The carpus is designed to absorb and dissipate force over a multitude of small bones, ligaments, and tendons. The dog’s “four finger drive” allows for remarkable movement and motion. This becomes especially clear when you consider that 60% of the dog’s weight is carried through the forelimbs. The forelimb is complex, with sophisticated engineering, and injuries are often of equal complexity. The carpus has greater motion than any other joint in the dog—10° hyperextension, 100° flexion, 20° mediolateral angulation—and 90% of the motion is at the radiocarpal joint.

An Engineering Marvel
With more “moving” parts than the average Volkswagen beetle, the carpus readily collapses at multiple levels during non-weight-bearing (flexion). It is composed of multiple small bones (7 in the carpus, 14 including adjacent bones, or approximately 30 in the distal limb), and its stability is highly dependent on surrounding soft tissues for support. However, no ligament spans the whole joint! Therefore, this assortment of oddly shaped bones is supported by multiple individual short ligaments that are like the links of a chain. Each of these individual ligaments is loaded under weight-bearing, producing the spring in the dog’s step.

Unfortunately, the strength of the chain is defined by its weakest link. Biomechanically, the dorsal surface is subjected to compression and the palmar surface undergoes traction. The accessory carpal bone works as a hinged lever. The carpus is supported in a similar fashion to an inverted suspension bridge.

Like the carpus, the tarsus absorbs weight-bearing forces through its own four-toe drive, which act as independent struts to concentrate force through a single articulation (talocrural joint). The tarsus propels itself with a large lever, the calcaneus, which acts like an oar in water to thrust forward. Different from the carpus, the lever arm of the tarsus is unhinged, providing sturdy support, but compromising its range of motion (110°). The standing angle of the tarsus is quite different from the carpus (approximately designed more for forward thrust than support). The thrust is also transferred to the stifle, generating cranial thrust that is counteracted by the cranial cruciate ligament. Note that your own tuber calcaneus rests on the ground as you stand opposed to your dog. Like the carpus, the tarsus is composed of a multitude of small, interdependent bones attached by ligaments and tendons, thus another potential house of cards. Fortunately, the tarsus function and architecture is much simpler, working essentially as a hinge joint with a large lever arm. It has three very large plantar ligaments that span multiple articulations. Its most proximal joint, the tarsocrural joint, provides the majority of the tarsus movement. The multiple lower intertarsal joints provide a dampening or shock-absorption function.

Specific and meticulous palpation with assessment of laxity, pain, and swelling is key in this region. Evaluate symmetry between bony prominences, periarticular fibrosis, or joint effusion, if present. Firm, generalized swelling often indicates degenerative joint disease. The area to be palpated to determine the presence of joint effusion in the carpus is the space located cranially overlying the radiocarpal articulation. Observe the standing angle of the carpus and tarsus during weight-bearing. Raise each foot in succession to maximize weight-bearing on each forelimb, and observe the standing angle of the carpus.

Carpal Hyperextension Injuries. Palmigrade stance. Often recognizable fractures are not present, so stressed view radiographs are essential to confirm diagnosis. These injuries can occur at three levels: antebrachiocarpal joint, middle carpal joint, and carpometacarpal joint. Carpal instability injuries do not respond well to conservative treatment (rest, casting, or splinting) and require surgical treatment. Unfortunately, primary fixation is not consistently successfully at this time. Pancarpal arthrodesis is the most dependable treatment, but partial carpal arthrodesis will preserve partial carpal motion. Carpal arthrodesis can only be performed when the antebrachiocarpal joint is not involved.

Tarsal Luxations. As with the carpus, when one fracture occurs, look out for others! Specific luxation is important and impacts the method of repair. Luxations include talocrural, talocalcaneal, proximal intertarsal, and distal intertarsal joints. Intertarsal arthrodesis preserves the function of the talocrural joint and has very good function for injuries of the middle and distal intertarsal joints. If the plantar component is unstable, an intertarsal arthrodesis needs to be performed. These repairs typically have consistently good outcomes.
Involvement of the talus necessitates pantarsal arthrodesis. Function following is surgery is pretty good, but variable.

**Carpal and Tarsal Fractures**

**Accessory Carpal Bone Fractures (hinged lever).** This is an injury that mostly occurs in racing greyhounds, whippets, and similar dogs. Five types of accessory carpal bone injuries have been described, as well as subluxations. In all but the worst of these injuries, primary surgical fixation is possible with an approximately 50% chance of return to successful racing with screw fixation or fragment removal.

**Calcaneus Fractures.** The calcaneus is the large lever arm of the tarsus. These large lever forces can produce avulsion of the common calcanean tendon or fracture/luxation of the calcaneus. Calcaneoquartal luxation can be treated with calcaneoquartal arthrodesis.

**Radial Carpal Bone Fractures.** This is the compression side of the carpus, so forces are going to produce sagittal and dorsal slab fractures. These are articular fractures; therefore, they must be treated with perfect surgical reduction and rigid stabilization (lag screw fixation) or fragment removal.

**Central Tarsal Bone.** Like the radial carpal bone, this is the bone under compression, and therefore it is susceptible to slab fractures. These have been classified into five types treated by lag screw fixation. Be aware of associated breakdown fractures. Common triad examples include the central tarsal bone, fourth tarsal bone, fifth metatarsal, and calcaneus.

**Distal Radius/Ulna Fractures.** These fractures are especially prone to instability and failure due to their proximity to the carpus and are often confused with carpal injuries.

**Distal Tibia Fractures.** Most commonly this is a physeal fracture in immature dogs. Outwardly, on physical examination, these dogs look like a talocrural luxation, but the immature dog will usually fracture its physis (the physis is weaker than the ligaments). Cross pin fixation is the treatment of choice, and due to its close proximity to the joint, accurate reduction and pin placement is essential.

**Metacarpal/Metatarsal Fractures.** Most metacarpal fractures are more forgiving due to the presence of multiple parallel bones (team effort). The remaining intact metacarpal bones act as an internal splint. Unfortunately, this advantage disappears when they are all broken. When they are all broken, internal reduction and fixation of a few of the metacarpals will facilitate the alignment, comfort, and recovery of these patients. Beware of multiple very proximal metacarpal/metatarsal fractures, which may not act as a metacarpal fracture, but as a distal hyperextension injury, therefore changing the ideal treatment options.

**Collateral Ligament Injuries.** The most common carpal collateral ligament injury is the radial collateral ligament rupture resulting in medial instability at the antebrachiocarpal joint. Primary repair is possible supported with a large figure-of-eight suture prosthesis placed through bony tunnels or bone anchors. In the tarsus, two functional bands exist that provide stability through a range of motion. The two functional bands include a short collateral ligament and a long collateral ligament. The talocrural joint must be evaluated for instability in flexion (short band) and extension (long band). Disruptions in either will result in functional instability and lameness. Complete stability and normal talocrural motion require restoration of both. Primary fixation of ligaments typically has very poor strength; thus, reliable fixation requires bone attachment. This is performed with large, permanent sutures placed through bone tunnels, suture anchors or around screws. Bone tunnels and suture anchors provide easier placement with better stability and a lower profile implant (the screw head can interfere with joint motion, especially at the insertion of the short collateral).

**Shearing Injuries.** These injuries usually result from road traffic accidents in which the animal’s leg is used to extend the car tire’s braking surface (completely eroding off the contact surface against the road, including skin, muscle, tendons, joint capsule, and bone). An open wound is produced, and in the more severe injuries, primary reconstruction is not possible (since primary tissue does not exist). If nervous structures, tendons, muscle, and articular cartilage are intact enough to allow return of joint function, mechanically the joint can be stabilized by sutures and screws (bone tunnels or bone anchors) and allowed to heal by second intention. Amazing results do occur! However, severe damage will result in an arthrodesis of the joint in a functional position. In worst-case scenarios or in financially challenged cases, amputations are performed.
In shearing injuries of the carpus, external fixation is most commonly applied to support the leg (in arthrodesis or reconstruction) and allows access to the open wound.

**Tarsal Collateral Ligaments.** Thankfully, the tarsal collateral ligaments have a great deal of symmetry and are easier to understand than the carpus. The medial and lateral collateral ligaments of the tibiotalar joint consist of two functional bands. This is essential to understand, since one or both may be injured and require functional repair. Similarly, large plantar ligaments are present that are essential to the stability of the intertarsal joints. Many tendons and muscles cross this joint, and nearly every one of them has a described injury. The common calcaneal tendon (Achilles' tendon mechanism) has a very essential role in support and movement in the tarsus.

**Malleolar Trauma.** Malleolar fractures are articular with an avulsion fracture of the origin of the lateral or medial collateral ligaments. Repair will be challenged by a substantial tractional force; therefore, sturdy fixation is essential to counteract this force. When a large fracture fragment is present, tension band fixation of the fragment is performed (pins and “figure 8” wire, or lag screw fixation). When the fragments are too small for reliable fixation, then the primary fixation should be supported by suture prosthesis. Shear injuries in which a shear force removes supportive anatomy leave little original structures for repair (usually the result of being dragged against abrasive pavement). The medial aspect of the tarsus is the most prevalent location. Due to the protruding regional anatomy, the collateral ligaments are at particular risk and are commonly injured. Most of these injuries need to be managed as open wounds for several weeks (average healing time is 4 to 10 weeks). Prosthetic ligament repair is most commonly performed 3 to 6 days following presentation, with initial management consisting of staged debridement and lavage, but pantarsal arthrodesis is another alternative.

**Common Calcaneal Tendon Injuries (laceration, avulsion, or rupture)**
The common calcaneal tendon consists of three parts: gastrocnemius, superficial digital flexor, and the common tendon of the gracilis, semitendinosus, and biceps femoris muscles.

Any or all of these components can be damaged and should be repaired independently. These dogs most commonly present in a plantigrade stance (standing on their heels) and a laceration or palpable deficit is present. If the digits are flexed, the superficial digital flexor tendon is intact (if lax, then it is ruptured). Ultrasonic evaluation can provide additional information in regard to degree of injury, length of injury, and whether contralateral pathology is present. Functional length needs to be restored, which can be simple in laceration or more challenging when a long zone of injury is present.

**Trochlear ridge fractures** include medial and lateral lesions. Osteochondrosis most commonly affects the plantar aspect of the medial trochlear ridge of the talus, but can occur anywhere on the trochlear ridges. Rottweilers and Labrador retrievers make up 70% of the cases, with bull terriers and bull mastiffs also being overrepresented. Forty percent are bilateral lesions. Onset is 5 to 7 months of age, but over one-third of dogs are adults before they are diagnosed (a little embarrassing!). Dogs present with a hyperextended tarsus and synovial thickening (effusion and fibrosis). My trick to diagnosing these cases is flexing the tarsus and placing direct digital pressure over the lesion that elicits pain and exacerbates the lameness. A full five set radiographic series is required to fully visualize both trochlea, but diagnosis is commonly made by a standard extended dorsoplantar view, which provides visibility of the plantar aspect of the medial trochlear ridge.