Fractures of the third carpal bone (C-3) include small osteochondral fragments (chip fractures), frontal slab fractures of the radial (most common) or intermediate fossae, or both, sagittal slab fractures, most commonly occurring in the radial fossa, and table surface collapse resulting in subchondral lucency of C-3. Small osteochondral fragments are the most common fracture type, and involve only the proximal articular surface. Slab fractures involve both the proximal and distal articular surfaces. It is important to differentiate true slab fractures from chip fractures, since surgical management and prognosis differ. In Thoroughbred (TB) racehorses right C-3 fractures are more common, whereas in Standardbreds (STB) the distribution is nearly equal. Number of fragments, degree of displacement, presence of comminution of C-3 or other associated carpal bone fractures, and amount of cartilage damage all affect surgical decision making and prognosis. Breed, sex, and value of affected horses affect often determine owner acceptance of surgical alternatives as well.

Fractures of C-3 like those of the distal aspect of the third metacarpal/metatarsal bone, are now known to not be single-event catastrophic failure, but rather occur as the result of abnormal bony remodeling in response to race training. Sclerosis of the dorsal aspect of C-3 from impact loading is a normal adaptive response to training and results in thickened trabeculae in subchondral bone which in some horses can span the distance between the proximal and distal subchondral plates. Varying degrees of increased radiopacity (sclerosis) can be seen in the tangential (skyline) radiographic image of C-3. Sclerotic subchondral bone may induce abnormal shear forces in overlying cartilage and may be prone to ischemia or injury. Areas of resorption and necrotic subchondral bone may form when the remodeling process of resorption outpaces bone deposition, resulting in areas of bone loss, which appear radiolucent in radiographic images. These biomechanically inferior regions are thought to predispose C-3, and specifically the radial fossa to chip or slab fracture. This abnormal remodeling process is important to keep in mind, since even after surgery and rest, the process may recur when the horse returns to training, especially if conformational or other factors are constant. Bone scintigraphy is useful in identifying horses with areas of abnormal bony remodeling and early detection of subchondral injury, before overlying articular cartilage becomes damaged and more signs such as effusion and positive response to flexion occur.

Diagnosis of C-3 fractures requires well-positioned and well exposed radiographic images. Importantly, the skyline radiographic image must be positioned to see the entire radial fossa without overlap from the radial carpal bone. Accurate determination of the distal extent of large C-3 chip fractures, best judged on the lateral or dorsolateral-palmaromedial oblique image is required to differentiate these from true slab fractures, since on the skyline radiographic image, this determination can be difficult. Medial C-3 corner chip fractures, subchondral lucency, and incomplete C-3 chip fractures need to be differentiated from sagittal slab fractures, since these conditions are best handled by arthroscopic evaluation without internal fixation. True sagittal slab fractures can be seen on the dorsomedial-palmarolateral (MLO) oblique radiographic image, but numerous images may be necessary to demonstrate the fracture line. Unusual L-shaped fractures of the radial fossa and the palmar aspect of C-3 can involve both sagittal and dorsal (frontal)-plane. In many horses with displaced C-3 dorsal-plane slab fractures, a separate wedge-shaped osteochondral
fragment exists between the large fragment and parent bone. Large wedge-shaped fragments that can be seen radiologically before surgery are generally associated with substantial cartilage damage. In severely lame TB racehorses with numerous C-3 chip fractures or displaced slab fractures, care must be taken to evaluate radiographs for hidden comminution or slab fractures of the overlying radial carpal bone or other carpal bones. Chip fractures of other bones within the same middle carpal joint are common and may worsen the prognosis. Radiographic images of the opposite carpus are mandatory since contralateral chip fractures, and less commonly, slab fractures occur.

Chip fractures are best handled by arthroscopic removal and curettage of surrounding cartilage and subchondral bone damage. Associated intercarpal ligament injury or occult fragmentation should be assessed.

Management of dorsal-plane slab fractures will depend on fracture size, the degree of lameness, presence of displacement, and degree of cartilage damage seen at the time of surgery. Preservation of articular surface by use of internal fixation is important but horses can race after removal of even large fragments. The most likely way of achieving quality healing of articular surface is to repair slab fractures with screws placed in lag fashion, even in horses with non-displaced, incomplete fractures. However, prognosis is good with rest alone in horses with incomplete fractures, particularly in those without associated chip fractures of other carpal bones. In horses with complete or displaced fractures, arthroscopic evaluation is useful in formulating a management plan. Thin fragments, particularly those with substantial cartilage damage on the fragment, or those with large wedge-shaped fragments, are best removed. Rather large fragments can be removed using arthroscopic techniques, but the dorsal capsular attachment should be completely severed, and large rongeurs are necessary. The piece can be broken with an osteotome and removed. Larger fragments with intact articular cartilage should be repaired using 3.5 or 4.5 mm screws. In many horses a single 3.5 mm screw is sufficient, since capsular attachments and fracture incongruity help maintain rotational stability, but numerous screws are preferred in larger fragments. Debridement of loose cartilage and subchondral bone fragments is necessary. If a large defect exists between the fragment and parent bone allowing the screw threads to be seen, consideration should be given to removal of the fragment or a combination of removal of the proximal articular surface of the fragment and preservation of the distal aspect of the fragment with a more distally located screw. Arthroscopic procedures are usually used for management of all C-3 fractures, but frankly, it is often easier, less time consuming and less expensive for the surgeon (often you break instruments trying to remove large fracture fragments using arthroscopic techniques) to use conventional arthrotomy. The decision to perform arthrotomy rather than arthroscopy may require repositioning the patient, unless dorsal recumbency is used.

*Repair of a Frontal Slab Fracture of C-3 using an arthroscopic technique*

Little has changed from the original description for repair using an arthroscopic technique. I prefer to position the horse in lateral recumbency with the affected limb uppermost. Others prefer to perform most arthroscopic procedures with the horse in dorsal recumbency, a more versatile position if the surgeon decides to abandon arthroscopic techniques and perform arthrotomy. A standard dorsolateral arthroscopic portal is used to examine the affected middle carpal joint and to make a surgical plan. If possible I try to repair the fracture first before debridement to limit periarticular fluid extravasation; in some horses with large wedge-shaped fragments interposed between the fracture fragment and parent C-3 it is necessary to debride first. Needles (22 g) are placed at the medial and lateral limits of the fracture and in the carpometacarpal joint (CMCJ). In horses with small frontal slab fractures of only the radial fossa, a single cortex bone screw will suffice; I usually
use a 3.5 mm screw. An 18 g. spinal needle (3.5 in.) is then placed in the center of the fracture (it is important to use the actual center as judge by the position of the needles outside the joint, not by how it looks inside the joint the arthroscope magnifies things close to it), skimming the table surface of C-3, and buried in the palmar intercarpal ligaments, parallel to the C-2/C-3 junction. An incision is made midway between the table surface of C-3 and the CMCJ and centered between the medial and lateral needles and directly distal to the spinal needle. The limb is flexed to align the fracture fragment with parent C-3 (this maneuver is important). Additional elevation may be necessary in horses with large, displaced fractures requiring the use of a standard instrument portal, dorsomedially. Standard technique is then used to drill, measure, tap and insert a 3.5 mm screw in lag fashion. No countersinking is necessary with 3.5 mm screws. In what direction do you drill? The spinal needle will give you the proper direction relative to the C-2/C-3 junction (medial/lateral direction) and obviously the proper position relative to the center of the fragment. The spinal needle will give you a general direction in the proximal/distal direction but must be positioned directly along the table surface of C-3. Additional guidance is gained by aligning the drill perpendicular to the third metacarpal bone (McIII) and then elevating the drill to aim slightly (10-15°) distopalmarly in order to direct the screw away from the middle carpal joint. I usually drill completely through C-3 to avoid the potential to “bottom out” in an incomplete drill hole with either the tap or a screw (using 3.5 mm screws there is little room for error if you inadvertently tighten a long screw in a short hole). Usually, a 28-36 mm screw will be used (fragments are usually 10-12 mm in width, so using a screw that is 2.5-3X as long as the fracture is wide is suitable). In horses with large fragments involving the entire radial fossa, 2, 3.5 mm screws are placed (rather than placing a screw half way between the medial/lateral needles, 2 screws are placed at 1/3 and 2/3, respectively). In horses with fractures involving both the radial and intermediate fossae, I have used 3, 3.5 mm screws but 4.5 mm screws may be best, particularly in horses in which perfect anatomical alignment of the fracture cannot be achieved. Once the screw (s) is placed, the fracture line and other fragments can be debrided using a standard instrument portal. Prognosis is affected by size of fragment, degree of comminution, presence of a large trough between the fragment and parent bone, cartilage damage on C-3 or other carpal bones, presence of additional small osteochondral fragments, and other factors such as stage of race training/racing and race class.

**Sagittal slab fractures of C-3**

Sagittal plane C-3 injury must be carefully evaluated and it is imperative the fracture be seen on both the tangential and DMPLO radiographic images. I feel surgical is superior to conservative management in racehorses with authentic sagittal fracture and fractures can be debrided or repaired. Eight of 9 horses that had arthroscopic debridement and all 7 horses in which fractures were repaired raced, compared to 7 of 16 horses that raced after non-surgical management. Authentic sagittal slab fractures can and should be repaired using a single 3.5 mm screw, but because the screw is positioned close to C-2, I prefer arthrotomy rather than arthroscopic techniques. In either case the horse is positioned with the affected limb lowermost and fracture repaired in this position. With arthroscopic techniques the arthroscopic and instrument portals end up close together and manipulation can be limited. Fluoroscopic or digital radiographic imaging is hugely important to determine correct screw placement, particularly in horses in which arthroscopic techniques are employed. In horses managed conservatively non-union of the fracture line can occur, an occurrence that may not preclude future racing but likely prolongs down time and leads to in
congruity in joint surface. Horses with sagittal crush-type injuries of the radial fossa (not true slab fractures) are best managed with arthroscopic debridement of the triangular area of damaged cartilage and subchondral bone.

Repair of sagittal slab fractures of C-3 – the horse is positioned in lateral recumbency with the unaffected limb lowermost (affected limb down for medial approach). A small, routine dorsomedial arthrotomy is performed, medial to the extensor carpi radialis tendon. I prefer a curved skin incision (axially based) and linear incision in the joint capsule. If necessary a small additional incision can be made to position the screw between C-2/C-3. A self-retaining retractor and suction are useful to evaluate the articular surface. The fracture line can be debrided using direct visual inspection. A single, 3.5 mm cortex bone screw can then be placed in lag fashion using the medial corner of C-3. The head of the screw ends up being close to C-2 or between C-2/C-3. It is difficult to position the screw exactly perpendicular to the fracture line, but a functional screw in lag fashion is placed either through the original arthrotomy or just medial to it through a separate stab incision. The incision is closed routinely in 3-4 layers.

References