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WILDLIFE

Open reduction and internal fixation of a comminuted femoral fracture with plate–rod technique in a wedge-capped capuchin (*Cebus olivaceous*)

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SUMMARY

A 3-year-old intact male wedge-capped capuchin (*Cebus olivaceous*) was diagnosed with a complete fracture of the left femur. Radiographs confirmed a closed, complete, comminuted fracture of the distal one third of the left femur with caudolateral displacement. External co-aptation and intramedullary pinning techniques were considered inadequate owing to the possibility of implant failure or the development of fracture disease. A biological fixation of the fracture was accomplished using a 2 mm veterinary cuttable plate and a 2 mm Kirschner wire. Following apposition and alignment of the fracture, the pin was placed normograde and the plate was applied as a bridging plate. Owner compliance was critical to prevent patient self-mutilation. The intramedullary pin, plate and screws were not removed. Postoperative wound healing was uneventful. Progressive secondary bone healing was noticed on serial radiographic study carried out on the 12th, 35th and 63rd postoperative days. Full weight bearing was evident by the 35th postoperative day.

BACKGROUND

We believe this is the first report of the use of the plate–rod technique for comminuted femur fracture repair in a small-sized primate. This report has established that open reduction and internal fixation of a closed complete comminuted diaphyseal femur fracture could be successfully accomplished in a small primate which was agile and difficult to restrain.

CASE PRESENTATION

A 3-year-old intact male wedge-capped capuchin (*Cebus olivaceous*) weighing 1.2 kg was referred to the School of Veterinary Medicine, Trinidad with a history of acute non-weight bearing lameness of the left hindlimb resulting from a traumatic injury. Initial treatment of a suspected femoral fracture with a plaster of Paris cast at a private clinic was unsuccessful. On presentation, the animal was bright and alert but had a poor body condition and was mildly dehydrated. The animal was aggressive and was sedated with xylazine 2 per cent (Bomazine 2 per cent, 20 mg/ml, Bomac Laboratories, New Zealand) and ketamine (ketamine 10 per cent, 100 mg/ml, Dutch Farm Veterinary Pharmaceuticals, Holland; 20 mg/kg intramuscularly). Following removal of the cast, abrasions were noticed in the distal femoral region and a small pressure sore was present in the medial aspect of the thigh. A clinical diagnosis of a closed complete comminuted diaphyseal fracture of the left femur was made. Orthogonal radiographic views of the left femur confirmed a closed complete comminuted diaphyseal fracture of the distal one third of the left femur with a caudolateral displacement (Fig 1). The cortex appeared thin and had reduced radio-opacity.

INVESTIGATIONS

The haematological study included a complete blood count and blood smear evaluation. The biochemical evaluation included kidney and liver function tests and estimation of serum calcium, phosphorous, alkaline phosphatase, total proteins and albumin.

TREATMENT

The owner was advised to implement measures to improve the animal's body condition, nutritional status and hydration levels before it underwent surgery. A week before surgery, boiled eggs, sausages and shredded chicken, citrus fruit juices, shredded tomatoes, groundnuts, chick peas, carrots, yoghurt and chewable calcium treats were provided. Preoperatively, meloxicam (Petcam 1.5 mg/ml, Cipla, India; 0.2 mg/kg orally, once a day) and amoxicillin trihydrate/clavulanate potassium (Enhancin 457 oral suspension, Ranbaxy Laboratories Limited, India; 11 mg/kg orally twice daily) were administered for three days to prevent the abrasions and pressure sore from developing infections. The abrasions and pressure sore were cleaned and dressed twice daily with silver sulphadiazine ointment (Flamazine Cream 1 per cent, Smith and Nephew pharmaceuticals Ltd, Hull, UK). The animal was fasted 6 hours before surgery and subsequently premedicated with diazepam (Valium 10 mg/2 ml, F-Hoffmann-La Roche Ltd, Switzerland; 1 mg/kg intramuscularly) and ketamine (15 mg/kg intramuscularly). An intravenous 24 gauge catheter was placed in the right cephalic vein and propofol (Diprivan 10 mg/ml, Fresenius Kabi, IL 60047, USA; 3 mg/kg intravenously) was administered to induce anaesthesia. Fluids were delivered during surgery (Veterinary Lactated Ringer Injection USP, Abbott Laboratories, Illinois 60084, USA; 15 ml/kg/hour intravenously). The animal was intubated and

FIG 1: Mediolateral (left panel) and craniocaudal (right panel) radiographs showing a closed comminuted fracture of the distal one third of the left femur with a caudolateral displacement in a wedge-capped capuchin.

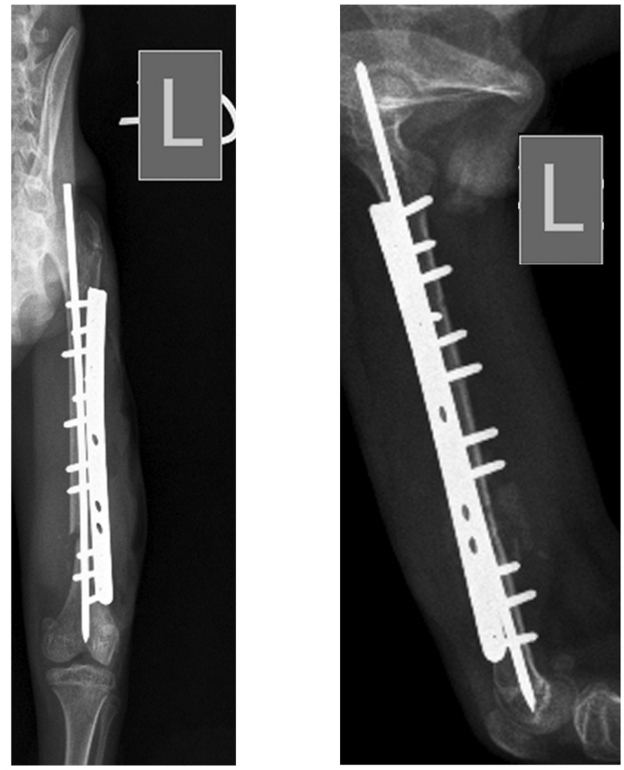

FIG 2: Mediolateral (left panel) and craniocaudal (right panel) radiographs demonstrating the plate–rod in position on the immediate postoperative day.

maintained on 2 per cent isofluorane in oxygen using a Bain circuit.

After sterile preparation and draping, the animal was placed in right lateral recumbency. A craniolateral skin incision (Piermattei and Johnson 2004) was made extending from the level of the greater trochanter of the femur to the patella and the biceps femoris, and the vastus lateralis muscle separated to expose the fracture site. The fracture edges were gently debrided to remove redundant tissue, minimally manipulated and reduced. The fracture haematoma was left undisturbed. A 2 mm Kirschner wire that filled up approximately 40 per cent of the medullary canal was passed normograde and seated into the distal metaphysis of the femur.

A 14 hole 2 mm veterinary cuttable plate (Veterinary Instrumentation, Sheffield, UK) was selected based on the length and diameter of the femur, contoured to the shape of the femur and applied as a bridging plate. A total of eight screws on the proximal fragment and three on the distal fragment were placed. The length of the screws ranged from 8–12 mm. The fascia lata and subcutaneous tissue were sutured in a continuous suture pattern. The skin was closed with 3–0 prolene in an intradermal pattern and reinforced with cruciate sutures. The incision site was dressed with a thin layer of sterile gauze impregnated with silver sulphadiazine ointment. Pain management with butorphanol (Torbugesic 10 mg/ml, Fort Dodge Animal Health, New York 10017, USA; 0.2 mg/kg intramuscularly twice daily) was instituted for two days. Immediate postoperative radiographs indicated good alignment and apposition of the fracture fragments (Fig 2). The length and position of the implants were appropriate. Upon waking up from the anaesthesia, the animal was able to bear weight on the operated limb.

The animal was placed under cage rest for the following four weeks. Routine wound dressings were carried out. Cold packs were placed around the operated area twice daily for two days. Postoperatively, acetaminophen (Children's Tylenol oral suspension 160 mg/5 ml, McNeil Consumer Health Care, Pennsylvania, USA; 15 mg/kg orally twice daily) and amoxicillin trihydrate/clavulanate potassium (Enhancin 457 oral suspension, Ranbaxy Laboratories Limited, India; 11 mg/kg orally twice daily) were given for a week.

OUTCOME AND FOLLOW-UP

The animal remained bright and active throughout the postoperative period. The sutures remained intact and were removed on the 12th postoperative day. Serial radiographic evaluations were carried out on the 12th, 35th and 63rd postoperative day. Progressive secondary bone healing with initial formation of a periosteal bone collar progressing to the development of a palpable bridging callus was recorded. Full weight bearing was observed by the 35th postoperative day. At the 63rd postoperative day, there was radiographic evidence of reorganization of the callus with bony union and disappearance of the fracture line (Fig 3). The implants were in position and the fracture site was stable. Full weight bearing and activity was evident to warrant pin removal but the owner opted to leave the pin in place. The plate and screws were not removed.

DISCUSSION

There is a paucity of information available on the management of long bone fractures in small-sized primates such as the capuchin. This article places on record the surgical management of a femoral fracture using a veterinary cuttable plate and a pin in a wedge-capped capuchin. Injuries sustained during falls from heights may be the most frequent cause of long bone trauma among small-sized primates and tibial fractures are commonly encountered. In the wild, fracture patterns appear to be closely associated with locomotor mode, arboreality and body mass of the animal (Jarrell 2011). Open reduction and internal fixation

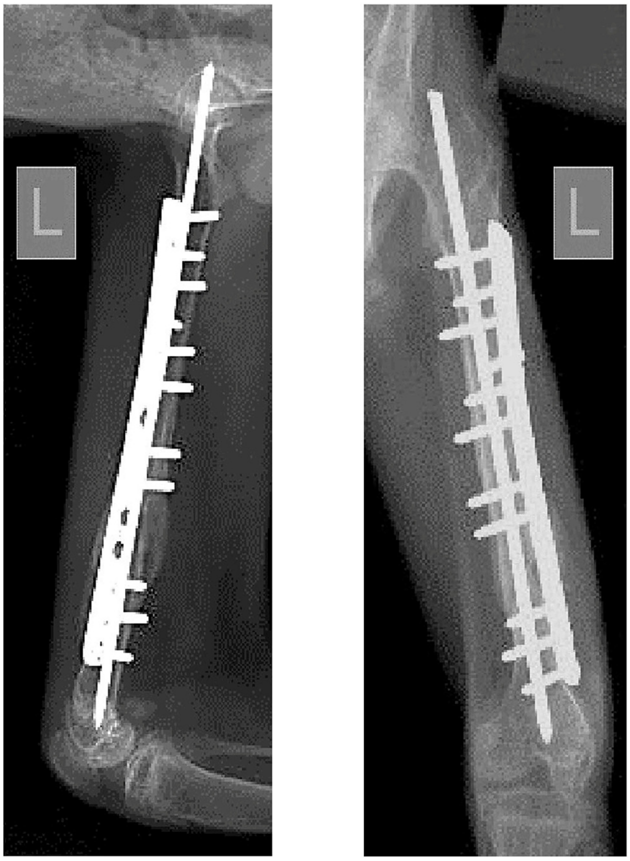

FIG 3: Mediolateral (left panel) and craniocaudal (right panel) radiographs taken on the 63rd postoperative day showing the implants in position. Note secondary bone healing indicated by callus formation. There is disappearance of the fracture line with bony union.

of long bone fractures in capuchins is technically challenging due to the temperament and activity of the animal, reduced cortical thickness, minimal soft tissue covering of bone, and the need for constant supervision in restraining and preventing self-mutilation. Capuchins distribute most of their weight on their hindlimbs to enhance forelimb flexibility for arboreal activity. An untreated hindlimb fracture can lead to fracture disease or complications such as malunions or non-unions which can result in non-weight bearing lameness. A stable fixation is hence required to promote fracture healing and weight bearing and to prevent catastrophic implant failure or refractures.

Rigid internal fixation with intramedullary pinning is the preferred method of fracture immobilisation as non-human primates rarely tolerate plaster casts (Mahoney and Wolfe-Coote 2005). A successful femoral fracture repair in a rhesus monkey using an intramedullary pin has been reported and was attributed to the animal not interfering with the implant (Singh and others 2012). Intramedullary pins when used alone will not counter rotational instability and pin loosening and proximal migration with possible sciatic entrapment or non-unions can occur. Hence the technique of pinning alone was not considered as a sole method of fixation. A normograde application of the pin with the hip extended and the pin directed laterally is advocated to reduce the probability of nerve entrapment. The application of a T-plate for the management of a proximal epiphyseal fracture of the tibia in a capuchin has been mentioned but the technique was not reported (Vnuk and others 2009). A plate–rod procedure using a veterinary cuttable plate and a Kirschner wire was considered, taking into account cost, the activity of the animal, and the anticipated excessive amount of bending and rotational forces expected to act at that site. The veterinary cuttable plate can be cut to the required length for fixation during the surgical procedure, contoured to the shape of the bone, and the required number of screws can be inserted allowing stable fixation at the fracture site (Brüse and others 1989). A plate which spanned more than 75 per cent of the length of the bone was selected. A longer plate is used to improve the lever arm of each screw and for decreasing the screw pullout (Gautier 2009). In the present case, although there was a possibility of inserting a fourth screw in the short distal fragment to augment stability, it was not attempted due to the concern of misdirecting the screw into the stifle joint. The AO principles of placing a minimum of three screws proximal and distal to the fracture were followed. Plates applied alone as a buttress plate (also described as biological or bridge plating in the new terminology) are subjected to considerable bending stress during weight bearing, which can cause fatigue failure of the implant (Piermattei and Flo 2006). Intramedullary pins increase bending strength of the repair significantly and maintain axial alignment. An intramedullary pin that fills up 35–40 per cent of the medullary canal has been advocated (Hulse and others 1997).

The plate–rod combination is a biological fixation and a bridge plate technique. The function of the bridging plate is simply to prevent axial deformity as a result of shear or bending forces (Johnson and Houlton 2005). A plate–rod construct reduces plate strain and improves the overall stiffness of the construct, increasing the fatigue life of the plate while the risk of plastic deformation is decreased (Hulse and others 2000). Load sharing between the bone and plate–rod was achieved in this case. Minimal separation of muscular attachments and preservation of the periosteum at the fracture site ensured good extra osseous vascular supply, a critical factor in the healing process. The plate was applied with a modification to the principles of bridge plating (Schatzker 1995). The number of screws placed in the proximal fragment was increased to ensure stability and prevent catastrophic implant failure, taking into consideration the quality of the bone and the activity of the animal. The beneficial effects of biological fixation with minimal interference to the fracture haematoma and preservation of the periosteal sleeve promoted callus formation with secondary bone healing in this case.

Biological fixation of femoral diaphyseal fractures in small species can also be attempted using interlocking nails, the advanced locking plate and the 2 mm mini locking plate. Interlocking nails can be placed in closed fashion under fluoroscopic guidance with minimal disruption of soft tissue while protecting the extraosseous blood supply. The size of the animal in the present case warranted a customised system which was unavailable. The radiation hazard with a fluoroscopic procedure may also be high for a small primate. Advanced locking plates provide construct rigidity even with monocortical screws and have been reported to reduce rates of infection, reduce damage to vascular supply and improve the rate of fracture healing. Locking plates provide angular stability, especially in bones of poor quality, and promote minimal plate–periosteum contact without interfering with vascular supply to the bone. The cost of the implants and instrumentation were factors which influenced the decision to opt for a veterinary cuttable plate, which was comparatively inexpensive and suitable for biological fixation. The use of an external fixator tie-in technique was not considered in this case due to the difficulty in providing intensive postoperative care; the technique also produces a less rigid stabilisation than plating, and there is a high possibility of the animal manipulating the fixator, leading eventually to early loosening of the implant, loss of stability and refractures.

Capuchins are very agile and dexterous and hence potential complications of self-mutilation can occur. Preoperatively, oral antibiotics were given for three days to prevent the abrasions and the pressure sore from getting infected and provide adequate antibiotic concentration at the fracture site. To protect the surgical site, intradermal sutures reinforced with cruciate sutures were placed. Non-absorbable sutures were used intradermally to provide prolonged mechanical support to the surgical wound and to withstand the effects of possible self-mutilation by the animal. Aloe vera gel, which has wound healing, anti-inflammatory and immunomodulatory properties (Danhof 1987), was applied at the surgical site until wound healing was complete. Aloe vera has a bitter taste which prevented the animal from licking the wound.

In conclusion, the application of AO principles of open reduction and stable internal fixation (Brinker and others 2013) with a plate–rod construct using a veterinary cuttable plate and a Kirschner wire can be considered for repair of closed complete comminuted femoral diaphyseal fractures in small-sized primates to promote rapid healing and full weight bearing.

Contributors AS: The primary surgeon in the case was responsible for planning and performing the operative procedure. KS: Assisting surgeon in the case. NL: Responsible for induction, monitoring and maintenance of anaesthesia. NFAM: Responsible for pre- and postoperative imaging studies. JJ: Responsible for postoperative care and for monitoring the progress of the case.

Competing interests There are no competing interests.

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