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Case Report

The Use of the String of Pearls Locking Plate System in the Stabilisation of a Comminuted Calcaneal Fracture in a Giant Breed Dog

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An eight-year-old male Pyrenean mountain dog was presented with a comminuted fracture of the right calcaneus following motor vehicle trauma. The fracture was stabilised with a plate-rod construct, using the String of Pearls locking plate system and an intramedullary pin. Healing was uncomplicated.

1. Case History

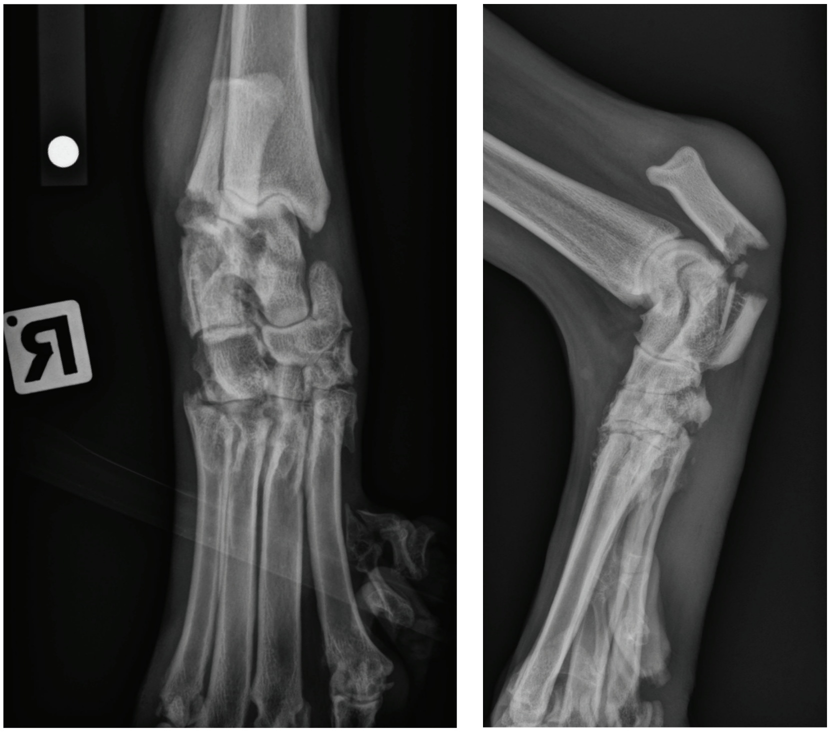
An eight-year-old male neutered Pyrenean mountain dog weighing 65 kg was presented for repair of a right calcaneal fracture 72 hours after being run over and becoming lodged under the owner's car. Stabilisation of the dog by the referring veterinarian included administration of analgesia, antibiotics, intravenous fluids and application of dressings covering soft tissue wounds on both hind legs. Thoracic radiographs and abdominal ultrasound examination were considered within normal limits.

2. Clinical Findings and Diagnosis

On presentation, the dog was not ambulatory. There were no peripheral or central neurological deficits, but cranial drawer was noted in the right stifle joint, consistent with complete rupture of the cranial cruciate ligament. Abrasions were present on the medial aspect overlying the right stifle joint and the lateral aspect of the left crura. Radiographs of the lumbar spine, pelvis, and left stifle joint were within normal limits. Radiographs of the right stifle joint showed increased soft tissue opacity and reduction of the fat pad consistent with joint effusion but no evidence of degenerative joint disease. These findings supported a presumptive diagnosis of acute cranial cruciate ligament rupture, likely associated with the trauma rather than preexisting disease. Radiographs of the right hock joint showed a complex fracture of the calcaneus with proximal displacement of the tuber calcanei and a comminuted sagittal fracture of the tuber calcanei extending to the articular surface (Figure 1). Severe osteoarthritis of the intertarsal and tarsometatarsal joints was present, consistent with preexisting disease.

3. Treatment

After premedication with acepromazine (Acezine 2, Ethical Agents) (0.01 mg/kg sc) and morphine (DBL Morphine Sulfate, Hospira) (0.5 mg/kg sc) anaesthesia was induced with a combination of ketamine (Ketamine, Parnell Technologies) (10 mg/kg iv) and diazepam (Pamlin, Parnell Technologies) (0.5 mg/kg iv), and maintained with isoflurane (Attane, Bomac) administered in oxygen via an endotracheal tube at 2% to effect. Intravenous antibiotics were administered (cefazolin (DBL Cefazolin Sodium, Hospira) 22 mg/kg iv every two hours during anaesthesia). The dog was positioned in left lateral recumbency and a caudolateral approach made to the right hock. The superficial digital flexor tendon was reflected and the calcaneal tuber was exposed and isolated. An interfragmentary K-wire was placed across the largest fragments of the calcaneal body. The remaining fragments were aligned, and 18-gauge orthopaedic wire was positioned



(a) (b)

Figure 1: Preoperative dorsoplantar and lateral radiographs showing comminuted fracture of calcaneal body and distraction of calcaneal tuber.

around the bone and K-wire before tightening. The tuber calcanei was then reduced and held in position with bone reduction forceps. A 10-hole 3.5 mm String of Pearls (SOP) locking plate (Orthomed Halifax) was contoured to fit the caudolateral surface of the calcaneus and attached with two screws in the calcaneal tuber proximally and one unicortical screw in the calcaneal body at hole four. Screws were placed in the distal four holes of the plate to secure it to the metatarsal bones. The comminuted calcaneal body and tarsal bones were bridged by the plate. After placement of the plate, a 4 mm Steinman pin was driven from the proximal to distal calcaneus. Prior to placement, the pin was notched with large pin cutters at a distance from the tip calculated on measurements taken from the radiograph of the contralateral intact calcaneus. This allowed the end of the pin to be recessed below the level of the common calcaneal tendon to avoid postoperative local irritation.

Postoperative radiographs showed accurate reduction and realignment of fracture fragments (Figure 2). After surgery, soft dressings with a primary layer of Allevyn (Allevyn, Smith and Nephew) were maintained postoperatively to support healing of the soft tissue injuries, and a closed urine collection system was provided for three days to simplify postoperative management. Dressings were changed daily for the next four days and the wounds irrigated with saline. Cephalexin (Cephalexin, Apex Laboratories) (22 mg/kg twice daily po) was administered for the next three days, morphine administered at 0.5 mg/kg sc every 4 hours for the next two days, and carprofen (Rimadyl, Pfizer) (2 mg/kg twice daily po) for the next three days.

4. Outcome

The dog was discharged from the hospital four days after surgery with carprofen (2 mg/kg twice daily po for 10 days) and cephalexin (22 mg/kg twice daily po for seven days). Recommendations to the owner included performing range of motion exercises for each joint, massage, and sling-assisted walking. The dog walked without sling assistance ten days after surgery. Wound dressings were changed every two days and wound epithelialisation occurred in two weeks. Exercise was restricted until follow-up radiographs of the right calcaneus were obtained. Further recovery was uneventful and stabilisation of the cruciate deficient stifle was not undertaken. Radiographs taken nine weeks postoperatively showed good healing of the fracture (Figure 3). There was a good range of motion of the hock joint with no crepitus or pain evident on manipulation. The dog's gait at a walk was normal. Eight months after surgery, the dog continued to weight bear well on the right hind leg and the hock joint had a good range of movement and was apparently pain free.

5. Discussion

Fracture of the calcaneus is a disabling injury as it destroys the ability of the gastrocnemius muscle and the rest of the common calcaneal tendon to prevent hyperflexion of the hock joint, resulting in a plantigrade stance. Muscle tension on the tendon results in considerable pull on the calcaneal tuber which results in marked displacement of the fragment from the body of the calcaneus [1].

Figure 2: Postoperative radiograph showing fracture repair with 10 hole 3.5 mm SOP plate, interfragmentary and cerclage wire, and intramedullary pin.

Figure 3: Nine-week postoperative radiograph showing satisfactory healing of calcaneal fracture.

The model for calcaneal fractures is cantilever bending. Cantilever bending on bone occurs when a force causes an object to bend about an axis [2]. After a fracture, the resulting bending force must be resisted by orthopaedic implants to prevent significant separation and micromotion at the fracture site. Fractures in which cantilever bending is of significance can be stabilised by tension bands, where implants are positioned to convert tension forces into compressive forces at the site of fracture [3]. Calcaneal fractures are subjected to a high cantilever bending force due to the pull of the common calcaneal tendon, creating tension on the plantar aspect of the calcaneus and compression on the cranial face. The use of tension bands, lag screws, and plates to repair fractures of the calcaneus has been described [1, 4–6].

Complicating factors in determining a fracture repair plan for this dog included its heavy weight, requiring implants strong enough to oppose the distractive forces generated on weight bearing, and the comminuted nature of the fracture of the calcaneal body making anatomical reconstruction of the fracture fragments to achieve load sharing a problem. These factors dictated the use of a plate-rod construct with the plate attached towards the tension surface of the calcaneal tuber proximally and to the metatarsal bones distally. This plate would act as a tension band to counteract distractive forces on the fracture and bridge the comminuted fracture of the body of the calcaneus and the low motion intertarsal and tarsometatarsal joints.

The String of Pearls veterinary implant system is a locking plate system that utilises standard cortical screws which provide a versatile method of fixation. These plates can be contoured in six degrees of freedom, that is, lateromedially, dorsoventrally, and torsionally, and precise contouring to the bone surface is not required as constructs do not rely on bone-plate friction for stability, unlike conventional plates [7]. Use of SOP plates has been reported for the repair of Y-T humeral fractures [8], stabilisation of vertebral bodies in thoracolumbar disc protrusions [9], and as a transilial plate stabilisation of a sacral fracture [10]. Other locking plate technologies have been applied to long bone fractures [11–13], treatment of cervical spondylotic myelopathy [14], and arthrodesis of the tarsometatarsal joints in a cat [15].

String of Pearls plates are stiffer and stronger than equivalent size limited contact dynamic compression plates (LC-DCPs) [16] and remain as strong and stiff as an uncontoured conventional dynamic compression plate even after contouring [17]. The use of conventional plates such as dynamic compression plates (DCP) or veterinary cuttable plates as bridging plates dictates that screw holes over the fracture site will be left unfilled. Unfilled screw holes act as stress risers to concentrate forces generated by weight bearing, making these plates more susceptible to bending on cyclical loading [3]. The design of LC-DCPs removes stress from empty screw holes by reducing the area moment of inertia (AMI) of the solid part of the plate thus does not result in a stronger plate compared to a conventional DCP of a similar size [3]. The design of the SOP plate achieves an inherently greater AMI at the screw hole than an equivalent-sized conventional plate or LC-DCP making it a suitable choice for buttress fixation [16].

The strength of this repair was further increased by the use of a Steinman pin in the calcaneus as a component of a plate-rod fixation. This combination increases the bending strength of the repair significantly [18, 19]. The eccentric position of the plate on the caudolateral aspect of the calcaneus made placement of this pin straightforward.

Surgery to stabilise the stifle following rupture of the cranial cruciate ligament was not undertaken at the time of injury due to financial constraints. The dog was able to return to its preinjury level of activity within three months and no effusion or pain was evident in the stifle joint on examination.

Calcaneal fractures in giant breed dogs are subject to strong distractive and bending forces. The authors conclude that the String of Pearls plate may be considered as an appropriate implant for repair of calcaneal fractures with the addition of pin support to provide greater stability and strength of the repair.

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