AVIAN ORTHOPEDIC SURGERY

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Learning Objectives

• Review recommendations for initial evaluation and diagnosis of avian patients with suspected fractures
• Review the special considerations for avian bone and fracture healing
• Describe fracture immobilization techniques
  o Non-surgical
  o Surgical
  o Provide examples by affected bone
• Review post-operative care recommendations for avian patients
• Identify and prevent common complications of fracture repair in birds

Initial evaluation

• History
  o Nature of injury
  o Duration problem
  o Bleeding noted
  o Diet/other husbandry issues
  o Concurrent medical problems
• Physical Exam
  o Evaluation from distance: posture, lameness, abnormal wing position
  o Complete examination
  o Proximal to distal evaluation of limbs to prevent further injuries
• Stabilization of the patient
  o Supportive nutrition, temperature and fluid therapy +/- blood transfusion
  o Analgesics (opioids and NSAIDs) +/- prophylactic antibiotic and antifungal treatment
  o Temporary immobilization
  o Wound care (open fractures; careful w/ pneumatic bones!!)
• Diagnostic procedures
  o Under anesthesia when stable
  o Radiographs +/- CT
  o Ultrasound: concurrent tendon injuries
  o Pre-operative blood testing (hemogram, biochemistry panel)
• Formulate treatment plan
  o Consider spp., size, use, concurrent medical problems, finances, DVM experience
  o Fracture repair goals
    ▪ Promote functional use of affected bone
      • Wild Birds: Full Restoration
      • Captive/Companion Birds: restoration to comfortable and pain-free life
    ▪ Share load of bone during healing
      • Rigid stabilization in early stages and w/ limited use coaptation
      • Longitudinal and axial alignment
    ▪ Early return to normal function
    ▪ Low morbidity
      • Pre and post-operative care
      • Minimal surgical manipulation of fragments and damage to soft tissues (atraumatic surgery)
Avian Fracture Repair and Healing

• Challenges
  o Relatively long bones and strong muscles
  o Reduced soft tissue over bones and distal limbs
    ▪ Damage nerves and blood vessels
    ▪ Open fractures
  o Pneumatic bones → thin, brittle cortices
    ▪ Open fractures
    ▪ Decreased holding power for hardware
  o Bipedal locomotion
    ▪ Problem for leg fractures (immediate load bearing required)
    ▪ Advantage for wing fractures
  o Flight requirements: problem for wing fractures
  o Proximity of injury to joints
  o Exposed bone will sequester
  o Limited to no bone grafting options (minimal cancellous bone to harvest)
  o Rapid healing process → immediate immobilization required

• Healing main differences
  o Time
    ▪ Experimental (ulna)
      • Internal fixation: 5 weeks
      • External coaptation: 8 weeks
    ▪ Clinical
      • Internal fixation: 3-4 weeks
      • External coaptation: 4-6 weeks
  o Callus formation periosteal > endosteal surface
  o Blood supply to periosteum from surrounding soft tissues > intramedullary circulation

Methods for fracture immobilization

Cage rest

• Limited use for
  o Fractures of the digits
  o Metabolic bone disease fractures
  o Fractures of non-weight bearing bones in canaries and finches
• Important to limit activity by
  o Reducing photoperiod
  o Housing in aquarium or plastic carrier with no perches

External coaptation

• Indications
  o Distal limb fractures in small birds (cannot hold hardware)
  o If there is no requirement for full flight
  o Temporary stabilization
  o Coracoid fractures
  o Metabolic bone disease fractures
  o High anesthetic risk patients
• Principles
  o Immobilize the joint proximal and distal to the fracture
  o Counteract rotation, bending and compression forces
• Advantages
  o Easy and economic option
• Disadvantages
- Limited to proximal pelvic limb fractures and wing fractures
- Limits “normal” limb use (bulky, joint immobilization)
- Poor alignment and unstable fracture site
- Prolonged use → decreased range of motion of joints, damage to propatagium
- Can be damaged (parrots) or become loose

- Wing
  - Figure of 8 bandage: fractures distal to elbow
  - Body wrap: fractures proximal to elbow
  - Combination

- Pelvic limb
  - Robert Jones (body weight < 500 g)
  - Schroeder-Thomas Splints
  - Tape splint (body weight < 100 g)
  - Tibiotarsal-tarsometatarsal splint
  - Ball bandage

- Healing > 3-4 weeks

- Bandage care
  - Wing fractures
    - Wild birds: PT under anesthesia recommended after 7-10 days, 2-3 times per week
  - Leg fractures
    - Bandages should be replaced 5-7 days after (under anesthesia) or PRN
    - Replace or remove 21 days post-fracture; recheck every 7-15 days after
Surgical fixation

- **Options**
  - External skeletal fixator
  - Intramedullary pin (IM)
  - External skeletal fixator and IM pin tie-in
  - Cerclage
  - Bone plate
  - Open reduction
  - Closed reduction (preferred)

- **Equipment**
  - Hand tools vs. "power" tools
  - IM pins
  - ESF pins
  - Connecting bar
    - Metal
    - Hexalite
    - PMM/bone cement

- **External skeletal fixator (ESF)**
  - Type I, Type II, Type III
  - Advantages
    - Rotational stabilization
    - Maintain length of bone
    - Minimal damage to tissues, blood vessels and fracture site → minimal interference with healing process
  - Disadvantages
    - Weak opposition to bending forces
    - Requires appropriate pin placement and device construction
    - Pin pull-out or loosening occurs easily w/out threaded pins
  - ESF Type I
    - Uses: fractures of the humerus, ulna, metacarpus, femur
    - Partially threaded pins approximately 20% diameter of the bone and through at 30-45° angle
    - At least 2 pins in the proximal and 2 pins in the distal bone fragment

- **Intramedullary pin (IM)**
  - Uses: fractures of the radius and/or ulna, tibiotarsus, coracoid, humerus, metacarpus
  - Advantage: natural curvature of the avian bones facilitates application
  - Disadvantages
    - Only opposes bending forces → Required additional stabilization to limit torsional, compressive and tensile forces
    - If coaptation used for additional stabilization → ankyloses and other problems associated with coaptation
    - Risk joint damage and alter blood circulation and bone healing → should not be used when complete return to function is required
  - General principles
    - Materials: stainless steel vs. titanium vs. plastic/acrylic/PMM rods
    - Diameter 60-70% medullary canal (single vs. multiple pins)
    - Open vs. closed reduction
      - Closed: normograde
      - Open:
        - Retrograde → normograde (direction depends on bone)
        - Pin bending (titanium)

- **Tie-in technique**
  - Technique similar to application IM pin and ESF type-I
Advantages
• Combine advantages of both techniques
• Good fixation w/ normal range of motion of joints

Uses
• Best option for humeral and femoral fractures
• Also applicable to ulna, metacarpal bones and tibiotarsus

General principles
• IM pin: 50-60% diameter of bone
• ESF pins: positive profile thread w/ roughened shafts
• Connecting bar: as for ESF
  o Cerclage: use in birds contraindicated in general since it can cause fissures and further bone fractures
  o Bone plates
    • Advantages
      • Rigid stabilization with minimal callus formation and not affecting joint function
      • Maintain anatomical alignment preventing all types forces
      • More stable → faster healing → earlier return to limb function
      • Well tolerated by birds
    • Disadvantages
      • Requires specialized equipment and hardware
      • Cost and prolonged time of anesthesia
      • Avian bones are brittle and have thin cortices→ difficult holding and risk of iatrogenic fractures
      • Need to be removed when there is minimal soft tissue coverage because plates can conduct cold and lead to deep bone pain (especially in wild birds)

Complications
• Bone fracture
• Bending
• Long bone fractures in birds may require longer plates than similar canine and feline fractures
• Combination IM pin and bone plate reduces internal plate stress

Most case reports in larger species/bones (example: coracoid fractures in bald eagles)
Post-operative care

- **Immediate**
  - Bandage: gauze sponges (ESF, tie-in) and bandage
  - Antibiotics pre and post-operative
  - Analgesics (opioids, NSAIDs)
  - Change bandage (if present) after 24 hours
- **Later**
  - Clean and monitor skin-pin areas
  - Radiographs: post-op, 10, 21, and 35 days
  - Animal rehabilitation protocols 3-5 d post-op
  - Load sharing 21-28 days
  - Destabilize repair devices
- **Animal rehabilitation**
  - Under anesthesia
  - As early as 5-7 days post-op, 2-3X/week
  - Gentle stretch and hold
  - Gentle range of motion

Complications

- Synostosis, infection (bone, joints), implant failure, malunion/non-union, decreased range of motion joints/arthrodesis, pododermatitis

  - **Prevention**
    - Protect and preserve soft tissue during surgery
    - Avoid iatrogenic damage to joints
    - Achieve rotational and longitudinal alignment
    - Achieve early rigid stabilization
    - Allow early return to function
    - Protect contralateral weight-bearing structures
    - Utilize regular schedule of post-op physical therapy

- Pododermatitis
  - **Prevention**
    - Analgesia
    - Adequate immobilization for early return to normal weight bearing
    - Bandage/padding perches/surfaces
    - Opposing foot
      - Ball or foot bandages
      - Expanded, closed-cell polypropylene shoes (EPP, AKA “Fun Noodles”)
Management of specific bone fractures

Coracoid

- External coaptation
  - May be adequate for small birds
  - Proceedings AAV 2009: 99% success rate in raptors with conservative management coracoid luxation or fractures
  - Complications:
    - Malunion and shortened bone
    - Entrapment of tendons or ligaments in the callus
    - Large callus can impinge on local soft tissues (ex: esophagus)
    - Bandage complications (patagium contraction, elbow stiffness, joint ankyloses, muscle atrophy, tendon contracture)
- IM Pin with open reduction
  - Advantages:
    - Better stability and results than external coaptation
    - Cheaper and faster than bone plates
  - Disadvantages:
    - Prolonged recovery (6 months)
    - Still requires external coaptation (w/ all of its complications)
    - Migration of pin to coelomic cavity or shoulder joint
    - Inferior stability to bone plates
- Bone plates
  - Same advantages and disadvantages as described above
  - Use limited to larger birds
  - Case reports
    - JAMS 2005 4 (fracture Bald eagle)
    - JAMS 2007 3 (luxation Bald eagle)
- Luxation of the coracoid attachment to sternum requires surgical correction

Clavicle and scapula

- Less frequent than coracoid fractures
- Treatment
  - Body weight < 300 g: cage rest
  - Body weight > 300 g: body wrap +/- figure 8 bandage

Humerus

- Special anatomical characteristics
  - Proximal end: pectoral crest and bicipital crest
  - Distal end: brachial fossa
- Techniques for fracture immobilization
  - Proximal fractures
    - Large size propatagialis muscle complex → external coaptation may be sufficient for stabilization some cases
    - Tension band + body wrap (if body weight < 300g) or wire application
  - Distal fractures: cross pinning technique with tie in fixator
  - Midshaft fractures: tie-in fixator, ESF type I, IM pin and external coaptation
- Tie-in technique
  - Dorsal approach
  - IM pin
    - Retrograde (open fractures or reduction)
• Pin introduced at the fracture site and driven retrograde, exiting proximal humerus just distal to the shoulder
• Reduce fracture and drive pin into distal fragment
  • Normograde (closed fractures or reduction)
    • Small incision dorsal aspect distal humerus just proximal to lateral/dorsal humeral condyle
    • Caudal retraction triceps tendon ➔ insertion pin normograde direction ➔ reduce fracture ➔ engage cortex proximal humerus at level of the pectoral crest
    • Care to prevent damage to triceps tendon
  o Cross pins (positive profile pins)
    • Distal
      • Placed first
      • Skin incision just proximal to highest point of dorsal condyle
      • Pin driven dorsal/ventral direction through condyles (except distal fractures or spp. with deep intercondylar sulcus ➔ risk entrapment triceps tendon)
    • Engage both cortices
    • Proximal:
      • Fold wing against body for proper alignment
      • Identify site insertion: highest point pectoral crest
      • Drive pin parallel to distal one (engage both cortices)
  o Free proximal end IM pin bent 90° approximately 2 cm from skin and align with ESF pins
  o Connect pins with PMM, hexalite or connecting metal bars

Radius and ulna

• Techniques for fracture immobilization
  o External coaptation
    • Smaller birds, fractures with good alignment and only one bone fractured
    • Proximal radius fractures (larger muscle masses)
    • Synostosis common complication ➔ unable to fly (lift and descend requires radius to rotate around ulna)
  o Internal fixation
    • Indicated for fractures with severe displacement and/or fracture of the 2 bones
    • Techniques
      • IM radius only
      • IM both with external coaptation
      • IM radius and tie in fixator ulna
      • Bone plate (JAMS 2005 3 and JAMS 2008 4)
  o Poor prognosis for fractures close to joint
  o Repair of avulsion fractures olecranon not reported birds
• IM pin alone
  o Radius
    • Placed first, retrograde from fracture site to exit carpus joint (held in flexion during pin placement)
    • Blunt proximal end pin to reduce risk elbow joint damage
    • Reduce fracture and drive pin into proximal fragment
  o Ulna
    • Normograde
    • Insertion point at proximal caudal aspect ulna between shafts of second and third to last secondary feathers (do not pluck secondary flight feathers!!!)
    • Skin incision ➔ pin introduced almost 90° angle caudal bone cortex ➔ gradually reduce angle to align pin with long axis bone ➔ reduce fracture ➔ insert pin to distal fragment
    • Tie in fixator ulna
      o IM pin- as described
      o Cross pins
• Proximal: between proximal end of the ulna and the IM pin
  • Distal: proximal to carpal joint
  o Bend IM pin and attach to cross pins as described above for humerus

Carpometacarpal bones

• Challenges
  o Limited soft tissue structures and blood supply → difficulty and prolonged healing (5 weeks)
  o Open and comminuted fractures common

• Techniques
  o External coaptation with splint
    • Sandwich splint
      • Molded from thermoplastic splint material to fit
      • Affixed to the ventral surface of the metacarpus
      • Hold in place with adhesive tape +/- body wrap
  o ESF Type 1
    • Allows fracture immobilization with no manipulation of comminuted fragments (important for healing)
    • Immobilizing of the wing against body helpful to prevent premature loss of ESF device with wing flapping
    • Asymmetric (proximal and distal fractures)
    • Symmetric (midshaft fractures)
  o Tie in (retrograde IM pin into metacarpus with wrist hold in flexed position)
  o IM pins alone not recommended (no rotational stability)

Femur

• Techniques
  o Mid-shaft fractures
    • Tie in fixator
    • IM pins alone (BW < 100g)
  o Distal or condylar fractures: cross-pinning with or without ESF pin fixation
  o Proximal fractures: tension band wire and pins

• Tie in fixator
  o IM pin inserted proximal fragment → normograde → out lateral and caudal to the hip → normograde → reduce fracture → inserted into distal fragment
  o ESF Positive profile pins
    • Slight cranio-lateral → caudomedial direction to avoid neurovascular bundle
    • Distal: placed first, through the condyles; into lateral condyle
    • Proximal: insert just distal to dorsal acetabular rim; use smaller pin; align with distal pin; difficult to confirm appropriate seating pin but should not have more than 1-2 threaded lengths past medial cortex

Tibiotarsus

• Normal anatomy
  o Fibula attached to tibiotarsus at fibular crest
  o Blood vessels and nerves to limb between fibula and the tibiotarsus above and below the crest → avoid lateral approach to the tibiotarsus distal to the crest
  o Ossified supratendinous bridge over extensor digitorum longus muscle tendon → avoid tendon entrapment
  o Primary loads: compressive

• Fractures
  o Common in raptors, especially newly jessed hawks
  o Often located just distal to fibular crest due to change from an approximately triangular to more round shape bone
  o Transverse fractures
Damage/entrapment tibial and/or fibular nerve common

**Techniques**
- Tie-in fixator
  - ESF type II
  - Combination of an IM pin or K-wire and external coaptation (BW, 300 g)
  - External coaptation: Robert Jones (<100g), tape splint (<50-75 g)
  - Interlocking nail (JZWM 35(1) 2004 Bald eagle)
  - Plate, IM pin and cerclage wires (JAMS 2007 3 Bald eagle)
  - Ring fixator device for bone transport osteogenesis (JAMS 2008 1 Amazon parrot)
  - Type 1A hybrid (JAMS 2005 Bald eagle)
- ESF type 2
  - Application similar to described for tie in technique
  - Angle proximal pins proximolateral-distomedially to prevent injury to body wall

**Tarsometatarsus**

- Normal anatomy
  - Variable shape
    - Hawks: long, flat C-shaped cross-section, almost no medullary cavity
    - Parrots: short, round to oval, with medullary cavity
  - Interosseous tendon canal in distal tarsometatarsus to digit 4 for extensor digit IV
  - Dorsal aspect: digit extensor tendons, nerves and artery
  - Ventral aspect: digit flexor tendons
  - Medial aspect: medial metatarsal vein
  - Tibial cartilage
    - Caudal aspect hock joint
    - Gastrocnemius and superficial digit flexor tendons: superficial
    - Deep digit flexor tendons: within cartilage
- Techniques
  - External coaptation:
    - Indicated for most psittacines
    - Robert Jones, tape bandage, tibiotarsus-tarsometatarsus splint
  - ESF Type 2
    - Lateral approach
    - Careful placement hawks: bone shape can result in entrapment flexor tendons
    - Kirschner wires vs. positive profile pins
  - IM pins not recommended due to damage to the flexor tendons

**Phalanges**

- Closed phalangeal fractures
  - Cage rest (flexor tendons and their sheaths provide good support)
  - Splinting results in the formation of adhesions and a stiff toe.
- Compound fractures commonly result in osteomyelitis, and amputation should be considered
- Dislocations of phalangeal joints: reduced under anesthesia; may need external support
- Damaged collateral ligaments: repaired with 3-0 or 4-0 polyglactin suture.
References and further reading


