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Internal fixation for the treatment of multiple physeal tibial fractures in a growing dog

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This case report describes pinning fixation for the treatment of three tibial physeal fractures in a 3-month old mixed-breed dog.
The radiographic study revealed a severe proximal dislocation of the tibial diaphysis along with multiple, closed fractures of the proximal and distal tibial physes, distal femoral physis and the fibula.
Open reduction and internal fixation (ORIF) were performed using crossed Kirschner wires for proximal and distal tibial physeal fixation and a tension band to manage the tibial tuberosity avulsion fracture. Postoperative radiographs showed proper fracture reduction, tibial alignment and correct implant positioning.
Clinical and radiographic checks documented progressive limb weight-bearing, gradual resolution of distal limb oedema and fracture healing.
The described open surgical treatment had a satisfactory clinical outcome with restoration of tibial anatomy, preservation of joint function and an early return to normal motor activity at 45 days of follow-up.

INTRODUCTION

The longitudinal growth of long bones in skeletally immature subjects is determined 75%-80% by mineralization of the cartilage matrix in the physes.[1-3] The physes (or growth plates) are thin cartilaginous areas located between the metaphysis and epiphysis of long bones and vertebrae. Not being of bone matrix, the physes are structurally weak areas and for this reason they are often fractured, dislocated or compressed if subjected to trauma or excessive loads.[1-4] Salter and Harris classified physeal fractures into five types (SH I-V)[5] depending on their configuration and the anatomical components involved. Tibial fractures are often traumatic in nature and 50% of such fractures occur in skeletally immature individuals.[6,7] The most frequent tibial fractures are SH I or II fractures of the proximal growth plate alone or in association with an avulsion fracture of the tibial tuberosity.[6] Numerous surgical treatments have been described,[8,9] including open and closed (percutaneous pinning) techniques.[2] The technique most frequently used in the reduction and fixation of physeal fractures involves the placement of smooth Kirschner wires that can be inserted in parallel, crossed, converging, diverging, passing through the cortex or left inside the medullary

Physeal fractures of the tibia are common and can be treated surgically with open or closed techniques.

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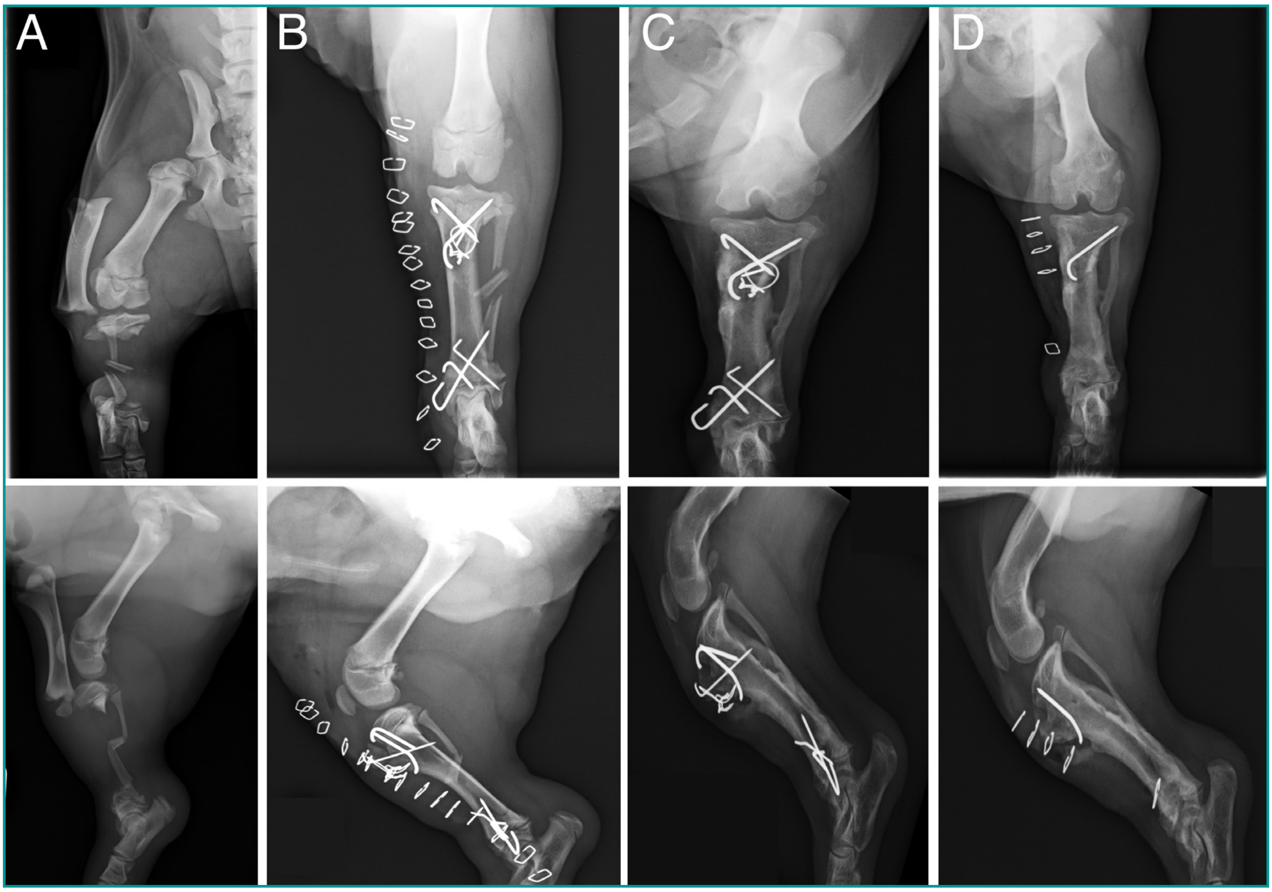

Figure 1 - Perpendicular X-rays (**A**) prior to surgery, (**B**) after surgery, (**C**) at 20 days and (**D**) following removal of the implant, at 30 days. (**A**) The preoperative X-rays show severe, proximal, lateral dislocation of the right tibial shaft associated with fractures of the proximal and distal parts of the tibia. Fractures of the tibial tuberosity, fibula, distal physes of the femur and subluxation of the femoral head can also be seen. (**B**) The postoperative images show the reduction of the tibial shaft with good frontal and sagittal alignment. (**C**) This X-ray documents bone healing at 20 days. (**D**) Removal of the implanted fixation devices 30 days after surgery: a proximal nail was left in situ because it had become incorporated in the periosteal callus.

cavity in contact with the endosteum (Rush pinning).[4] The present clinical case describes the diagnosis and surgical treatment of fractures of all the tibial physes in a puppy. This case is singular for the severity of the tibial dislocation, the involvement of soft tissues and the configuration of the fractures diagnosed.

CASE REPORT

A 3-month old, mixed-breed, sexually intact male dog weighing 3.7 kg was brought to the University Veterinary Teaching Hospital at Padua following a collision trauma. On inspection, the dog, clearly in pain, had difficulty in maintaining a quadrupedal stance with lack of support of the right hind limb, which dangled and appeared swollen with loss of axis of the limb, valgus and external rotation of the foot. Both pelvic limbs had several lacerated-bruised skin wounds that involved the subcutaneous and superficial fascial layers without exposing the bone. Stabilization of the patient and pain management (butorphanol 0.2 mg/kg) enabled deep palpation which revealed severe shortening of the right leg, total distal mobility of the foot and a break in the continuity of the bone distal to the knee. The tarsal joint was palpable and stable.

The radiographic examination of the pelvis and pelvic limb, with perpendicular views, showed a physeal fracture (SH II) of the proximal tibial epiphysis, avulsion fracture of the tibial tuberosity (SH I) and physeal fracture (SH I) of the distal tibial epiphysis with proximal displacement of the tibial shaft, in the subcutaneous tissue, laterally to the femur (Figure 1A). There was also a displaced segmental fracture of the fibula, and a distal physeal compression fracture (SH V) of the ipsilateral femur with subluxation of the femoral head. With the subject sedated, the wounds were debrided and irrigated with sterile isotonic solution. The skin wounds were then dressed and protected with a soft, sterile bandage.

Given the severe muscle contraction and limb oedema as well as possible lesions from interrupted vascularization, the clinical plan was to monitor the patient's haematological parameters (blood count, platelet count and blood glucose), manage the pain and start antibiotic

prophylaxis (intravenous cephalosporin 25 mg/kg TID), postponing the surgery for 48 hours.
The operation involved a surgical access medial to the tibial shaft along its entire length, taking care to preserve the integrity and viability of the vessels, nerves and muscles. By blunt dissection of the subcutaneous tissue, the tibia was exposed and freed in order to be replaced in its correct anatomical position (Figure 2). After assessing the integrity of the margins and continuity of the bones, the tibial shaft was reduced using bone reduction forceps, trying to protect the periosteal tissue. The shaft was fixed at the proximal epiphysis by the insertion of two crossed Kirschner wires (Æ 1.5 mm), both introduced from the medial surface of the tibia, and at the distal epiphysis with three crossed Kirschner wires (2 of Æ 1.2 mm, 1 of Æ 1 mm) also introduced from the medial tibial surface. The tibial tuberosity was reduced and fixed using tension band cerclage, two Kirschner wires (1.0 mm) and a figure-of-eight cerclage (0.8 mm). The operation was completed with layered closure of the surgical access (Figure 2).
Postoperative radiographs showed reduction of the tibial physeal fractures, correct frontal and sagittal alignment of the tibia and correct positioning of the implants (Figure 1B). The patient was discharged on the second day to be treated at home with an antibiotic (cephalosporin 25 mg/kg SID) for 8 days and analgesia (tramadol 2 mg/kg BID) for 3 days together with complete rest in a confined space and then short walks on a leash, 3 times a day for 20 days, at an easy pace. A modified Robert-Jones bandage was applied for 5 days.

The tibial shaft was reduced by means of crossed, proximal and distal Kirschner wires. The tibial tuberosity was fixed with tension band cerclage.

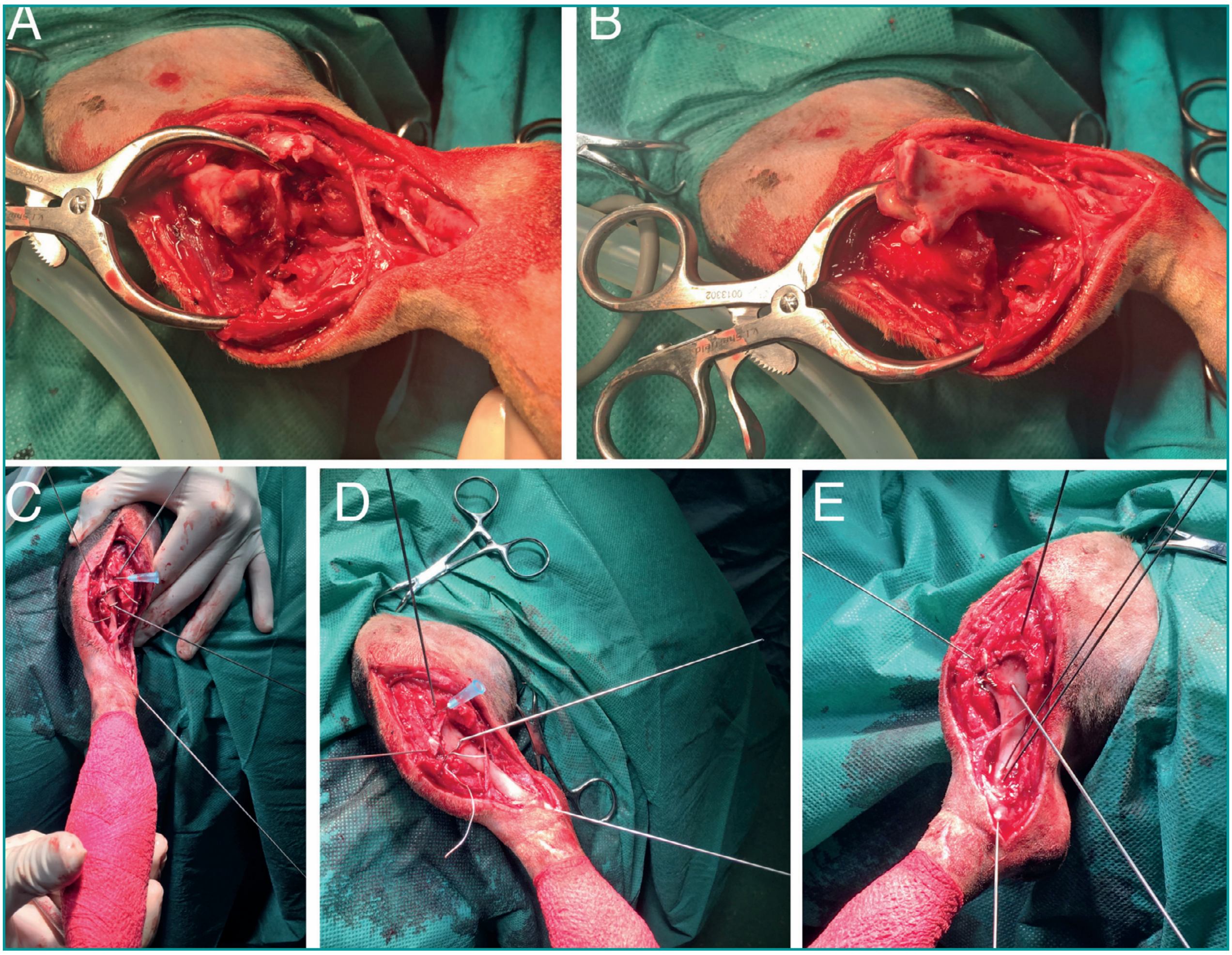

Figure 2 - Intraoperative images documenting (**A**) proximal dislocation of the tibia and (**B**) its subsequent reduction in the correct anatomical location. The cranial branches of the artery, vein and saphenous nerve have been preserved. (**C-E**) Fixation of the tibial fractures using crossed Kirschner wires and tension band cerclage. A 23 G needle was inserted into the medial side of the proximal tibia to identify the physis.

One week after surgery, the animal had grade III lameness of the operated limb, modest load-bearing and oedema of the foot. There were no signs of infection of the surgical incision or fracture site. After 20 days, an improvement in symptoms was evident, with grade II lameness, passive joint movements within the norm and modest pain on palpation of the limb. The control radiographs documented good frontal alignment, slight recurvatum and an abundant periosteal reaction (Figure 1C). At 30 days, the fracture healing was confirmed radiographically (Figure 1D) and, with the animal deeply sedated, the implants were removed. At the 45-day follow-up, the animal had grade I lameness of the right hind limb, which was improving progressively, and a normal range of joint movements. The dog's owner, who reported that the animal had returned to a normal life, was satisfied.

DISCUSSION

Successful surgical treatment of physeal fractures depends on several factors including the promptness of the diagnosis, the type of fixation and the age of the subject.[1] Early diagnosis and therefore immediate treatment facilitate anatomical reduction of fracture fragments with correct alignment of the limb.[1] A fracture that is diagnosed or treated late is more difficult to reduce and the reduction is often more traumatic because the fibrous callus must be removed from the already remodelling and spontaneously healing bone ends. Failure to treat physeal fractures, if dislocated, is a cause of rotational and axial bone deformities.[1-4] In this case, surgical correction requires not only a careful preoperative evaluation of the bone deformities, but also the use of fixation devices that guarantee both stable fixation of the fracture and preservation of the residual growth potential of the physes.

Open surgery was preferred because of the severe proximal dislocation of the tibia and the need to monitor the integrity of the nerves and blood vessels.

An internal pinning technique[1,4] was considered the best fixation strategy because of the subject-specific advantages it offered, which we considered fundamental for the success of the treatment. Above all, open surgery enabled an accurate assessment of the viability and integrity of the soft tissues (which, given the severity of the trauma, could have compromised bone healing, preventing the animal's convalescence) and prompt reduction and optimal fixation of all the fractures present with only moderate trauma to both soft tissues and bone.
Percutaneous pinning[2,11,12] was a potential surgical alternative. Fixation of the physeal fractures would have been achieved with the same devices but inserted with a minimally invasive technique, that is, through small skin incisions to introduce the Kirschner wires. The advantages reported in the literature for this type of technique include less postoperative pain, faster healing and less iatrogenic damage to structures such as the growth plates, joint capsule, periosteum and adjacent soft tissues that contribute to the vascularization of the surgical site.[2,11] The speed and accuracy of the whole procedure can be increased by the use of intra-operative fluoroscopy. Using this technique, we would have plausibly avoided the periosteal reaction detected in the follow-up X-rays. However, we could not use this technique in our patient because of the dislocation of the bone that needed to be reduced. Forced manipulation from the exterior could have created greater tissue damage than an open approach. In addition, although successful percutaneous fixation of tibial avulsion fractures has been described,[12,13] we considered that tension band cerclage guaranteed greater fixation stability.

Radiographic controls of physeal fractures are performed more frequently in skeletally immature subjects than in adult animals.

The frequency of radiographic monitoring of bone healing in skeletally immature patients is extremely important and different from that required for adult subjects. A young animal has a high healing potential[1,2] and bones usually heal within 3-4 weeks after surgery.[2] Removal of the implants is also important and must be planned in concert with radiographic healing because, if left *in situ*, they can hamper residual growth of the physes and cause further vascular damage.

Key factors in the surgical management of physeal fractures are early diagnosis and treatment, frequent follow-up and planning the removal of the fixation devices.

In conclusion, this clinical case illustrates the surgical management of a set of tibial physeal fractures: the treatment restored the tibial anatomy, preserved the function of the knee and tarsal joints, and ensured the puppy's return to normal activity. An early diagnosis and treatment, repeated clinical and radiographic monitoring and planning of implant removal are key factors for ensuring a good prognosis.

KEY POINTS

- Tibial physeal fractures are reported frequently in the literature.
- A rare, severe proximal dislocation of the entire tibial shaft was diagnosed.
- Open surgery enabled easy reduction of the tibial shaft.
- Radiological healing was present at 30 days.
- An early diagnosis and prompt treatment are important for the prognosis.
- Clinical and radiographic monitoring is required more frequently in a puppy than in an adult.

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