II, and metatarsal I. Tarsal bone II articulates with the central tarsal bone proximally, the third tarsal bone laterally, the first tarsal bone medially, and the second metatarsal distally. Tarsal bone III is larger than I or II and articulates proximally with the central tarsal bone, laterally with the fourth tarsal bone, medially with the second tarsal and metatarsal bones, and distally with metatarsal III. The fourth tarsal bone is the largest numbered tarsal bone. It articulates proximally with the
The tarsus has many ligaments that bridge from bone to bone to support the joint (Figs. 32-4 and 32-5). Many small, short ligaments run between bones within the joint, while portions of the medial and lateral collateral ligaments span the entire joint. Caudally, the collection of ligaments that support the joint is termed the plantar ligament.

The metatarsal bones are numbered I through V. Metatarsal I is inconsistently present, small, and with its associated digit, is commonly referred to as the "dew claw." The remaining metatarsals are similar in appearance to metacarpals II, III, IV, and V. Metatarsals II and V are nearly identical in shape and length, whereas metatarsals III and IV are similar in shape, but longer. The metatarsals collectively are shaped with a plantar concavity, as are the metacarpals.

The tarsal joints are composite articulations. The talocrural joint, or ankle joint, permits the greatest degree of movement. The trochlea of the talus, formed largely of two articular ridges, fits into reciprocal grooves which form the cochlea of the tibia. The grooves and ridges are not quite in sagittal planes; they deviate laterally about 25° so that the open angle faces dorsally. This allows the hind paws to be thrust past the forepaws on the outside when the dog gallops. Because of the presence of the central tarsal bone in the medial half of the tarsus, the intertarsal joint is divided into the proximal intertarsal joint and the distal intertarsal joint. The middle tarsal joint of the lateral side and the proximal middle tarsal joint of the medial side are coextensive; they are formed between the talus and the calcaneus proximally, and between the central and the fourth tarsal bones distally. Some side movement as well as flexion and extension are possible here as the slightly convex distal ends of the talus and calcaneus fit into glenoid cavities of the central and fourth tarsal bones. The four distal tarsal bones (the first to fourth) articulate with metatarsals I to V, forming the tarsometatarsal joints. The vertical joints between the individual bones of the tarsus are the intratarsal joints, all of which are exceedingly rigid.(10) Distal to the tibia, the term dorsal replaces cranial and plantar, replaces caudal.

SURGICAL APPROACHES
Many approaches are needed to adequately visualize the tarsus and metatarsus.

A lateral or medial approach to the joint, with the collateral ligaments intact, can prove frustrating. While some visualization is acquired, most surgery is performed through a small window. Osteotomy of either the lateral or medial malleolus will facilitate exposure and fracture reduction when dealing with the distal tibia, the fibular tarsal bone, or the tibial tarsal bone. Simple tension band wiring of the malleolus at the end of surgery will reconstruct the collateral ligament.(12,13)
The fibular tarsal bone is approached by either a medial or lateral incision directly over the bone. The tendon of the superficial digital flexor muscle should be identified and retracted prior to deep dissection.(12)

The central tarsal bone may be exposed by a dorsomedial skin incision directly over the bone. An incision between the tendon of the tibialis cranialis muscle and the dorsal branch of the lateral saphenous vein will expose both the central tarsal bone and tarsal bone II (12)

The metatarsals are approached by an incision directly over the bone. The extensor tendons and associated arteries and veins must be identified and retracted for best visualization of the metatarsal

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FRACTURES OF THE TARSUS
TIBIAL TARSAL FRACTURES
Fracture of the tibial tarsal bone is uncommon. Fractures may split the trochlea or may occur through the neck of the bone. Occasionally small chip fractures of the trochlea or lateral process are seen.

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CLINICAL PRESENTATION
Animals present with a non-weight-bearing limb. Palpation usually demonstrates a swollen, painful, crepitant joint. Partial subluxation may occur if the attachment of the medial collateral ligament is involved.

Radiography is helpful in determining the extent of the fracture. Often multiple views and oblique radiographs are necessary to demonstrate the nature of the fracture.

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CLOSED REDUCTION AND FIXATION
In some instances closed reduction is considered adequate. Minor chip fractures that are away from the articular surface do well if placed in splints. Nonarticular but well-aligned fractures of the neck of the tibial tarsal bone also do well if splinted. Massively comminuted fractures are often impossible to fix internally and are treated best in rigid external fixation. In all instances the talocrural joint should be placed in a normal standing angle.

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OPEN REDUCTION AND FIXATION
Open reduction is difficult at best owing to the anatomical constraints that prevent full visualization of the tibial tarsal bone. Simple two-part fractures are fixed best using multiple Kirschner wires or cortical interfragmentary lag screws.(11) Because of comminution it is often necessary to maintain distraction of fracture fragments with a device and to pack the defect with a cancellous graft. Severely comminuted fractures that cannot be repaired require talocrural arthrodesis.(24)

Chip fractures of the trochlear lips may be removed or, preferably, replaced using small Kirschner wires, which are countersunk below the articular surface.

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COMPLICATIONS
Since most tibial tarsal fractures are intra-articular, the most common complication is secondary degenerative joint disease accompanied by loss of range of motion, pain, and discomfort. Occasionally an entire repair will collapse, necessitating reoperation; however, nonunion is uncommon owing to the cancellous nature of the fracture fragments.

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PROGNOSIS
The prognosis is guarded at best. Most fractures of the tibial tarsal bone result in some secondary arthritis and limited range of motion. Pet animals function with occasional lameness; working animals must be retired.

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FIBULAR TARSAL FRACTURES
Most fractures of the fibular tarsal bone affect the tuber calcaneus; however, occasionally these fractures comminute and affect the entire bone. Very rarely the medial prominence, the sustentaculum tali will be fractured.
CLINICAL PRESENTATION
Most animals with fibular tarsal fractures present carrying the affected limb. Inspection of the tarsus demonstrates that the normal prominence of the tuber calcaneus is not present. Routinely there is laxity in the tendons of the gastrocnemius muscle.

Palpation demonstrates crepitus and a freely movable tuber calcaneus. Radiography is necessary to demonstrate the extent of the fracture and to determine if concomitant subluxation of the intertarsal joint is present. It is not uncommon for other fractures or luxations of the tarsus to occur when the fibular tarsal bone is fractured. (See Fig. 35-15.)

CLOSED REDUCTION AND FIXATION
Closed reduction or fixation of any fracture of the fibular tarsal bone is not possible. Because of the constant distraction caused by the gastrocnemius muscles, reduction cannot be maintained. Nonunion is the predictable result.

OPEN REDUCTION AND FIXATION
Reduction following surgical exposure requires extension of the talocrural joint to accomplish fragment alignment. Depending on the type of fracture present, many forms of fixation are applicable. All forms of fixation must take into consideration that traction from the gastrocnemius muscle must be neutralized; therefore fixation must be placed on the tension band side of the fibular tarsal bone, namely, the caudal surface.

The standard form of fixation is a classic tension band wire, that is, two parallel Kirschner wires in the medullary cavity and a tension wire over the plantar surface of the tuber calcaneus. (3) (See Fig. 35-12). Pins used without the tension band wire are likely to bend, break, or migrate. A single cortical or cancellous screw is just as likely to bend or break.

In instances of comminuted fractures, combinations of pins, wires, screws, or plates can be used to accomplish fragment alignment. In every instance, however, a tension band should be placed. It must be either wire or a plate placed over the plantar surface of the tuber calcaneus. No special aftercare is necessary; however, leash walking for 2 to 4 weeks is required. No splints are necessary.

COMPLICATIONS
Complications are rare if a tension band wire is used. If other forms of fixation (i.e., not using a tension band wire) are used, a high rate of failure may be expected. Failure is due to delayed union, nonunion, or total fixation failure.

PROGNOSIS
The prognosis for full return to function is excellent if the animal has been treated with the proper form of internal fixation.

FRACTURES OF THE CENTRAL TARSAL BONE
Fractures of the central tarsal bone are very rare in pet animals but are common in working animals. For a complete discussion of the topic, see the section Central Tarsal Fractures in Chapter 35.

FRACTURES OF THE TARSAL BONES II, III, and IV
Fractures of tarsal bones II, III, and IV are rare in pet animals. For a complete discussion of the topic, see the section Central Tarsal Fractures in Chapter 35.

LUXATIONS AND SUBLUXATIONS OF THE TARSUS
TALOCRURAL LUXATION OR SUBLUXATION
Total or incomplete luxation of the talocrural joint is common in pet animals. This injury is the result of severe twisting injuries of the tarsus, severe scrape injuries, or hyperextension of the talocrural joint. The injury may involve the tearing of one or both of the collateral ligaments, fracture of one or both of the malleoli, or fracture of the tibial tarsal bone. Any
combination of the above is possible (Fig. 32-6).

![Fig. 32-6 Dorsoplantar (A) and medial-lateral (B) radiographs demonstrate talocrural luxation in a dog. Note the shearing away of the lateral malleolus, intertarsal subluxation, and road debris in the subcutaneous tissues. Dorsoplantar (C) and medial-lateral (D) radiographs demonstrate repair of the lateral collateral ligament using two screws and a figure-of-eight wire and an intertarsal Steinmann pin.]

CLINICAL PRESENTATION
Animals with subluxation or luxation of the talocrural joint usually carry the affected limb. The lower part of the limb seems to "dangle" or swing because of its incomplete attachment of the remainder of the limb.

Palpation will demonstrate complete or partial instability. Careful palpation for collateral ligaments will allow for diagnosis of torn or stretched ligaments; if bony crepitus is evident, one or more malleoli are probably fractured. The tarsus is usually moderately swollen, grossly unstable, and not painful. Radiography will confirm the presence or absence of fractures.

CLOSED REDUCTION AND FIXATION
Closed reduction may be accomplished easily in many instances. Unfortunately, maintaining the reduction is much more difficult. If fractures are present, open reduction is indicated.

Closed fixation following reduction should be in a long-leg cast or a cranial half cast. The talocrural joint must be immobilized completely. If held rigidly for 6 to 8 weeks some luxations or subluxations will restabilize. The majority will not restabilize, however, and will require internal fixation.

OPEN REDUCTION AND FIXATION
Reduction of talocrural luxation or subluxation is relatively easy, but fixation of the fracture may be a problem. In instances of malleolar fracture, the malleolus must be reduced and rigidly fixed.(15) Tension band wires are a very stable form of fixation for this luxation. With collateral ligament tears, the ligament must be repaired as competently as possible. This requires placing a screw, pin, or staple into the proximal and distal attachments of the torn ligament and tightening a wire or nylon suture between them (see Chapter 69 for technique). This will temporarily reconstruct the anatomy, take the ligament out of tension, and allow fibrosis. After a ligament reconstruction, 4 to 6 weeks of splinting is necessary(56) (Fig. 32-7).

![Fig. 32-7 Dorsoplantar (A) radiograph demonstrates fracture of both lateral and medial malleoli. Talocrural luxation was present but was reduced in this view. Dorsoplantar (B) and mediolateral (C) radiographs demonstrate internal fixation using a tension band wire for the lateral malleolus fracture and medial collateral ligament reconstruction using two screws and a figure-of-eight wire after resection of the small malleolar fragment.]

In instances of severe fracture luxation, arthrodesis of the talocrural joint may be necessary. For a discussion of this surgery, see Chapter 55.

COMPLICATIONS
If the fracture or ligament can be repaired, complications are uncommon. Early failure of a wire or fracture fixation may occur but this is also uncommon.
PROGNOSIS
Most animals do well if an anatomical repair is possible. Dogs or cats requiring arthrodesis have obvious gait abnormalities and have a poorer prognosis for return to function.

INTERTARSAL AND TARSOMETATARSAL LUXATION OR SUBLUXATION
While intertarsal or tarsometatarsal luxation or subluxation is seen routinely following trauma, it is also commonly seen in dogs with rheumatoid arthritis or systemic lupus erythematosus.

CLINICAL PRESENTATION
Most animals presenting acutely carry the limb or bear only minimal weight. Chronic luxation or subluxation may be seen in animals with full weight bearing.

This injury is the result of tearing many intertarsal ligaments and most of the plantar ligaments of the tarsus.

Most animals demonstrate two prominences on the plantar surface of the tarsus; one is the tuber calcaneus and the other is the prominence over the subluxation or luxation. Manipulation of the site will demonstrate instability present predominantly in a dorsalplantar direction. Manipulation of the site rarely causes discomfort.

Radiography is used to demonstrate the extent of the injury and to determine if any fractures complicate the problem.

CLOSED REDUCTION AND FIXATION
Closed reduction is simple and can usually be accomplished without anesthesia. Fixation is impossible. External forms of fixation are not sufficiently rigid to allow for ligamentous healing. It is doubtful if ligamentous healing ever takes place in these animals.

The use of closed transfraction pins is not advised. Only complete arthrodesis of the joint will be successful. Placing metal across the luxation site without removing articular cartilage or the use of cancellous bone will not result in permanent fixation.

OPEN REDUCTION AND FIXATION
Exposure of the luxation or subluxation site is accomplished by a lateral incision directly over the tarsus. Careful dissection of underlying tissues allows the surgeon to visualize either the intertarsal site or the tarsometatarsal site of luxation.

No method of fixation other than arthrodesis has proven effective in intertarsal luxation. All forms of ligamentous repair of collateral ligaments, intertarsal ligaments, or the plantar ligaments fail. Arthrodesis is usually accomplished through the site of reduction. All articular cartilage is removed, and autogenous cancellous bone is added to the site. Fixation is accomplished using a bone plate either laterally or on the plantar surface across the luxation site.(1) Other successful methods of fixation include a large tension band wire or multiple pin fixation(8) (Fig. 32-8 and Fig. 35-16). The use of a single screw has been reported; however, this fixation is likely to fail without the addition of a tension band wire. A complete discussion of intertarsal and tarsometatarsal arthrodesis is found in Chapter 47.

COMPLICATIONS
Failure to adequately debride articular cartilage or to provide adequate bone graft may result in arthrodesis failure. This can
be avoided by careful surgery. Use of devices of inadequate size can also result in failure.

PROGNOSIS
Most animals have an excellent prognosis and return to normal function. Since this procedure does not alter the talocrural joint, a normal tarsal range of motion should remain.

METATARSAL FRACTURES
Metatarsal bone fractures are seen most commonly in young puppies or kittens that have been dropped from a height or stepped upon. The fracture or fractures can be incomplete, complete, two-part fractures, or comminuted fractures and may involve one or more bones. (4)

CLINICAL PRESENTATION
Animals present carrying the affected limb. On palpation there is soft tissue swelling and pain over the fracture or fractures, as well as crepitus if more than one bone is involved. Gross deformity of the paw will be evident if bones II through V are fractured.

Radiography will confirm the number and kinds of fractures present and the degree of the deformity.

ASSOCIATED SOFT TISSUE INJURIES
Very few complications occur when metatarsal bones fracture. Although the sharp ends of bone in a mature animal may lacerate tendons or vessels, this occurs only rarely.

EXTERNAL FIXATION
Incomplete fractures of one or more metatarsals are treated in external fixation. The splint or cast should immobilize the carpus completely to be effective.

Complete fracture of one or two bones can be properly treated in external fixation. If three or four metatarsals are fractured and displacement is present, external fixation is a poor choice. When multiple bones are fractured splint or cast cannot maintain reduction properly, and while union will probably occur, the time will be prolonged and deformity likely. Nonunion of metatarsal bones can occur when splints are used for three or four fractured bones.

INTERNAL FIXATION
Internal fixation is used for comminuted single metatarsal fractures or in animals in whom three or four bones are fractured. In multiple bone fractures the fixation can be used for all fractured bones for metatarsals II and V only. In the latter case it is assumed that by rigidly fixing bones II and V, bones III and IV will be aligned and will be stable enough to unite.

Internal fixation may be accomplished using small plates (see Fig. 35-6), intramedullary pins or wires (Fig. 32-9), or orthopaedic wire used with intramedullary fixation. Intramedullary pins are introduced dorsal to the metacarpophalangeal joint and driven proximally. The exposed pin must be carefully bent so that it does not interfere with joint function. Coaptation is often necessary following surgery, since the diameter of the pins used for fixation are small, implant bending may occur during weight bearing. Coaptation should be used until radiographic evidence of bony union is demonstrated.

FIG. 32-9 Dorsoplantar (A) and medial-lateral (B) radiographs demonstrate fractures of metatarsal bones 11 and 111. Dorsoplantar (C) and medial-lateral (D) radiographs demonstrate intramedullary fixation of metatarsal bone II. Note that the pin is bent dorsally to avoid the proximal interphalangeal joint.
COMPLICATIONS
Any method of fixation, open or closed, may fail and result in nonunion. Most metatarsal nonunions are painful and require subsequent surgery.

Proliferative callus associated with union or nonunion may incorporate flexor or extensor tendons and result in digital malfunction and pain.

PROGNOSIS
Overall, metatarsal fractures are treated successfully and uneventfully. Most animals have excellent results and return to normal function.

REFERENCES

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