Minimally invasive repair of a calcaneus fracture in a Standardbred foal

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Case Description—A 4-month-old Standardbred colt was examined because of a fractured right calcaneus of 8 days’ duration with increased distraction of the fracture fragment evident on sequential radiographs.

Clinical Findings—The foal was severely lame with diffuse periarticular tarsal swelling. Radiographically, a complete, displaced long oblique fracture of the right calcaneal body was evident. Because the fracture gap was increasing with time and lameness remained severe, despite medical management, surgical repair was recommended.

Treatment and Outcome—The foal was anesthetized, and minimally invasive fracture reduction and internal fixation were achieved by use of two 4.5-mm cortical screws placed in lag fashion via stab incisions over the lateral aspect of the calcaneus. External coaptation with a Robert-Jones bandage only was used after surgery. The foal recovered well and the fracture healed appropriately, but at 8 weeks following surgery, tenosynovitis of the tarsal sheath had developed. This was attributed to the tip of the distal screw encroaching on the sheath. The screw was removed under anesthesia and the tarsal sheath drained. The tenosynovitis resolved with rest and bandaging. Fourteen months after surgery, the colt was free of lameness.

Clinical Relevance—Findings suggested that a minimally invasive internal fixation technique for treatment of a calcaneus fracture in horses may be successful and may be associated with decreased morbidity, compared with the use of open reduction and plate fixation. (J Am Vet Med Assoc 2012;241:1209–1213)
A 20-gauge needle was inserted into the tarsometatarsal joint and several skin staples were placed over the lateral aspect of the calcaneus prior to obtaining intraoperative radiographs to localize the fracture and identify optimal positioning for screw placement. Two stab incisions were performed over the lateral aspect of the calcaneus. The proximal incision was 5 cm distal and 3 cm dorsal to the calcaneal tuber. The second incision was positioned similarly, but 3 cm distally. A 2.5-mm drill bit was inserted via the distal incision and used as a marker bit to predrill the glide hole in the proximal fragment and ensure the appropriate direction of the drill. The drill bit was angled in a proximoplantar-to-craniodistal direction such that screw placement would be perpendicular to the fracture line. This was verified with both a dorsomedial-plantarolateral radiograph and a flexed dorsoplantar radiographic projection of the calcaneus. The 2.5-mm drill bit was removed and a 4.5-mm drill bit inserted along the same path to create the glide hole. Positioning was verified throughout with the 2 radiographic projections. Once the fracture line was crossed, the bit was removed and a 2-mm Kirschner wire inserted into the hole to facilitate easy introduction of the 3.2-mm-4.5-mm double centering sleeve over the Kirschner wire. The Kirschner wire was removed, and the 3.2-mm drill bit was used to create the thread hole in the distal fragment at the level of the sustentaculum tali. The hole was measured 52 mm, and a full-limb Robert Jones bandage was placed from the coronary band to the stifle joint to reduce limb flexion during assisted recovery from anesthesia, which was uneventful. Radiographs taken following recovery from anesthesia showed no alteration in fracture reduction or implant positioning.

Postoperative medication included phenylbutazone (2.2 mg/kg, PO, q 24 h) for 72 hours after surgery and omeprazole (4 mg/kg, PO, q 24 h) for 2 weeks. After surgery, the colt was bearing full weight on the limb, with only mild lameness evident in the stall. The bandage was changed the day after surgery and minimal swelling noted. The colt was discharged 48 hours after surgery with instructions to maintain a full-limb, heavily padded bandage for 6 weeks, such that hock flexion would be minimized.

The foal was on strict stall rest for 8 weeks after surgery, during which time the bandage was changed twice weekly by the referring veterinarian. Radiographs taken at the farm at 6 weeks (Figure 2) confirmed appropriate progression of fracture healing, and the foal was reevaluated at the hospital at 8 weeks after surgery. No lameness was evident at the walk, and the incisions had healed uneventfully; however, there was notable effusion of the tarsal sheath of the right hind limb. Radiographs confirmed fracture healing was complete, but also revealed notable bone formation over the head of the screws; the position of the implants appeared unchanged relative to each other. Ultrasonographic examination of the tarsal sheath showed anechoic fluid within the sheath and a normal appearance to the deep digital flexor tendon. Sonographically, the medial surface of the calcaneus was disrupted by uneven callus formation and a focal hyperechoic point, consistent with the location of the tip of the distal screw at the level of the sustentaculum tali. Fluid aspirated from the sheath was analyzed and found to have a cell count and protein level that were within reference limits. The penetration of the tarsal sheath by the distal implant was considered to be the cause of the effusion, and screw removal was recommended.

The colt was premedicated and anesthetized via the same protocol as described for the initial surgery and was positioned once again in dorsal recumbency with the limb suspended from above. The location of the distal screw head was identified with skin staples, 20-gauge needles, and radiographic guidance. A 2-cm skin incision was made, extending deeper to include the subcutaneous tissue and periosteum. The screw head was
overlain by substantial bone, which was removed with an osteotome and mallet. The screw was then removed uneventfully, at which time synovial fluid from the tarsal sheath was observed to drain out of the hole. Curettage of the screw hole was performed to remove any debris and the site was lavaged with sterile saline (0.9% NaCl) solution. Closure of the subcutaneous tissue and skin was performed in a similar manner as at the initial surgery. A light bandage was placed, and the colt recovered uneventfully from anesthesia. The day after surgery, the foal was walking comfortably, and a notable reduction in tarsal sheath distension was evident when the bandage was changed. All medication was discontinued, and the foal was discharged the following day with instructions for a further 4 weeks of stall rest and bandaging prior to gradually resuming turnout. The horse was sound at turnout by 6 months after surgery. Follow-up communication at 14 months after the initial injury revealed that the horse was sound with mild diffuse periarticular swelling, compared with the contralateral tarsal region.

**Discussion**

Fractures of the hock and specifically the calcaneus, or fibular tarsal bone, are uncommon in horses. However, several calcaneal fracture configurations have been described including chip fractures, physeal fractures in foals, complete, simple fractures of the calcaneal body in the mature horse, and comminuted fractures. The etiology of such injuries to this bone is typically trauma as a result of the prominence of the calcaneal tuber forming the point of the hock, making it susceptible to external impact by sudden falls or kicks. Many such injuries are open, making affected horses less likely candidates for successful repair. There is a paucity of reports of calcaneal fracture repair, providing limited data on which to base a prognosis. To our knowledge, the minimally invasive technique described here has not been previously reported for the repair of this type of fracture.

The calcaneus is the largest bone in the tarsus, enlarged proximally to form the calcaneal tuber, which acts as the site of attachment for the gastrocnemius tendon, with insertion sites for the superficial digital flexor, biceps femoris, and semitendinosus tendons dorsally. Medially, the sustentaculum tali projects from the distal aspect of the calcaneal body. There is a fibrocartilage-covered groove on the plantar aspect of the sustentaculum tali over which the lateral digital flexor tendon runs within the tarsal sheath. In the event of a calcaneal fracture, the function of the gastrocnemius muscle-tendon unit, which acts as the caudal component of the reciprocal apparatus, is impaired. The tension exerted by the gastrocnemius tendon usually results in the proximal displacement of the proximal fragment. Therefore, calcaneal fractures typically result in excessive flexion of the hock when the stifle is maintained in extension (colloquially termed a dropped-hock appearance).

There are 3 case reports in the literature detailing calcaneal fracture reduction; 2 of the cases involved the calcaneal body, and 1 involved a physeal fracture. The cases are comprised of a horse with a simple, oblique, closed fracture of the calcaneal body, which is a similar configuration to the case described in the present report, and a calcaneal fracture with dislocation of the superficial digital flexor tendon. The third case report, published more recently, described the repair of a closed Salter-Harris type II fracture. In all 3 instances, the fractures were repaired with open reduction and internal fixation with bone plates via the tension band principle to neutralize distracting forces, and full-limb casts were placed for postoperative coaptation for varying periods of time. The fractures in all of the patients proceeded to heal satisfactorily; however, major postoperative complications were encountered. Infection resulted in cellulitis and osteomyelitis, which necessitated the plate removal at 2 months in one case and caused the formation of a draining tract at 5 months, prompting implant removal, in another. Elective plate removal was performed in the third case, and the presence of infection at the time of surgery was not described. However, Scott and Ferguson and Presnell reported notable postoperative stiffness and reduced range of motion, which they attributed to soft tissue adhesions within the subtendinous calcaneal bursa. The horses in both reports responded to prolonged physical therapy after implant removal.
The use of bone plates in equine fracture repair has led to a dramatic improvement in the treatment options for injuries that were once considered catastrophic. However, complications associated with plate fixation in both human and equine patients have long been recognized, and this is an active area of research. The presence of an implant, or foreign body, has been shown to significantly increase susceptibility to infection and formation of bacterial biofilms. The bacterial glycalyx surrounding the implant protects them from host defenses and antimicrobials so effectively that implant removal is often needed to resolve the infection. An obvious factor associated with the incidence of postoperative infection is the surgical technique used. In a review of 192 cases of equine long bone fractures and arthrodese, infection in cases treated by closed reduction and internal fixation was 3.6 times less likely, compared with cases treated by traditional open reduction and internal fixation. However, the number of patients treated by means of a closed approach was, not surprisingly, notably smaller. It has been suggested that a reason for reduced infection rate for minimally invasive procedures is that in addition to reducing the soft tissue trauma and disruption of local blood supply, the use of smaller incisions should reduce exposure of the fracture site to operating room contamination.

In addition to reducing the risk of infection associated with bone plate implants, another benefit of screw fixation alone is the reduction of soft tissue damage and subsequent fibrosis at the surgical site. This was cited as an important factor in postoperative morbidity for the 3 prior reports. The open approach for plantarolateral plate placement for repair of calcaneal fractures involves a long incision, the transaction of the superficial digital flexor tendon retinaculum, reflection of the tendon medially, and breaching of the calcaneal bursa. The plate is placed within the subtendinous calcaneal bursa, over the long plantar ligament distally. Thus, if plate application is performed, removal of the implant as soon as the union is evident minimizes the fibrosis of the bursa and superficial digital flexor tendon as well as improving the long-term mobility, but the overall prognosis for return to full performance remains guarded.

Medical treatment with rigid external coaptation alone has been unrewarding and is not recommended in light of continued fracture displacement because of morbidity associated with casting. Full-limb casts were used in the postoperative treatment of all of the previously reported calcaneal fracture cases for variable amounts of time. Nonsurgical management with a full-limb cast may have been an appropriate option in this patient because of the likely short duration required, compared with more severely displaced fractures in adult horses. Moreover, external coaptation is an essential component of calcaneal fracture repair in larger horses during the immediate postoperative period and specifically recovery from anesthesia. In light of the fracture configuration, minimally invasive approach and, more importantly, ease of manually assisting the patient described during recovery from anesthesia, we elected to substitute a full-limb cast for a Robert Jones bandage to avoid cast-associated complications and minimize expense. The most frequently encountered complications of a full-limb cast on a hind limb have been well documented. These include decubital ulcers, rupture of the peroneus tertius, or tibial fracture. Additionally, soft tissue laxity, notably of the flexor tendons, is a common sequela to cast immobilization in immature horses. However, in patients where a long incision is required in an open approach for fracture reduction and plate application, a possible additional benefit of coaptation might be immobilization of the surgery site to facilitate incisional healing. In contrast, as a minimally invasive approach was used in this horse, we considered that rigid immobilization would play a less critical role in maintaining incisional integrity. Furthermore, we speculate that the size of the foal resulted in reduced tension across the fracture site, compared with that in an adult horse, such that the implants alone would suffice in maintaining reduction. However, it is feasible that a small degree of motion as a result of bandaging rather than rigid coaptation may have been a component in screw migration. However, screw migration seemed less likely on the basis of the radiographic findings, as implant positioning appeared unchanged.

Tarsal sheath tenosynovitis in the patient described in the present report was ascribed to the presence of the tip of the distal screw within the tarsal sheath, which was not reported in other cases. The sheath distension resolved following screw removal, sheath drainage, bandaging, and administration of NSAIDs after surgery. This complication may have been attributable to the head of the screw pulling through into the bone and subsequent screw migration, as a washer was not used as in other cases, although radiographically, this did not appear to be the case. The findings indicate that the implants were in the original position, and therefore, excessive screw length could have resulted because of inaccurate intraoperative radiographic control or inaccurate measurement of the screw hole without compensating sufficiently for the width of the fracture. Fluoroscopic guidance or intraoperative CT may have aided the repair in this case. There was concern that premature removal of both implants may have resulted in subsequent fragment distraction because of the constant tension that the calcaneus is subjected to. As the proximal screw was not shown to be associated with any complications, it was left in situ.

In this patient, a successful repair and good outcome for treatment of a calcaneal fracture were obtained with a minimally invasive approach. The fracture configuration, in conjunction with the size of the patient, permitted the use of the lag-screw technique described. In particular, the obliquity of the fracture line and minimal displacement lent themselves well to this type of repair rather than plate fixation, which would be typically indicated for hock fractures of this nature. Unusually, there appeared to be little tension exerted across the fracture line, as indicated by the lack of pronounced distraction, especially over the caudal surface. In contrast with other reports, this patient experienced minimal postoperative complications. Additionally, the successful treatment of this patient required reduced financial investment by the owner, compared with the cost and potential complications of open reduction and plate fixation, rigid coaptation, more extended hospitalization, and implant removal.

a. Synthes (Canada) Ltd, Mississauga, ON, Canada.
b. Vicryl, Ethicon Inc, Somerville, NJ.
c. Monocryl, Ethicon Inc, Somerville, NJ.
References