

# Avian orthopaedic surgery

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### **Structure of avian bones**

The bones of birds have a number of differences from mammalian ones, most of which are adaptive for flight. The skull is pneumatized, has large orbits, and the jaws have been lightened by the replacement of the teeth with the horny beak. Many of the avian vertebrae are fused to each other to provide a more rigid framework for the muscles. The exceptions are the cervical vertebrae, where there are more vertebrae than in mammals and they are highly mobile. The vertebral column is sub-divided into cervical, thoracic and free caudal vertebrae, a fused synsacrum and a pygostyle.

The sternum (keel) is a ventral plate of bone that provides an important attachment for the pectoral flight muscles. In flightless birds, (such as kiwi and ostrich) the sternum is reduced or absent. Vertebral and sternal ribs attach the keel to the vertebral column. The thoracic girdle is composed of a coracoid, clavicle and scapula, which all articulate with the humerus. The coracoid bones are short and thick, and prevent the chest cage from collapsing during flight. The clavicles may fuse to form a furcula (poultry) or be attached only by connective tissue (parrots). The scapula is attached to the ribs by ligaments, and its length is proportional to the strength of flight.

The thoracic wing is composed of the humerus, radius and ulna, alula, carpo-metacarpus, the major digit with two phalanges and the minor digit with one phalanx. The humerus is pneumatized and connected to the clavicular air sac. The ulna is the larger of the two bones in the antebrachium and is more caudal in location. The primary flight feathers attach directly onto this bone. Both the radius and ulna are not pneumatized and contain marrow. The manus (hand) has been reduced to form a strong flat surface for attachment of the primary wing feathers and is relatively immobile. The carpus has only radial and ulna carpal bones and is restricted to flexion and extension of the joint.

The pelvic girdle is made of the fused synsacrum, which consists of sacral vertebrae, the ilium, ischium and pubis. The pubic bones are not fixed ventrally. Ventrally on the pelvis are the renal fossae for the caudal divisions of the kidney. The pelvic limb is composed of a pneumatized femur, and the tibiotarsus, fibula, tarsometatarsus, a metatarsal bone and usually four digits, with between 2 and 5 phalanges.

Avian bone has higher calcium content and a thin brittle nature compared to mammalian bone. This brittleness limits the use of plates and screws as iatrogenic fractures and fragmenting of the bone around these is common. There is little covering soft tissue compared to mammals and some bones are pneumatized and connect to the respiratory system. Pneumatized bones receive most of their vascular supply from the periosteum so it is important to maintain this wherever possible. However, avian bone heals more rapidly than mammalian bone. Clinical stability of a stabilised and opposed fracture can occur in as little as two to three weeks, and shows complete healing on radiographs by three to six weeks.

### **Fractures and repair**

The method chosen to repair a fracture should take into account the injury, the natural behaviour of the bird, and the expected future use of the limb. Companion birds will not necessarily require perfect bone alignment, whereas in wild birds where the aim is for rehabilitation back to the wild, full return to function is required.

Triage of wild bird patients is important to reduce unnecessary pain and suffering by attempting fracture repair in cases where release is not possible. The principles of fracture stabilisation are the same as for mammals. The aims are to cause minimal soft tissue damage, to maintain the length, rotation and angular orientation of the bone, to maintain anatomic alignment, and to provide rigid stabilisation. Stabilisation involves neutralising rotation, bending, compression and shearing forces. This will ensure minimal disturbance of callus formation.

Before attempting to stabilise a fracture, an assessment should be made of the viability of the neurological and vascular supply distal to the fracture. Avoiding ankylosis of joints should be a primary goal of the treatment. Physiotherapy should be instituted to achieve this as soon as possible after surgery and the use of restrictive wing bandages must be tempered by this complication.

The types of fixation used in birds are similar to those used in mammals, however, bone plating is rarely used due to the thin cortex of most species.

## **External coaptation**

The use of bandages and splints is the emergency stabilisation of choice for avian patients. There are situations when external coaptation will be the main method of fracture stabilisation. In very small patients, tape splints are often sufficient for many leg fractures. They may also be considered where fracture ends are minimally displaced, or where anaesthesia and surgery are considered to be life-threatening. In metabolic bone disease, the bone may be too soft to allow any other fixation than external coaptation.

Fracture disease consisting of mal-alignments, muscle atrophy, joint ankylosis and tendon contracture are common sequelae to the use of this fixation method.

## **Intramedullary pinning**

Intramedullary pins can be used in any long bone fracture. They provide excellent resistance to bending forces but not to rotational or shear forces. They can generally be placed either open or closed, retrograde or normograde. Their disadvantages include joint penetration, pin migration, and their tendency to cause peri-articular fibrosis. They can be combined with cerclage wires, inter-fragmentary wires, and external fixators. Rush or cross pinning can be used for fractures close to joints.

The diameter of the intramedullary pin should be no more than 50% of the bone diameter. This limits the weight and allows formation of an endosteal callus.

Another form of intramedullary pinning is the use of shuttle pins or rod/acrylic implants. However, these are permanent implants and require very invasive surgery. The advantage is that there is no external hardware, no joint intrusion and allow an immediate return to function. They are not usable with open, contaminated or comminuted fractures.

## **External fixators**

External fixators are good choices where there is sufficient fragment length to insert two or more pins. The advantages of this device are that it provides excellent rotational and moderate bending stability. Also, placement of the pins avoids excess trauma to the fracture site. Most importantly, this device protects joint integrity and allows physiotherapy to commence very rapidly after surgery. The disadvantages of external fixators are that there are multiple pin-holes and tracts and there is more weight than in other methods of stabilisation. Using acrylic bars (polymethylmethacrylate, or 'Knead-It') rather than the clamps and bar of the Kirchner-Ehmer device can reduce the weight of these devices. Also, weight can be reduced by using the smallest diameter pins, Kirchner wires, or even hypodermic needles that are consistent with the required device strength. Type I, type II and type III fixators have all been used successfully in birds, depending on the degree of stabilisation required.

When used in combination with an intramedullary pin (Tie-in technique) the stabilisation against bending, shear and rotational forces is excellent. Further, the fixator removes the load from the fracture and patients begin weight-bearing within days of the surgery. This is the technique of choice for mid-shaft fractures of the humerus and femur. The disadvantage is the longer surgical time, and increased material cost of the device.

The main problem associated with external fixators is slippage of the device if improper positioning of the pins occurs. The use of threaded pins helps in larger bones, or angling pins ~ 30 degrees to the perpendicular in different directions helps maintain the fixator position.

## Bone grafting

Bone grafting is a common technique to promote fracture healing. Autogenous bone graft collection sites in birds are limited to the ribs or the central portion of the keel (cortico-cancellous bone). In larger birds, cancellous bone may be harvested from the proximal tibiotarsus or ulna. The pneumatic bones (humerus, femur and pelvis) are unsuitable as sources of graft material. Allografts or xenografts have been used but are associated with a high incidence of incisional dehiscence, sequestrum formation and foreign body reaction.

## Recommended repair by fracture site

### Coracoid

- IM pinning
- Steel sutures

### Humerus – diaphyseal

- External fixator/IM pin Tie-in (preferred option)
- IM pin with body bandage
- Body bandage alone (poor prognosis for flight)

### Humerus – proximal

- External fixator/IM pin Tie-in
- Tension band
- No fixation (small birds)

### Humerus – distal

- Transarticular external fixator
- Cross-pinning
- Methacrylate and shuttle pin

### Radius/Ulna

- IM pinning (of one or both) with short term external coaptation
- External fixator (usually ulna - preferred option)
- External coaptation (if only one fractured)

### Carpo-metacarpus

- External coaptation (preferred option)
- IM pin
- External fixator

### Femur

- External fixator/IM pin Tie-in (preferred option)
- IM pinning ( $\pm$  cerclage or interfragmentary wire)
- External coaptation (spica splint)

### Tibiotarsus

- Type II fixator (preferred method)
- Type I fixator
- IM pinning (entry through tibial crest)
- External coaptation (Thomas splint - large birds, tape splint - small birds)

### Tarsometatarsus

- Type I or II external fixator
- External coaptation (Plantar splint, tape splint)
- IM pinning – no marrow cavity

## Digits

- External coaptation (snowshoe splints, digit to digit splints)
- Luxations

Luxations have approximately a 30% chance of full recovery if successfully reduced and stabilised early. Unstabilised luxations quickly (< 3 days) form peri-articular fibrosis.

## **Recommended repair by luxations site**

### Shoulder

- External coaptation (wing to body bandaging)
- Open reduction via dorsal approach and figure of eight wiring/suture of humerus to clavicle/coracoid

### Elbow

- Reduction by flexing the elbow and internally rotating, while applying pressure to radial head
- Stabilisation by figure of eight bandage (5-12 days) if no joint laxity, or by trans-articular external fixator if unstable

### Carpus

- Reduction by traction and dorsal abduction, then flexing and adducting
- Stabilisation by figure of eight wing bandage (5-12 days), or in large birds by trans-articular external fixator

### Coxofemoral

- Closed reduction and Spica splint stabilisation
- Surgical reduction and stabilisation sutures from trochanter to greater iliac crest
- Femoral head and neck excision arthroplasty for chronic luxations

### Stifle

- Surgical reduction and trans-articular external fixator
- Conjoined intramedullary pin placement
- Extracapsular stabilisation

### Beak

- Reduction under general anaesthesia using a pin through the frontal sinus as a fulcrum

## **Amputation**

Amputations are a last resort surgery but captive birds can cope well in a controlled environment. Limb amputations preclude the rehabilitation of wild birds. Indications for amputation may include avascular necrosis, distal limb neuropathy (e.g. brachial plexus avulsion), neoplasia and osteomyelitis.

### Wing

Wing amputations are best undertaken in the humerus where there is sufficient soft tissue for stump coverage. The bone is transected in the upper third of the humerus, and the skin and musculature is transected at the elbow. The major blood vessels and radial nerves are located medially.

### Leg

Leg amputations are best undertaken in the middle of the femur. The skin and musculature is transected at the stifle and used to form the stump. Psittacine birds can use their beaks to ambulate and cope very well, although the contra-lateral foot should be monitored for bumblefoot. The major blood vessels and ischiatic nerve are located medially.

## References and recommended reading

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