# Physeal fractures in immature cats and dogs: part 1 – forelimbs

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**Fractures in animals less than one year of age are frequently observed by vets and reported to comprise 50% of all fractures in dogs and cats[1,2].**


**Figure 1.** Mediolateral and craniocaudal radiographs of the antebrachium of a six-month-old labradoodle with a premature closure of the distal ulna physis and subsequent angular limb deformity with marked carpal valgus.

A total of 30% of these fractures are reported to affect the growth plate, or physis. This high incidence of physeal fractures is observed because the physis is composed predominantly of cartilage, rendering it mechanically weaker than adjacent areas of ossified bone.

The anabolic state of the juvenile skeleton means the repair process is rapid. However, damage to the physis – from the original injury or through trauma during surgery or the placement of transphyseal orthopaedic implants – can cause premature fusion of the physis.

While compensatory growth may occur at the remaining open physes in the limb, premature closure of one side of the physis or complete closure of a physis where paired bones exist (for example, radius and ulna) can lead to the development of an angular limb deformity (**Figure 1**).

This series of articles will cover considerations of physeal fractures of the forelimb (part one) and hindlimb (part two).

## Salter-Harris classification

The Salter-Harris classification system for physeal fractures is in common use (**Figure 2**) and was devised by Robert Salter and Robert Harris in 1963[3].

It was originally designed to prognosticate about outcomes following fracture repair, with Salter and Harris reporting the outcomes following experimentally induced physeal fractures of each type. However, it has now been shown the prognosis after experimental injury may not be applicable to clinical cases[4].

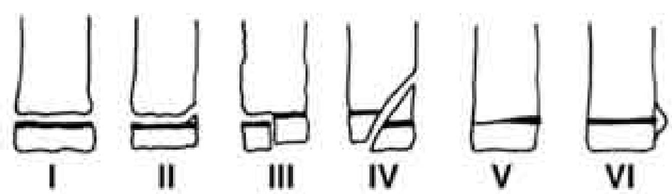


**Figure 2.** Schematic representation of the Salter-Harris classification system for physeal fractures.

A study of 13 physeal fractures showed the histological appearance of the physis in the injured animal correlated more closely with the clinical findings of growth retardation than the fracture configuration previously suggested by Salter and Harris. Nevertheless, the Salter-Harris classification system is still in use today as a standard system of nomenclature to describe physeal fractures (**Figure 2**).

## Principles of fracture fixation

Although bone healing in immature animals is rapid, it presents a unique set of challenges that should be remembered when planning fracture stabilisation surgery:

- Perform the least invasive method of reduction and fixation necessary to permit healing.
- Reduce fractures as early as possible and, as a maximum, 72 hours after the original injury.
- Bone is soft with a thick periosteum so care should be taken not to crush the periosteum or epiphyseal bone during manipulation or damage the germinal cartilage within the physis. Use pointed reduction forceps when necessary to manipulate fracture fragments.

- Implants should not span the physis unless completely necessary. When required, smooth Steinmann pins or arthrodesis or Kirschner wires (K-wires) should be used placed at angles as perpendicular as possible to the growth plate, to allow longitudinal growth to continue.

## Scapula fractures

Physeal fractures of the scapula are uncommon. The main physis present that can sustain fracture is the supraglenoid tubercle, which is reported to close at around six months in dogs and four months in cats.

### Supraglenoid tubercle avulsion

The originating biceps brachii muscle can result in avulsion fractures of the supraglenoid tuberosity – particularly in immature large breed dogs. For recent fractures, stabilisation is reported using a single lag screw into the neck of the scapula or placement of pins and a tension band wire.

Care should be taken during wire placement to avoid damage to the suprascapular nerve.

An osteotomy of the greater tubercle of the humerus may be necessary to gain access to the shoulder joint, although consideration should be given to the fact the greater trochanter may still have an open physis.

The initial lameness can resolve quickly, meaning some animals do not present in the acute phase and the diagnosis may be delayed. As the fractures are articular, non-reduced fractures will result in chronic secondary degenerative joint disease. In these cases, bicipital transection or tenodesis is indicated.

Even if early intervention is possible, a study of long-term follow-ups in 20 dogs showed 15% were free from clinical signs[5].

## Humerus fractures

**Figure 3.** Mediolateral radiographs of the humerus of a 12-month-old cavalier King Charles spaniel with a Salter-Harris type one fracture of the proximal humeral physis (left). This has been stabilised with parallel K-wires through the greater tubercle into the humeral diaphysis (right).

Physeal fractures of the humerus can affect the proximal or distal physes. The proximal physes usually fuse by 12.5 months in dogs, but can take as long as 21 months in cats.

The distal condylar physis has usually fused by six months in the dog and three months in the cat. However, although the pathogenesis is under debate, some breeds, such as spaniels, are reported to have incomplete ossification of the humeral condyle, meaning physeal injuries are observed in adult, otherwise skeletally mature, dogs, as well as juveniles.

## Proximal humeral physes

The humeral head and greater tubercle have separate centres of ossification, meaning they can fracture off alone or both can separate off and remain attached together (**Figure 3**) or separate completely, leading to a three-piece fracture.

The fractures of the proximal humerus are usually Salter-Harris type one, although an additional section of metaphyseal bone can remain attached to the humeral head, converting it to a Salter-Harris type two.

When the greater tubercle is fractured (with or without the humeral head attached), fixation is usually by two parallel K-wires so the articular surface of the humeral head is not traumatised (**Figure 3**).

An alternative in animals where the physis is close to fusing is a lag screw, but this will prevent any remaining growth potential across this physis.

Fractures of the humeral head alone are generally stabilised with two parallel K-wires inserted from the cranial aspect of the proximal humerus, just distal to the greater tubercle, so the tips of the wires reside in the humeral head.

## Distal humeral condyle

Salter-Harris type one fractures of the distal humeral condyle are uncommon, but more likely to be observed in cats than dogs. Treatment is open reduction and stabilisation with crossed K-wires, ensuring they do not broach the olecranon fossa, even though in cats this is imperforate.

**Figure 4.** Craniocaudal radiographs of the humerus of a 15-week-old border terrier with a Salter-Harris type four fracture of the distal humeral condyle (left). This has been stabilised with a transcondylar lag screw and washer and a K-wire along the lateral epicondylar ridge (right).

Cats have an additional supracondylar foramen and it is important to ensure this structure is avoided as the median nerve and brachial artery pass through it.

In dogs, it is more common to observe Salter-Harris type four fractures, which are articular and span the physis.

As aforementioned, two separate, distinct age ranges are usually apparent with dogs, presenting either at less than four months of age or greater than two years. These fractures can occur with surprisingly minimal levels of trauma.

The majority of cases (75%) will fracture only the lateral portion of the humeral condyle (**Figure 4**). A minority (5%) will fracture the medial portion of the condyle only and some dogs, unfortunately, present with bicondylar fractures (also called Y-fractures or T-fractures if very transverse).

The authors' preferred method of stabilisation for these fractures is using a transcondylar lag screw with a single K-wire for unicondylar fractures (**Figure 4**) or two crossed K-wires for bicondylar fractures if the patient is skeletally immature.

However, this fixation is under debate and some surgeons will always place unilateral or bilateral plates and screws and evidence now exists that this will result in a lower complication rate[6].

In mature dogs, the diameter of the transcondylar screw is made as large as possible, since the fracture line may never heal (4.5mm screw in a springer spaniel) and plates are placed on the lateral or medial epicondylar ridge, as necessary, instead of K-wires to provide additional stiffness.

## Radius and ulna fractures

**Figure 5.** Mediolateral radiographs of a skeletally immature domestic shorthaired cat with a Salter-

Harris type one fracture of the proximal ulnar olecranon physis (above). The fracture has been stabilised with two K-wires and a figure-of-eight tension band wire (below).

Physeal fractures of the radius and ulna are uncommon. However, damage to the distal physes leading to premature physeal closure – particularly in the ulna – is more common.

Due to the paired nature of these bones, damage to one physis with continued growth of the paired bone will result in an angular limb deformity.

## Proximal radius and ulna

Salter-Harris type one fractures of the radial head have been reported and are repaired with crossed K-wires. Fractures of the proximal ulna physis are apophyseal or traction fractures due to the distractive force of the triceps muscle.

They, therefore, require repair with pin and tension band wires to counteract the tension, to permit healing of the fracture. However, the tension band wire has the potential to limit growth across the physis. This is unlikely to be of any clinical consequence, though, as the fracture is proximal to the elbow joint (**Figure 5**).

## Distal radius and ulna

Distal radial or ulna fractures of the styloid processes can occur with or without carpal luxation, or concurrent Salter-Harris type one fractures of the distal radius. Fixation of the distal ulna is usually achieved with a single intramedullary K-wire or a K-wire angled obliquely into the radius with or without a tension band wire, if the animal is reaching skeletal maturity.

Fractures of the radial styloid process can be stabilised with parallel K-wires, a lag screw or K-wires with a tension band wire. The two latter methods should be reserved for animals close to skeletal maturity.

Salter-Harris type one separation of the distal radial growth plate can be stabilised with crossed K-wires (**Figure 6**)
or two parallel K-wires introduced from the cranial aspect of the distal radius and angled caudally and proximally to span the physis.

## Angular limb deformities

The distal ulna physis is predisposed to a crushing injury, classified as a Salter-Harris type five injury due to its conical shape (**Figure 1**).

**Figure 6.** Mediolateral (left) and dorsopalmar (right) radiographs of the antebrachium of a one-year-old domestic shorthair cat with a Salter-Harris type one fracture of the distal radial and ulnar physes. These have been stabilised with two K-wires.

Furthermore, the distal ulna growth plate is entirely responsible for longitudinal growth of the ulna distal to the elbow since the proximal physis is responsible for the length of the olecranon alone. Therefore, any retardation of the growth originating from the distal ulna physis is amplified.

In a study of 39 angular forelimb deformities, premature closure of the distal ulna physis accounted for 83% of cases[7]. These usually present with cranial and lateral bowing of the distal radius, radial shortening in the elbow and carpal valgus with external rotation of the foot.

Severe cases also have subluxation of the elbow.

Early corrective surgery is vital to prevent, or at least limit, subsequent degenerative changes in the elbow and carpus.

In skeletally immature dogs, a distal ulna ostectomy alone is sufficient for mild cases, while severe cases are likely to require a concurrent corrective radial osteotomy, ostectomy of the distal radius or radial lengthening procedures, which are beyond the scope of this article.

## Metacarpal fractures

Metacarpal fractures will be covered along with metatarsal fractures in the second article in this series.

- Physeal fractures in immature animals: part 2 – spine and hindlimbs

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