Salter-Harris type III fractures of the distal humerus in two dogs

G. M. Hayes; H. Radke; S. J. Langley-Hobbs
The Department of Veterinary Medicine, University of Cambridge, Madingley Road, Cambridge, UK

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Summary
Salter-Harris type III fractures of the distal humerus in a four-month-old male Labrador Retriever and a male crossbreed dog (estimated to be 3.5-months-old) are reported. Both fractures were treated with open reduction and interfragmentary compression by lag screw fixation. Both fractures healed and full limb use was regained at four weeks postoperatively.

The occurrence of this unusual fracture type may be related to the physeal closure pattern of the distal humeral physis, and a different mechanism of injury compared to the more common Salter-Harris type IV fracture seen in this region.

Case one
A four-month old male entire Labrador retriever, weighing 14.1 kg, was presented with a non-weight bearing lameness of the right forelimb of one day duration. The puppy was kennelled and owned by a pet food manufacturing company. The day before presentation the puppy was reported to be slightly lame in the morning and completely non-weight bearing on the right forelimb by the afternoon, although no trauma was reported.

Radiographic examination demonstrated a medially displaced fracture of the medial aspect of the physis of the right humeral condyle (Fig. 1). Parenteral methadone (0.3 mg/kg intramuscularly every 4 hours) and carprofen (4 mg/kg subcutaneously every 8 hours) were administered and surgery was scheduled for the following day. The puppy was premedicated with acepromazine (0.015 mg/kg intramuscularly) and methadone (0.3 mg/kg intramuscularly) prior to induction with thiovet (1 mg/kg intravenously) and anaesthesia was maintained with oxygen and halothane. A medial approach to the left elbow was performed to locate the fracture fragment. The epiphyseal fragment, comprising the medial part of the humeral condyle and medial epicondyle, was further displaced to allow inspection of the fracture surface. A 3.5 mm glide hole was drilled in a retrograde manner prior to reduction of the fracture fragment and placement of a 40 mm length 3.5 mm cortical screw with washer in lag fashion. Due to interdigitation of the epiphyseal fracture fragment, no further anti-rotational fixation was deemed to be necessary and routine wound closure was performed. Bupivacaine (1 mg/kg) was injected intra-articularly during closure. Postoperative radiographs were taken (Fig. 2) and a spica bandage was applied for three days postoperatively. Opiate analgesia (methadone 0.3 mg/kg IM every 4 hours for 24 hours then buprenorphine 0.02 mg/kg subcutaneously every 8 hours) was maintained until discharge three days after surgery. The puppy was discharged and the owner received instructions to administer carprofen (2 mg/kg per os every 12 hours for 5 days) and to limit activity to cage rest and short lead walks. At the time of discharge the puppy was beginning to bear weight on the affected limb. Follow-up radiographs were taken four weeks postoperatively and these showed signs of complete fracture healing (Fig. 3). At this point, the elbow had a normal range-of-motion and the puppy was sound. A plan of increasing leash exercise was advised over the following four weeks. Subsequent recovery was unremarkable and the dog received regular veterinary examinations until the pet food manufacturing company

Introduction
Salter-Harris physeal fractures of the distal humerus occur frequently in immature animals. The most common of these is a type IV fracture of the lateral portion of the humeral condyle, but types II and I are also encountered in dogs with decreasing frequency (1–3). To the authors’ knowledge, Salter-Harris type III fractures of the distal humeral physis have not previously been described in the veterinary literature apart from a single case noted in a short review comprising 32 distal humeral physeal fractures (3). Type III injuries involve the physis and the epiphysis, and as such, require accurate anatomic reduction and rigid internal fixation in order to restore articular congruency (4). Salter Harris type III fractures of the distal humeral physis are reported here in two young dogs. The pathogenesis, classification and treatment of this unusual fracture is discussed and compared with the more common type IV fracture that is seen in this region (5).
closed the kennels two years later and the dog was lost to follow-up.

**Case two**

A male entire crossbreed dog, estimated to be 3.5-months-old and weighing 6.85 kg was presented to a rehoming centre with a non-weight bearing lameness of unknown duration and unknown aetiology. Radiographic examination demonstrated a fracture of the medial aspect of the epiphysis of the right humeral condyle with medial and proximal displacement. There was no evidence of callus formation or bone resorption suggesting that the fracture had occurred very recently, estimated to be within the last 24 to 48 hours (Fig. 4). Parenteral methadone (0.3 mg/kg intramuscularly every 4 hours) and meloxicam (0.2 mg/kg subcutaneously) were administered and surgery was scheduled for the following day. The puppy was premedicated with acepromazine (0.01 mg/kg intramuscularly) and methadone (0.3 mg/kg intramuscularly) prior to induction with propofol (4 mg/kg intravenously) and anaesthesia was maintained with oxygen and isoflurane. A medial approach to the left elbow was performed to locate the fracture fragment. The epiphyseal fragment, comprising the medial part of the humeral condyle and medial epicondyle, was rotated distally to allow inspection of the fracture surface. A 2.7 mm glide hole was drilled in a retrograde manner prior to reduction of the fracture fragment and placement of a 32 mm length 2.7 mm cortical screw with washer in lag fashion. Two 1.1 mm Kirschner wires were then inserted from the medial epicondyle into the metaphysis to prevent fragment rotation and augment the fixation prior to routine wound closure. Postoperative radiographs were taken (Fig. 5) and opiate analgesia (buprenorphine 0.02 mg/kg intramuscularly every 6 hours) was continued until discharge two days after surgery. The dog was discharged and the owner received instructions to administer meloxicam (0.1 mg/kg every 24 hours for 7 days) and to limit activity to cage rest and short lead walks. Follow-up radiographs were taken four weeks post-operatively and these showed signs of complete fracture healing (Fig. 6). At this time, the elbow had a normal range of motion and the dog was sound. A plan of increasing leash exercise was advised over the following four weeks. Eight weeks after surgery the dog was presented with a large seroma focused over the lateral aspect of the 

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*Metacam: Boehringer Ingelheim, Bracknell, UK  
Propofol: Abbott Laboratories, Maidenhead, UK*
elbow but it was not lame. No angular deformity or length discrepancy was noted on clinical examination at this time. Although no implant migration was present on radiographs, the implants were removed under general anaesthesia and the seroma was aspirated. A compressive bandage was applied for five days postoperatively. The seroma resolved over the following two weeks and no further complications arose in the following six weeks after which the dog was rehomed and lost to follow-up.

Discussion

Salter Harris type III fractures of the medial aspect of the distal humeral epiphysis were successfully stabilised with lag screw fixation and interfragmentary compression, and at the short-term follow-up examination, both dogs had regained good function in the limbs. The Salter-Harris classification is based on the mechanism of injury and was initially proposed to be helpful in humans in determining the appropriate method of treatment and prognosis following physeal injury (3, 5). The most commonly encountered distal humeral physeal fracture in dogs is the Salter-Harris type IV fracture of the lateral aspect of the distal humeral physis (1–3). This fracture is thought to result from shearing forces transmitted up the weight-bearing axis from the radial head and is associated with minor trauma in young dogs of around four months of age (1, 2). The type IV fracture, which is intra-articular, extends from the joint surface through the epiphysis, across the full thickness of the epiphyseal plate, and through a portion of the metaphysis, thereby producing a complete longitudinal split (5). The fractures reported herein are also intra-articular fractures, but the fracture extended from the joint surface to the weak zone of the epiphyseal plate and then extended along the plate to the periphery (5). The distal humeral epiphysis in the dog is not straight but diverges proximally on the medial and lateral aspects of the bone so the medial and lateral epicondyles are part of the epiphysis. The mechanism of fracture of the medial aspect of the humeral condyle in dogs is unknown, but in humans this injury is thought to occur due to a fall onto an outstretched arm with the elbow forced into valgus (6). The firmly attached medial collateral ligament and flexor tendons cause avulsion of an epiphyseal fragment through the weak physis and intercondylar notch (Fig. 7). A similar mechanism involving valgus stress on the physis is impli-
cated in the pathogenesis of Salter-Harris type III fractures of the medial aspect of the distal femoral epiphysis in humans (7). Type III fractures are uncommon both in domestic animals and humans, the reason for this may be that they occur from a specific mechanism of injury to certain hinge joints at a precise time during early growth plate closure. To the authors’ knowledge, the pattern of growth plate closure has not been reported in the dog, but reference to cadaver bones does suggest that a specific pattern of growth plate closure occurs in other species, similar to humans (8). Certain physes are known to fuse from the centre towards the periphery and in this fracture, a valgus stress is thought to be transmitted through the collateral ligament, which opens the physis medially, propagates towards the centre of the physis, then down the intercondylar notch (7). Evaluation of radiographs of the distal humerus in three to five-month-old dogs would support this theory as the abaxial aspects of the physis are wider than the axial region (unpublished observation). The Til-laux fracture (Salter-Harris type III) of the anterolateral distal tibial physis of humans has a similar pathogenesis and occurs following forceful external rotation of the foot during the 18 month time period when the distal tibial physis is closing. This physis has been shown to close centrally then from medial to lateral, thus supporting the hypothesis that Salter-Harris type III fractures are an injury related to the pattern of closure of the growth plate (8).

The cases reported here were treated with open reduction and internal fixation to achieve good articular congruency, which is the primary objective for type III fractures (5). Compression was obtained by transcondylar lag screw fixation. Whilst an anti-rotation Kirschner wire is routinely used for type IV fractures, a correctly reduced type III fracture should not require ancillary fixation. The use of additional Kirschner wires in case two and the use of a postoperative dressing in case one were clinical decisions made at the discretion of the individual surgeons. The cause of the lateral seroma eight weeks after a medial approach in case two is unknown. Seroma formation is uncommonly reported after humeral condylar fracture repair, but it is very common after surgery for incomplete ossification of the humeral condyle (9, 10). An overtly long screw tip protruding into loose subcutaneous connective tissue around a high motion joint may predispose to this complication.

Although the distal humeral physis accounts for 20–40% of humeral growth, only around seven percent of canine physeal fractures result in growth deformity (3, 11). Salter-Harris type III and IV fractures may be more likely to result in varus or valgus deformity than other types by causing premature partial physeal closure (5). This did not appear to occur in the cases described although radiographic follow-up at complete skeletal maturity was not available. A recent prospective case control study which evaluated dogs following repair of Salter-Harris type IV fractures of the lateral aspect of the humeral condyle did not find any evidence of humeral shortening or deformity, but a paradoxical slight proximal physeal overgrowth of the affected humerus. That study did not find any evidence to support the routine removal of distal humeral physeal implants (12). A review of physeal fractures in children reported that 12% of the fractures were complicated by premature physeal closure and this was associated with the mechanism of injury and the amount of initial displacement (13). Another recent human study of Salter Harris type III and IV fractures reported a two percent risk of premature physeal closure and suggested that prompt open surgical reduction and internal fixation improved their patient outcomes as compared to the findings described in other published reports (14).
To conclude, a Salter Harris type III fracture can occur in the distal humerus of the dog, however the pathogenesis is likely to be different from that of the common Salter Harris type IV fractures of the distal humeral condyle. Firm conclusions cannot be made on prognosis based on the results of only two cases with only short-term follow-up.

References


