Case Report

The use of epoxy putty external-skeletal fixation in the management of calcaneal fractures in two toy breed dogs

Mu-Young Kim[1] Hyun-Jung Han[2,3*]

Abstract

A 1.63-kg Poodle dog and a 2.25-kg Bichon Frise dog were presented for evaluation of nonweight-bearing hindlimb lameness after a falling injury. On radiography, mid-body calcaneal fractures without suspected articular involvement were revealed in both dogs. Both fractures were reduced in a closed fashion and stabilized with external skeletal fixation (ESF) using epoxy resin. The ESF structure was solely applied to the calcaneus without involving other bones, which allowed normal range of motion of the tarsal joint. No postoperative crepitation or limited range of motion was identified during passive motion of either calcaneus. Postoperative radiographs showed appropriately aligned calcaneal fractures, and the dogs recovered normal ambulation within 3 weeks. In both dogs, complete healing of the calcaneal fractures was identified on radiographs taken 6 weeks postoperatively. Based on the excellent outcomes, including satisfactory functional recovery and complete bone healing, ESF with closed reduction is considered a suitable surgical option for stable and successful biologic osteosynthesis of calcaneal fractures, especially in very small dogs, in which surgical stabilization with traditional implants is typically challenging.

Keywords: calcaneal fracture, closed reduction, dog, epoxy resin, external skeletal fixation

[1]*Department of Veterinary Clinical Sciences, College of Veterinary Medicine, Purdue University, West Lafayette, IN, USA*
[2]*Department of Veterinary Emergency and Critical Care, College of Veterinary Medicine, Konkuk University, Seoul 05029, Republic of Korea*
[3]*KU Center for Animal Blood Medical Science, Konkuk University, Seoul 05029, Republic of Korea*
****Correspondence**: ab1234@konkuk.ac.kr* (H. Han)
Received: May 12, 2022
Accepted: July 31, 2022
https://doi.org/10.14456/tjvm.2022.94

Introduction

Fractures of the tarsus, involving the calcaneus, tarsal bones, and talus, are commonly seen in racing or working dogs (OST *et al*., 1987; Perry *et al*., 2017). These fractures are considered fatigue or stress fractures (Devas *et al*., 1961; Gannon *et al*., 1972; Perry, 2020). Except for the calcaneus, tarsal fractures rarely occurred in the pet population (Perry, 2020). Most fractures of the calcaneus in nonracing dogs were mid-body (68%) and comminuted (40%) (Perry *et al*., 2017). This is likely because most calcaneal fractures in nonracing dogs rather than fatigue fractures occur secondary to trauma (Perry *et al*., 2017). Conventional surgical stabilization techniques for canine calcaneal fractures include external coaptation, tension band wiring for midshaft fractures, lag screw fixation for slab fractures, bone plate application supplemented with an intramedullary pin for simple or comminuted fractures, and arthrodesis of the calcaneoquartal joint (Dee, 2005; OST *et al*., 1987).

In particular, in very small dogs, there are several limitations in applying conventional surgical techniques. Implant selection and fracture stabilization are more difficult due to the small bone fragments of the calcaneus. Additionally, there is less soft tissue coverage that promotes bone union and reduces tissue irritation caused by internal implants. Only limited types and sizes of implants are available in very small breed dogs. In the dogs described in the present study, the application of plate and screw systems to the calcaneus were limited due to small bones and less soft tissue.

This report describes surgical techniques that use external skeletal fixation (ESF) to successfully manage and improve the functional recovery of calcaneal fractures in very small dogs that weigh less than 2.3 kg. The fractures were reduced in a closed fashion, and the configurations of ESF, allowing normal tarsal joint range of motion, were fixed with epoxy resin.

Clinical description

A 1.63 kg, 2-year-old, neutered female Poodle (dog 1) was presented for evaluation of nonweight-bearing left hindlimb lameness after falling from a height of 1 m. Radiographs of the left tarsus showed a mid-body fracture of the calcaneus with cranioproximal displacement of the tuber calcanei (Figure 1). The other fractures or dislocations of the tarsal bones were not observed. Surgical repair was performed the day after injury. Under fluoroscopic guidance, the proximal calcaneal fragment was reduced to the normal position in a closed fashion with pointed reduction forceps placed on the tuber calcanei. A 1.5 mm Kirschner wire was placed longitudinally through the calcaneus to temporarily maintain proper alignment of the calcaneus. Then, the tarsal joint was tested for mobility by extending and flexing the tarsus. No crepitation or limited range of motion were noted. For external skeletal fixation, four centrally threaded positive profile pins that were 2.0 mm in diameter were selected, which matched 35% of the width of the narrowest part from the lateral view of the calcaneus (Figure 2). Two pins were placed in the proximal fragment, and the two other pins were placed at the distal fragment. The medial and lateral protruding ends of the four fixation pins were bent to maximize the strength of the epoxy resin connecting bar. After reconfirming the final position of the calcaneal fragments with fluoroscopy, the fixation pins were fixed with epoxy resin. After the epoxy resin was hardened, the temporary Kirschner wire was removed.

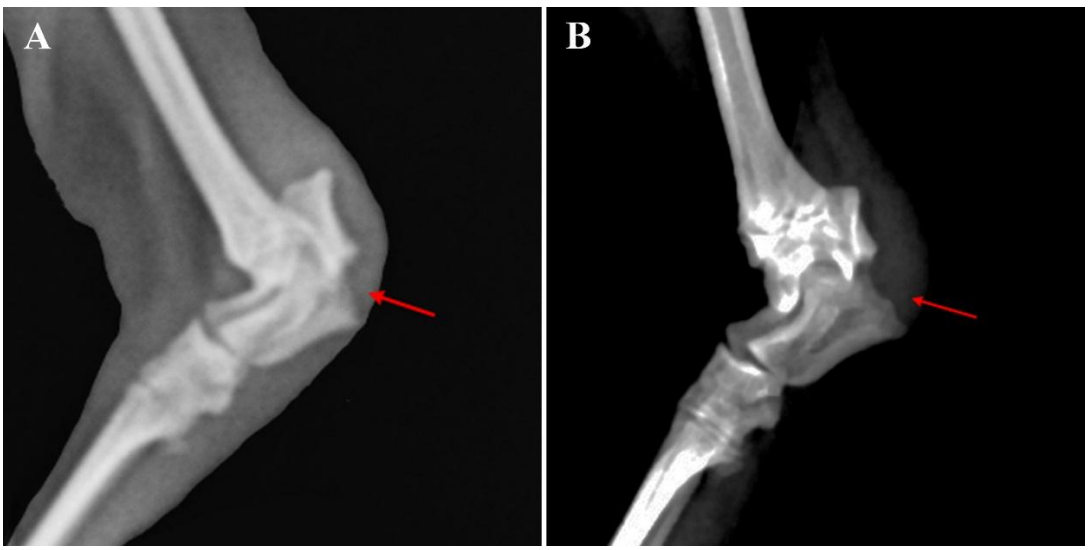

Figure 1 Preoperative lateral stress view radiographs of the affected tarsus in dog 1 (A) and dog 2 (B). The calcaneal tubers (red arrows) were fractured transversely at their base and displaced proximally in both dogs.

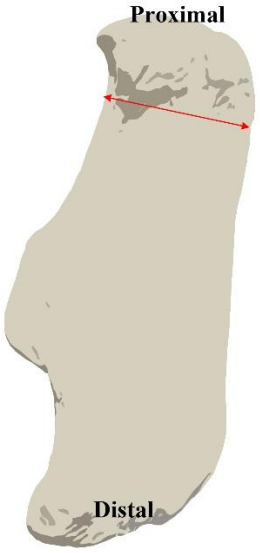

Figure 2 Diagram of canine calcaneus. The width of the narrowest part from the lateral view of the calcaneus (red line) is used as a criterion for determining the thickness of positive profile pins.

Postoperative radiographs showed a properly reduced calcaneus with a small gap between the fracture fragments (Figure 3). After the operation, a low-compression elastic bandage was applied over the epoxy resin and tarsal joint for 7 days to prevent surgical site infection. Since the dressing was not for stabilizing the tarsal joint, the joint range of motion was not strictly restricted. The dog started to bear weight on the operated limb three days postoperatively and was discharged from the hospital on the seventh day after surgery. The 3-week postoperative reevaluation showed that the dog had no lameness and had full range of motion without crepitation on manipulation of the tarsal joint. Complete healing of the fracture was observed on radiographs taken 6 weeks after surgery, and all the implants were removed.

A 2.25 kg, 7-month-old, neutered female Bichon Frise (dog 2) was referred for repair of a right calcaneal fracture 24 hours after the dog fell from the owner's arm. Radiographs of the right tarsus revealed an extra-articular mid-body calcaneal fracture. The calcaneal tuber was fractured transversely at its base with proximal displacement. The fracture was reduced under fluoroscopy and a 1.5 mm Kirschner wire was inserted from the proximal end of the calcaneal tuberosity to the level of the base of the calcaneus. Crepitation and abnormal mobility were not detected during passive range of motion of the affected tarsal joint after reduction. Four 2-mm positive profile pins, which matched 30% of the width of the narrowest part from the lateral view of the calcaneus, were inserted into the proximal and distal fragments in a similar way as described in dog 1. Parallel alignment of the fragments was confirmed with fluoroscopy. The pins were bent in the same way as dog 1. The protruding end of the Kirschner wire was bent laterally and connected with the lateral ends of the positive profile pins using epoxy resin. The medial ends of the pins were fixed with epoxy resin.

Postoperative radiographs revealed a correctly aligned calcaneus (Figure 4). As with dog 1, a soft bandage was applied for 1 week. The dog started to bear weight on the affected hindlimb without sling assistance 5 days after surgery. The 3-week postoperative reevaluation showed that normal ambulation was recovered without complications related to external skeletal fixation. Radiographs taken 4 weeks postoperatively showed adequate healing of the fracture to sustain the partial load of walking, so the intramedullary Kirschner wire was removed. Complete healing of the fracture was achieved after 6 weeks of surgery, and the residual pins were extracted from the calcaneus (Figure 4). After two days of mild lameness caused by the pin removal procedure, the dog recovered full weight bearing hindlimb locomotion without any signs of pain or instability.

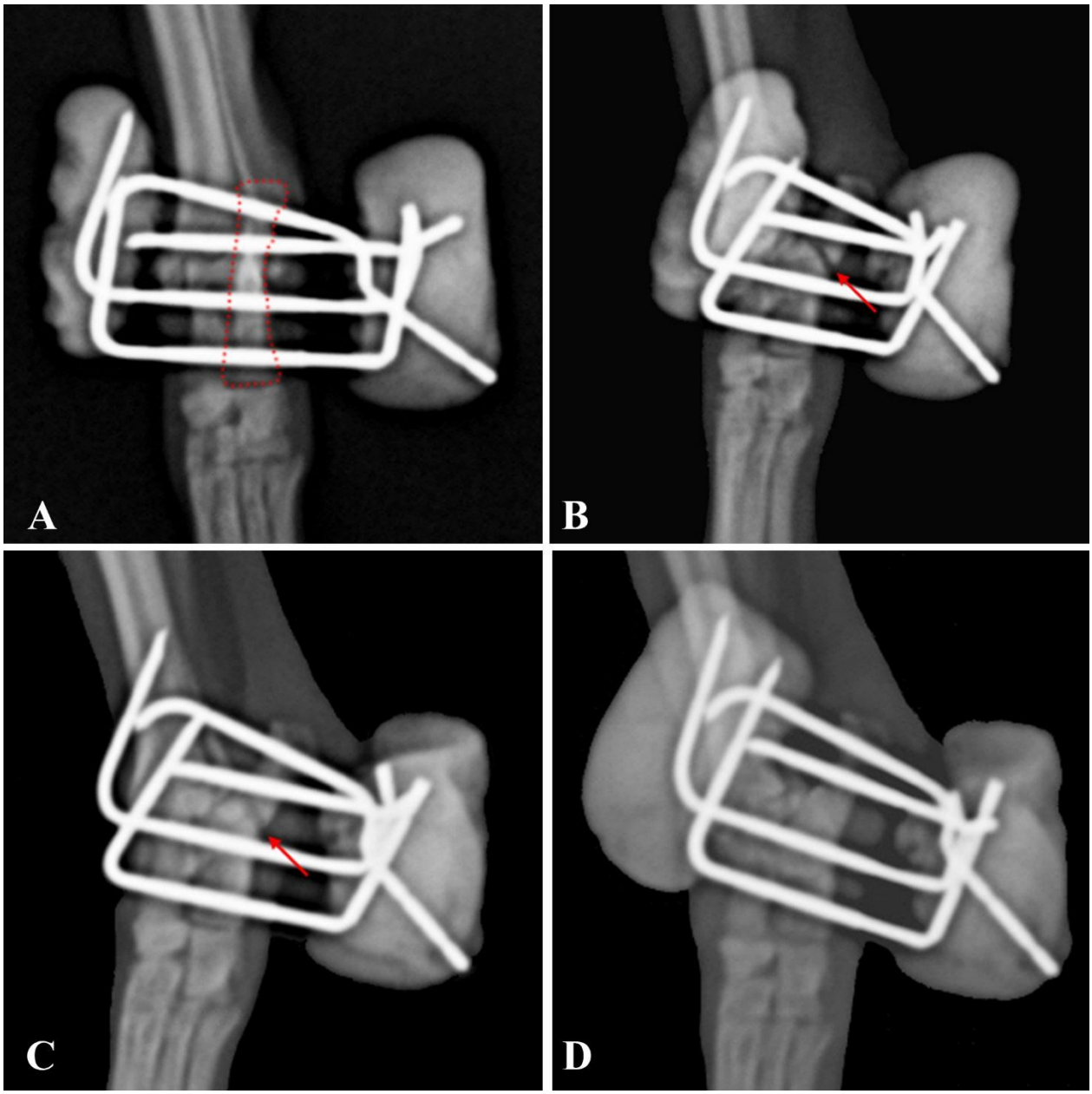

Figure 3 Postoperative serial radiographic views of the calcaneus of dog 1; (A), (B): 1 day, (C): 3 weeks, (D): 6 weeks. The red dotted line shows the alignment of the calcaneal fragments after surgical fixation. As the healing process progresses, the fracture line (red arrows) disappears. At 6 weeks postoperatively, no visible fracture line was observed, indicating complete bone healing.

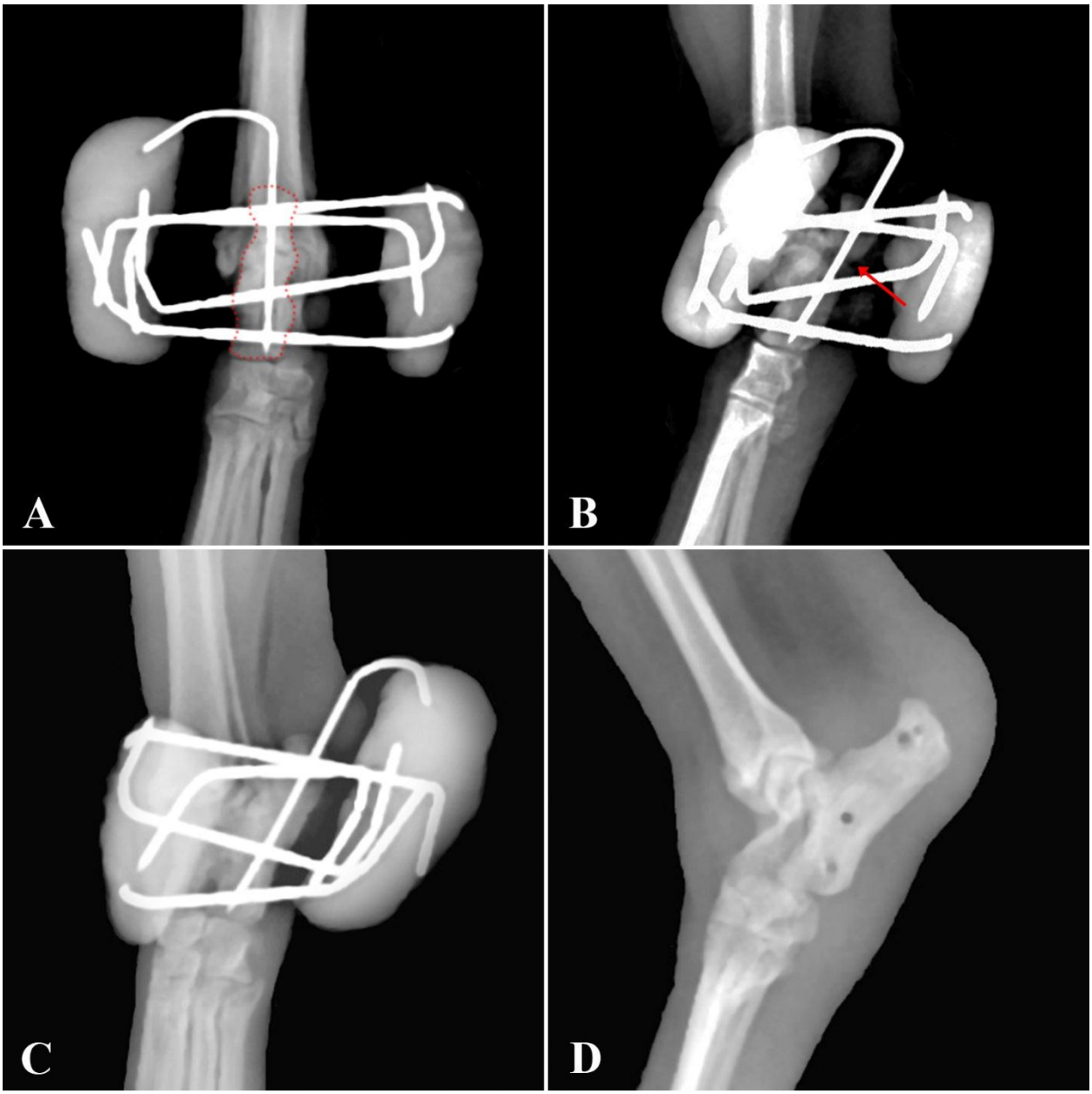

Figure 4 Postoperative serial radiographic views of the calcaneus of dog 2; (A), (B): 1 day, (C): 4 weeks, (D): 6 weeks. The red dotted line shows the alignment of the calcaneal fragments after surgical fixation. As the healing process progresses, the fracture line (red arrow) disappears. At 4 weeks postoperatively, the fracture line was not observed on radiography. The whole frame of the external skeletal fixation was removed at 6 weeks after surgery. Radiograph at 6 weeks shows complete healing of the calcaneal fracture.

Discussion

The surgical techniques for the reduction and stabilization of calcaneal fractures are contingent upon fracture configuration, the presence of intertarsal luxation or subluxation, and the presence of concurrent tarsal joint injuries (Dee, 2005; OST *et al*., 1987). Among the numerous reduction and stabilization techniques that have been developed to treat calcaneal fractures, open reduction and internal fixation using bone plates remain common practices (OST *et al*., 1987; Perry *et al*., 2017; Scrimgeour *et al*., 2011). Open techniques allow fragment observation and reduction through direct manipulation of the fracture fragments; however, these approaches disrupt the soft tissue coverage and the blood supply to the fracture site, resulting in delayed bone healing and an increased complication rate (Perren *et al*., 2002). In addition, the disruption of soft tissue and blood supply described above could be exacerbated due to the space occupying the internal fixation implant. The morbidity associated with the open technique could be minimized by closed or minimally invasive surgical techniques (Githens *et al*., 2017; Hudson *et al*., 2009).

This study shows the successful application of an external skeletal fixation technique on a calcaneal fracture, reduced in a closed fashion, without limiting articulatory movement of the tarsal joint. In veterinary medicine, there have been no reports of using an external fixation technique for a calcaneal fracture, except that trans-articular external skeletal fixation was applied to stabilize the tarsal joint, which inevitably limits joint mobility. Short-term joint immobilization has been reported to have a protective effect; however, immobilization concurrently causes negative effects on

synovial fluid production, cartilage, bone, and range of motion (Denny *et al*., 2000; Jaeger *et al*., 2005).

The characteristics of this technique are closed reduction, external skeletal fixation, and unrestricted range of motion of the tarsal joint after surgery. By using closed reduction and external skeletal fixation, already damaged soft tissue supporting structures of the tarsus were minimally disrupted. Additionally, the blood supply to the fracture lesion could be preserved to a greater extent than open and internal fixation. This repair technique effectively sustained joint motion, allowed early weight bearing with normal range of motion, and was strong enough to resist the distractive force exerted on the calcaneus. This technique might be most efficient in toy breed dogs with a small size calcaneus and a small amount of soft tissue, which limits the use of an internal fixation system. Even though the fixation pins were solely inserted into the calcaneus without limiting tarsal joint movement, this technique could stably fix a fractured calcaneus of a lightweight dog. In addition, epoxy putty-external skeletal fixation can be varied in configuration for each individual and easily removed without additional surgery.

This study has limitations because of its small sample size and incomplete presurgical diagnosis. In the dogs presented in this study, computed tomography was not performed owing to the owner's financial concerns. Additional diagnostic tests may have provided more information to accurately identify the presence of other abnormalities in the tarsus and to determine the proper treatment. Considering that both dogs quickly regained their normal gait and that crepitations were not detected on intraoperative and postoperative tarsal joint manipulation, the possibility of other bone or articular involvement was low. It cannot be postulated that this technique is appropriate for heavier or larger dogs. Further studies are required to objectively evaluate the acceptability of this technique in other dog breeds.

Conflict of interest: The authors declare that there is no conflict of interests regarding the publication of this paper.

Acknowledgements

The authors thank Konkuk University Animal Medical Center for providing patient data for this study.

References

Devas MB 1961. Compression stress fractures in the greyhound. J Bone Joint Surg Br. 43: 540-551.

Dee JF 2005. Fractures of the tarsus. In: AO Principles of Fracture Management in the Dog and Cat. 2nd ed. Johnson A, Houlton J, Vaninni R (eds). Davos: AO Publishing. 349-359.

Denny HR, Butterworth SJ 2000. The tarsus. In: A Guide to Canine and Feline Orthopaedic Surgery. 4th ed. Hamish D (ed). Oxford: Blackwell Science. 575-597.

Gannon JR 1972. Stress fractures in the greyhound. Aust Vet J. 48: 244-250.

Githens M, Shatsky J, Agel J, Bransford RJ, Benirschke SK 2017. Medial external fixation for staged treatment of closed calcaneus fractures: surgical technique and case series. J Orthop Surg. 25: 1-8.

Hudson CC, Pozzi A, Lewis DD 2009. Minimally invasive plate osteosynthesis: applications and techniques in dogs and cats. Vet Comp Orthop Traumatol. 22: 176-182.

Jaeger GH, Wosar MA, Marcellin-Little DJ, Lascelles BDX 2005. Use of hinged transarticular external fixation for adjunctive joint stabilization in dogs and cats: 14 cases (1999-2003). J Am Vet Med Assoc. 227: 586-591.

OST PC, Dee JF, Dee LG, Hohn RB 1987. Fractures of the calcaneus in racing greyhounds. Vet Surg. 16: 53-59.

Perren SM 2002. Evolution of the internal fixation of long bone fractures: the scientific basis of biological internal fixation: choosing a new balance between stability and biology. J Bone Joint Surg Br. 84: 1093-1110.

Perry KL 2020. Tarsal fractures: part 1. UK Vet Companion Animal 25: 31-36.

Perry KL, Adams RJ, Woods S, Bruce M 2017. Calcaneal fractures in non-racing dogs and cats: complications, outcome, and associated rick factors. Vet Surg. 46: 39-51.

Scrimgeour AB, Worth AJ 2011. The use of the string of pearls locking plate system in the stabilization of a comminuted calcaneal fracture in a giant breed dog. Case Rep Vet Med. 2011: 188-193.