Avian Orthopaedics

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This paper will discuss the use of internal and external fixation in avian fractures. Prognosis for these injuries will be discussed. The use of bone plates, intramedullary pins, external fixateurs in the treatment of fractures will be covered as will more conservative treatment, including cage rest and strapping techniques.

Introduction

Fractures are a common reason for presentation on avian practice. The main principles you will need to apply are those that you are familiar with from treating fractures in other species. If the surgeon is unfamiliar with the surgical anatomy this can be found in many useful texts and articles.[8,9,10,11,33]

Avian fractures heal similarly to those in mammals.[21] One study[16] demonstrated that fibrous callus forms initially to be replaced by cartilaginous callus. This develops from both periosteum and endosteum. Avian fracture healing is faster than mammals and radiographic evidence is visible as early as 8 days.[21] The swift healing may be due to rapid mobilisation of fibroblasts and the formation of collagen fibres to develop a fibrous union rather than new bone.[21] True bony union takes 22 days and remodelling takes 6 weeks.[21]

Fracture Management

The initial assessment you perform will help you to decide if this case is to be managed as a surgical or a nonsurgical case. As in most other species, this decision will be affected by a multitude of factors. These will be discussed throughout this paper.

Nonsurgical techniques are often employed in many of the smaller birds (under 200g) and should always be the method of repair first considered.[2]

The advantages of nonsurgical management include: less injury to surrounding tissues and blood supply and decreased problems with infection.[2] In some cases this style of fracture management is the preferred option and will result in a satisfactory return to normal function.

The longbone fractures of birds often can be managed by nonsurgical means, particularly many of those fractures encountered in the wings.[2] Using the natural contour of the bird's body as a splint, good alignment can be achieved.

Surgical repair is usually preferred if there is significant overlapping of the fracture fragments or in the case of an open fracture. In these cases, surgery is usually the only successful method or returning the bird to full functional flight.

An important consideration of repair technique used is the birds future functional performance. The flight

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capability and quality of functional return required for a Peregrine Falcon (*Falco peregrinus*) will be quite different to that required for a pet bird destined to spend the remainder of its time in a cage or aviary. If the bird is not being returned to the wild, a simpler, less expensive nonsurgical management regime is likely to be chosen. In my experience, it is much more common that surgery will be required for a wild bird to be returned to good flight capability.

Redig[2] has developed a table of commonly encountered fractures with management recommendations and prognosis for healing and recovery (Table 1).

Radiology

Definitive diagnosis of any suspected fracture requires good radiographs. In many cases a V-D view is adequate but two standard views at 90 degrees will usually give you more of the information you require to decide on the management you will use.

Anaesthesia

Isoflurane is used for all my orthopaedic cases. It is used for radiology and initial assessment as well as for treatment. I feel anaesthesia is particularly useful with wild birds, as any handling (even to apply bandages or splints) can be extremely stressful.

Initial Assessment and Care

As when treating any other animal, with birds it is most important to remember the old adage that "to each fracture is attached a patient".

As part of the initial assessment give the bird a full and thorough physical examination to assess any problems that may be present.

Many birds will be in a shocked state. For these, minimal handling and interference is recommended. Use simple methods of immobilising the limbs - such as masking tape or Vetrap. Only minimal cleaning of wounds should be performed, depending upon your assessment of how much the bird will tolerate.

Delay anaesthesia until the bird has fully recovered from its shock. Often this will be 48-72 hours.

Altman[4] recommends the strapping of both wings to prevent the bird attempting to fly. I have not found this to be as successful as strapping only the affected wing. As the wing that is free helps them to maintain their balance more easily.

Antibiotics are a useful adjunct both pre-operative and post-operative, especially with open fractures.

In the initial phase I find Amoxycillin (100-150 mg/kg) or Amoxycillin/Clavulanic Acid (125-150 mg/kg) by IM injection to be reliable drugs. This may be changed if it become obvious that infection is developing and the choice will be based upon culture and sensitivity if the if the client can afford the additional cost. In many cases this is not available or there is not time to wait for results so I will use IM injections of one of the following:

Amikacin (18-20 mg/kg bid)
Piperacillin (100-200 mg/kg bid)
Enrofloxacin (15 mg/kg bid).

Fracture Evaluation

As a rule of thumb, proximal fractures where the joint is not involved have a better prognosis for return to functional use than distal fractures. The more distal the fracture, the more guarded the prognosis for flight will be.[6]

Significant soft tissue damage that results in local ischaemia will result in non-union or a delayed union. Time should be spent assessing the function of all tissues surrounding any fracture. A simple technique to allow bruising to be more easily seen is the application of 70% alcohol over the joints or ling bones.[2] This is particularly useful when a birds inability to fly cannot be explained by palpation or radiographs.

Assessment of motor nerve function distal to a fracture should be performed prior to surgery. Significant nerve function damage may select amputation or euthanasia as more realistic treatments.

Determine the degree of injury open reduction may cause to surrounding tissues. If the sequelae to open reduction are likely to be worse than other forms of repair, the open reduction may not be justified.[6]

Post-operative Care

All birds need strict confinement for at least the first week. Close observation is required to assess how well the bird is coping with the surgery, cast or external fixation apparatus. A major cause of failure of fracture healing is too much exercise early in the healing phase.

To limit any exercise the bird should be confined to a small cage. The only exercise permitted outside the cage is mild physiotherapy of the limb to overcome any joint constriction. This may have to be performed twice daily by the client after the correct technique has been demonstrated at the hospital prior to discharge. I instruct the client in the use of a bicycling motion of the limb with just enough pressure to take the limb as far towards its normal limits as possible without causing overt signs of pain or struggling. This is not possible with all fractures or patients.

The decision to use physiotherapy is not always an easy choice. I am tending to use it more frequently to avoid the development of adhesions. I have seen cases where adhesions between damaged tissues directly limited the muscle and joint movement. This has also been reported by MacCoy.[1,6]

At the end of two weeks I prefer to radiograph the fracture to assess the stage of healing. In many cases the level of exercise can be increased to allow climbing around the cage or limited flapping of wings.[2]

A physical examination should be performed before the bird is allowed to begin normal exercise. To avoid any struggling this may be performed under light anaesthesia with Isoflurane - this can be done as an outpatient.

If then bird is unable to perch it may damage its tail on the floor of the cage. This is easily overcome by taping or lightly stapling a paper envelope over the distal portion of the tail.

Soft perching material should be provided for birds that have to perch on a single foot. The ventral aspect of the foot and digits should be inspected regularly for pressure sores. Soft material (e.g. Vetrap) may need to be placed on the perches is problems develop.

In some instances birds will chew at casts, bandages or external fixation apparatus. Elizabethan collars or neck braces may be needed to reduce this vice. In most instances this is not necessary. Redig (1986) feels that excessive picking at a bandage is a sign that it is uncomfortable and needs to be adjusted.

Bandages & Splints [1,6,7]

Bandages and splints are extremely useful for temporary stabilisation of many fractures. As well they can be used for permanent stabilisation in selected fractures.

The normal position of the wing is along the natural curve of the bird's body. This can be used as a means of positioning the wing with bandages or stockinette to align and immobilise the wing during the fracture healing process.

The major factor determining the selection of a bandage or similar means of reduction and immobilisation is the position of the fracture. Midshaft fractures are more amenable to this technique. Fractures at the proximal and distal ends, particularly if the articular surface or surrounding tissues are damaged will not be as stable or well aligned as you would wish.[6]

Splints

A splint is defined by McCluggage[7] as the application of bandages with or without some form of added structural support (e.g. wire, wood plastic).

Depending upon the position of the fracture, appropriate splints can be made from "sticky" materials such as masking tape, sticky-tape, draftsman tape or medical bandages (e.g. Leukoplast). As a general rule I dislike using these materials on wings or areas covered by feathers but prefer to use tapes that are self adhesive such as Vetrap. An alternative support bandage is orthopaedic stockinette. The "sticky" materials are commonly used on lower leg fractures.

Splints are really only limited by the clinician's imagination. Rubber balls can be used for toe splints.[1] In other areas, splints can be made from any light material that is rigid. Examples include: plastic spoons, tongue depressors, drinking straws, feather quills, Hexcelite, fibreglass cast materials, wooden dowels, paper clips.

I always use Isoflurane anaesthesia for splint application to ensure the splint is applied well without any injury from the patient struggling.

McCluggage[7] provides the following list of fractures with a good prognosis for external coaptation:

- Coracoid, Scapula, Furcula
- Humerus, midshaft to distal, closed
- Radius, midshaft to distal, closed or open
- Ulna, proximal to distal, closed
- Radius & Ulna, midshaft to distal, closed
- Carpometacarpus, closed

- Femur, proximal and midshaft, simple
- Tibiotarsus, simple, anywhere
- Metatarsus, simple

Figure-of-8 Bandage

This is a useful bandage for wing fractures, particularly radius and ulna, carpometacarpus and phalanges. It is also recommended for humeral fractures in birds less than 100 grams.[1,7]

I prefer to use self adhesive bandages such as Vetrap. Fold the wing and align it in its normal position. The bandage passes around both the elbow and the flexed carpus in a figure-of-8 pattern. The primary flight feathers help act as splints and support the bandage. The bandage must not be applied too tightly and should be checked regularly, particularly during the first 24 hours, to ensure it is not interfering with circulation.

A modification of the figure-of-8 bandage is the bandoleer bandage advocated by MacCoy.[1] This is a figure-of-8 applied to hold the wing onto the body wall with the pattern encircling the body and the wing. The normal wing is left free.

Binding the Leg to the Body

This is a simple technique recommended by McCluggage[7] for proximal and midshaft fractures of the femur. The bandage or tape passes dorsally over the synsacrum, along the lateral aspect of the flexed leg ventral to the flexed foot and then over the opposite side of the body to the origin of the tape. Pad the foot and give a good bearing surface to avoid pressure necrosis.[1]

Kirschner-Ehmer Apparatus

These have been extensively used in small animals for some time and in general the same indications and restrictions apply.[1] The main advantage of this technique is that it provides much better stability than coaptation splinting as well as maintaining the bone length to its normal distance and allows adjustment for correct alignment of the fragments.[1]

When adapted for birds the weight of the apparatus must be modified. The size of the device used must be kept to a minimum and so they must be placed as close to the patient's skin as possible. Top avoid the bird damaging itself MacCoy recommends placing the bird in a smooth sided enclosure with a low perch or covering the splint with a bandage.[1] As well the apparatus must be protected from the bird by the use of bandages, neck braces or elizabethan collars. The beak of large parrots can easily damage the pins and crossbars.

The shape of the bird limits the use of this apparatus to the extremities.

MacCoy[1] lists several different configurations of Kirschner-Ehmer Splints:

! Type Ia double clamp
  Advantages
    simple to apply & connect pins
    good flexibility in aligning fragments
  Disadvantages
    weight
    protrusion from limb
    double clamp can slip under stress

! Type Ia single bar
  Advantages
    fewer elements - lower weight
    can replace clamps with glued joints (epoxy).
    closely conforms to patient
  Disadvantages
    more difficult to apply
    more care required to align during placement

! Type Ia double bar
    same as above but a double bar

is used for increased strength and to make pin placement easier

! Type Ib

This is two type Ia single bar splints placed at an angle to each other and joined with end bars
Used to replace Type II in humerus, femur, tibiotarsus, radius, ulna and carpometacarpus

! Type II - a bilateral frame

Advantages

double cross bars increase rigidity and can be used to apply compressive or distractive forces
reduce torsional forces allows less bending of pins or loosening of apparatus

Disadvantages

increased weight and size of apparatus
positioning of second bar limits use in humerus, femur, tibiotarsus, radius, ulna and carpometacarpus

! Type III - a trilateral frame

Advantages

the most stable external fixation
ten times as resistant to axial compression as Type I
most useful for dealing with extremely unstable fractures in large birds

Disadvantages

The mass and size limits its use to fractures below the stifle joint

Application of Kirschner-Ehmer Splint

Careful selection of pins is necessary. As a rule-of-thumb, the pins should not be larger than 20% of the diameter of the bone.[1] Any larger and the risk of shattering the bone is increased. The most commonly used pins are Trochar-tipped Kirschner wires on sizes 0.025", 0.028", 0.035" and 0.045"

Pins placed close to a joint should be parallel to the joint surface.

The stability of fixation increases with the number of pins in each fragment.

Pins should be placed at least half of the bone diameter away from the fracture line.[1,7]

Hairline fractures or fissures in a fragment should be supported by cerclage wire before pin placement. Pins should be placed as far away from the fissures as possible.

Pins should fully penetrate both cortices. Fixation pins should be placed at 45 degrees to one another in each fragment to decrease the danger of the pins backing out.[1,7]

Connecting bars may be stainless steel, epoxy, plastic (Hexcelite) or fibreglass casting material.[1,12]

For the formation of epoxy connecting bars, many different tubular materials have been tried to support the epoxy while it sets. Silastic tubing, drinking straws, penrose drain tubing or similar structures must be placed over the fixation pins in each fragment. Clamps are used to temporarily hold the fragments in alignment while radiographs are taken to assess alignment.

Position the tubular material just above the skin so a pin-cutter can be used for removal. This will also keep the heat from the exothermic reaction of the epoxy from damaging the underlying structures.

The epoxy glue is injected into the tubular material and allowed to set. Kirschner wires can also be inserted here for extra strength if it is needed - this forms the so-called biphasic connecting bar.

Once the glue has cured all extra clamps are removed. The fixation pins are trimmed as closely as possible to the cured tube.

Because epoxy cannot be adjusted once it has set, fibreglass or hexcelite is best suited to Type II devices.

Internal Fixation

Stable internal fixation promotes early use of the limb to minimise muscle atrophy and freezing of joints that can occur with immobilisation.[15]

Intramedullary Pinning with Steinmann Pins or Kirschner Wires

These are a form of surgery that most practitioners will be comfortable with because of previous experiences with small animals.

I find it quite useful in birds however other authors[1] do not recommend the technique.

The main advantage I find is that it is a relatively quick procedure. I prefer to use 1-3 small Kirschner wires rather than a single larger, heavier pins to help reduce and align the fragments. Often they will be inserted in a manner similar to Rush pinning. In most patients external coaptation is combined with this technique to provide rotational stability and support. In all cases I, once I have determined the correct depth for the pin, I withdraw it slightly, cut it and then drive it fully into the bone so nothing is protruding. I intend to leave the pin in situ unless complications arise so I do not leave any pin protruding to damage the surrounding structures.

The disadvantages include: Care must be taken to avoid the articular and peri-articular surfaces. In some pneumatic bones, such as the humerus, there is minimal cancellous metaphysis and the cortex must be penetrated to provide firm seating for the pin.[7]

An alternative intramedullary pin is described by Gaines.[23] He uses 20 gauge spinal needles. They are lightweight, hollow, non-reactive and inexpensive. As well he claims they are flexible enough to be manoeuvred around. He uses up to 2 or 3 in a single fracture repair. I have no personal experience with these but they would be suitable in some cases.

Doyle[24] prefers small intramedullary pins to K-E devices. he claims that during normal healing bone is resorbed at the fracture interface before new bone is laid down. As a result K-E devices hold the bone ends apart and apposition is lost. To supplement his intramedullary pins he applies tiny pins at oblique angles, one distal and the other proximal to the fracture site. Each pin has a hook in the end to allow rubber bands to be attached traversing the fracture. The aim is for the compression of the bands to maintain apposition. He recommends checking the bands each 3-4 days to ensure they do not cause necrosis at the fracture site. I have not had experience with this technique but mention it as one more opinion found in the literature.

Intramedullary Pinning using Plastic Rods[7,14,26,30,31]

Plastic rods may be used as an intramedullar device. MacCoy[7] lists the following advantages and disadvantages:

Advantages
- low weight
- surgical interference with tissues is limited to the fracture site
- fracture fragments can be accurately aligned
- it provides good rotational stability even with transverse fractures

- stability is adequate for bone healing
- material is readily available, easily sterilised and easily cut with hand tools

Disadvantages
- lack of absolute rigidity
- the short length of rod that can be used
- the plastic rod needs to be transfixed with Kirschner wires producing stress concentration at the pin holes and increasing the risk of distracting cortical fissures to the point of fracture

The plastic rods are available as polypropylene welding rods.

Prior to placing the pin, the fragments must be examined and any fissures supported with cerclage.

The ideal pin size is one which fills the medullary canal. The length will be determined by the depth the pin can be inserted into the first fragment and then toggled back to fill the opposite fragment. To aid in toggling, a hole is drilled in the centre of the pin and stainless steel wire or nylon is inserted. Once the pin is fully placed into the medulla of the first fragment, the fracture is reduced and then by pulling on the toggle, the pin is pulled into the second fragment. The fracture is aligned as well as possible. A fine (0.025") Kirschner wire is then driven transversely through the bone and the plastic pin to emerge through the opposite cortex. The protruding pins are cut as close to the cortex as possible and the wound is close in the normal manner.

An alternative method of fixing the pin in the intramedullary cavity is methyl methacrylate bone cement. Degernes has described its use in midshaft fractures of the humerus and tibiotarsus.[14] For this technique small barbs, projecting towards the middle of the pin, are cut into the pin as a means of providing seating for the bone cement.[30] The bone cement is injected into the medullary cavity just prior to inserting the pin.[14,30]

Cerclage

Stainless steel wire or nylon wire ties can be used as cerclage support for fissure fractures.

Care must be taken with applying wire that the compression applied does not fracture the relatively thin cortex. This is less of a problem with nylon ties as they cannot be overtensioned. However their size is such that they are not suitable for birds under 300 grams.[7]

Bone Plates

Bone plates have not been used extensively in birds because of their size and weight. As well birds have thin brittle cortices that do not support plates and screws well.[16,17,18] Unstable implants will result in non-union or malunion of the fracture and contribute to excessive fracture callus. If available, bone plates often allows weight bearing immediately after surgery.

One report[15] cites the use of bone plates in birds over 400 grams body weight in humerus, radius & ulna, tibiotarsus and femur. It combines the use of bone cement and plates. The bone cement is used as a mechanical bond to the bone, inside the medullary cavity where it acts as a substitute for bone to support the tapping and screws.

The medullary cavity needs to be lavaged with warm sterile saline and any callus curetted away. The medulla is then thoroughly dried with cotton buds before the bone cement is injected. The bone cement is injected so that it completely fills the medullary cavity. To allow the cement to be deposited into the depths of the medulla, it is recommended[15] that a 12ml syringe have a 4cm length of sterile PVC intravenous tubing attached to its tip. To backfill the medulla insert the tubing as far as possible then inject the cement while slowly withdrawing the tube. The volume required will vary from 2 -10 ml in most large birds. The cement will solidify usually within 10 minutes, depending on the amount of solvent used. Any excess protruding from the tip of the fragment will interfere with apposition and needs to be removed with rongeurs.

Plates used in this study[15] were AO/ASIF veterinary cuttable plates that are 30 cm long. The appropriate size is selected and cut to the correct length. It is then contoured and applied to the bone in the usual manner.

This technique is recommended only for closed, non-contaminated fractures as the bone cement may lead to sequestration of infection. It is of particular use for leg fractures in large birds.

Surgical Approaches to long bones

Several articles discuss the approach to the long bones.[6,8,9,12,15,19,33] Kuzma & Hunter recommend the medial approach to the humerus, radius/ulna and tibiotarsus but the lateral approach for the femur.[15]

Surgical Closure

In all instances I use 2/0-4/0 Dexon for closure of muscles and 4/0 Dexon for skin closure. This has never resulted in complications and avoids the necessity to remove sutures.

Wound closure in most instances involves only skin closure. It is not recommended that muscles be purposely tacked over fractures to help callus growth. This has been found to result in muscle fixation and poor limb function (particularly wings). This technique is only performed when devitalised cortex lies beneath.[6]

Fractures & Injuries of Pectoral Limb

1. Shoulder

This is not a commonly diagnosed fracture as the birds will not always show any misalignment of the wings but will be unable to fly well. Close observation will reveal that the bird is unable to elevate the wing above the horizontal plane.[2] Unless a radiograph is taken and examined carefully this type of injury is easily missed. In my experience it is most commonly seen in Kookaburras (Dacelo gigas) and Sacred Kingfishers (*Halcyon sancta*) as a result of a head-on collision with a solid object such as a window or motor vehicle.

The bone most commonly involved in injury in this region is the coracoid. Less commonly is fracture of the scapula or furcula (wishbone).

Cage rest and wing immobilisation for 4 weeks usually results in good return to function. Elastic stockinette and a figure-of-8 bandage is very useful to help hold the wing in the preferred position for healing. I prefer to only immobilise the affected wing and leave the normal wing free.

Coracoid Fracture

Surgery may be indicated for coracoid fractures if fragments are displaced or for birds of high flight performance such as Peregrine Falcons (*Falco peregrinus*).[2,5] MacCoy[1,6] recommends open reduction and internal fixation for all birds over 400g.

Coracoid fractures repaired with Kirschner wires must be handled gently to avoid further damage due to the thin cortex on the diaphysis.[6] The K-wire can be passed either normograde or retrograde but the articular surfaces must be avoided. Alternately 26ga orthopaedic wire can be used as a suture to align the fragments. The hole for the wire is best drilled with a small hypodermic needle to avoid splitting the fragment.[6]

Surgical Approach to the Coracoid[6,20]

Place the bird in dorso-lateral recumbency. Extend the wing on the side the fractured coracoid is found. Prepare the adjacent neck, breast and shoulder for surgery. Incise along the edge of the clavicle and curve down to 1/3 length of the keelbone. Incise the superficial pectoral muscle at its attachment to the clavicle. Reflect the crop if it overlays the area. A nutrient blood vessel may be found at the midpoint of the clavicle and can be sacrificed if required. Continue the incision along the keel to allow elevation of the superficial pectoral muscle. A periosteal elevator can be used to reflect the pectoral muscle from the clavicle and keelbone to reveal the coracoid. This bone lies just beneath and caudal to the supracoracoideus muscle (deep pectoral) which must not be damaged.

The pin may need to be flexed during its passage to avoid the articular surfaces.

Closure is achieved with 2/0-4/0 Dexon or PDS in a single interrupted pattern to attach the severed muscle. The K-wire is left in situ unless problems occur.

Foramen Triosseum

It is uncommon to fracture all three bones of the shoulder girdle. Open reduction is required if return to flight is expected. Even with surgery the prognosis is guarded to poor.

In small birds stockinette and a figure-of-8 bandage combined with cage rest for 3 weeks may be used.[6]

2. Humerus

Coles[21] emphasises that the proximal fragment often will be rotated along its longitudinal axis by the pull of the pectoralis muscle. If this rotation is not corrected it could lead to a change in the angle of attack of the aerofoil surface and aerodynamic properties of the wing.

Surgical approach to the Humerus[6,20,31]

The humerus may be approached from a dorsal or ventral aspect.

The ventral approach is useful for midshaft fractures. Place the bird in dorsal recumbency. The incision is centred over the bone just caudal to the edge of the biceps brachii. Retract the biceps anteriorally. The caudal surface of the humerus is covered by the humeral head of the scapulotriceps which may need to be elevated for exposure, as required. The Brachial artery crosses the ventral surface of the proximal humerus. The radial and ulnar arteries branch at the distal third of the bone. The basilic and brachial veins run anterior to the bone. Many of these blood vessels are difficult to identify and their position will vary with the shape of the wing.

The dorsal approach can be used for proximal, distal and midshaft fractures.

Proximal humerus is approached through an incision over the junction of the deltoideus major and retinaculum muscles with the scapulotriceps. Blunt dissection between the muscles will reveal the humeral head and proximal two-thirds of the shaft. The dorsal circumflex humeral artery is encountered at the most proximal part of the incision. It can be sacrificed if required. The radial nerve may be visible a the distal extent of the incision.

The midshaft of the humerus is exposed by an incision over the centre of the bone down to the level of the lateral humeral condyle. Once the skin is incised it is recommended that the deltoideus and retinacular muscles as well as the radial nerve be identified before further dissection is performed. retract the radial nerve and the scapulotriceps muscle posteriorally to expose the bone shaft.

The distal humerus is approached by extending the above incision to the level of and just caudal to the epicondyle

3. Elbow Luxation

This injury is not uncommon in wild birds. Clinically the birds are unable to extend the elbow. Bruising and swelling will be evident around the joint.

Mild luxation will respond to immobilisation of the wing in a figure-of-8 bandage for 2-3 weeks with bandage removal and physiotherapy (often under Isoflurane anaesthesia) as regularly as possible.[2]

Gross displacement of the radius or ulna or both carries an extremely poor prognosis. Surgery for this problem has been unrewarding. Roush[12] recommends open reduction and suturing to bind the bones together.

An interesting anatomical fact is the presence of a cartilaginous meniscus in the avian elbow.[12]

4. Radius and Ulna

In birds less than 100 grams and quiet birds with minimal displacement the use of figure-of-8 and bandoleer bandages can be quite effective.

In some cases there will only be a fracture in one of the bones in the forearm. In a quiet bird cage rest may suffice. In an active bird with only an ulnar fracture, extra support such as bandages or brailling may provide the necessary support to avoid stress fractures in the radius.[1]

If the radius if fixed to the ulna by a callus, it is recommended that the proximal radius, excluding the head, is removed to free the ulna for normal function.[6]

Surgical Approach to the Radius and Ulna[6,20]

The proximal radius & ulna and elbow joint may be approached dorsally or ventrally. Use a curvilinear incision that extends from the distal third of the humerus over the lateral humeral condyle and onto the forearm over the separation of the extensor metacarpi radialis and common digital extensor muscles. The muscles are retracted anteriorally or posteriorally.

If the extensor metacarpi radialis is retracted anteriorally it will expose the edge of the ulna with the attached feather follicles. The feather follicles can be freed from the bone with a periosteal elevator if required.

If the extensor metacarpi radialis is retracted anteriorally and the common digital extensor posteriorally it will expose the radius.

5. Carpus

Fractures of the radial and ulnar carpal bones is not common in other than large birds.[1] Prognosis for return to normal function is poor. The most likely technique to select would be external coaptation to support the joint in a comfortable position, while ankylosis occurs.[1]

6. Carpometacarpus

In small species splints are the recommended technique to employ. In larger species, intramedullary pinning with small K-wires or hypodermic needles can be used to align the fragments. In very large species a type II K-E apparatus could be used.

Surgical approach to Carpometacarpus

Since the important blood vessels cross the joint on its ventral surface, the incision is best on the dorsal surface. Very little soft tissue remains in this region, the primary structures encountered being skin, tendons,nerves and blood vessels.

Fractures & Injuries of Pelvic Limb

1. Femur/Hip

Hip joint luxation is treated similarly to small animals.[12] Closed reduction and slinging is preferred. Open reduction, suturing and slinging with or without transfixation with a smooth pin is possible in larger birds.[12]

Femoral fractures most commonly occur in the midshaft or distal section of the femur. Prognosis for return to normal function is good. In many small birds the size of the muscle mass is sufficient to retain the fragments in good alignment. Coaptation splints can be used to provide extra support. In waterfowl and many small cage birds, cage rest is adequate for femoral fracture repair.[2] Alternately the leg can be flexed and strapped to the body.[7,12]

Roush[12] uses a modified spica hip cast to help reduce and align femoral fractures. He uses a malleable material such as Hexcelite to enclose the leg with a lip that extends onto the dorsal body surface. This is then attached to the bird with conforming gauze and elastic self adhesive bandage such as Vetrap. The leg must be positioned in a position that allows perching.

Medium to large birds need surgery to reduce the overlapping of fragments and to prevent rotation.[2]

The recommended approach to the femur is the lateral approach.[15]

MacCoy[1] reports good success with Type Ia and Ib K-E splints. With this technique care must be taken that the pins do not puncture the medial thigh and impinge upon the abdomen.

Redig[3] prefers 2-4 small diameter intramedullary pins. The pins are introduced individually into the proximal fragment in a retrograde manner towards the hip. Once the fragments are aligned the pins are passed back into the distal fragment. Absolute cage rest is provided for 3 weeks after surgery.

Stifle injury in birds is uncommon. One report[27] discusses the technique of stifle repair by arthrodesis. Multiple Kirschner wires were placed in the lateral aspect of the femur and tibiotarsus and a type I external fixateur with an acrylic connecting bar were used. In both cases cited the result was an acceptable return to function.

2. Tibiotarsus

McCluggage[7] recommends tape splints for fractures of tibiotarsus and tarsometatarsus for birds under 125 grams. For birds 125-175 grams he also adds the wooden part of a cotton swab. To apply the splint, pluck all the feathers in the area. Reduce the fracture and position the leg in correct alignment, then sandwich the fracture site between two layers of the tape. Aim to incorporate the joints above and below the fracture. Trim the excess tape so it does not interfere with the bird. I prefer to use leukoplast or masking tape for this technique.

Rosskopf[25] states that in his experience 99% of tibiotarsal fractures in raptors and parrots can be splinted in preference to Intramedullary pinning.

An alternative used in this site is the Robert-Jones bandage.[7] Laminates of cotton wool (or cast padding) and conforming bandage are covered with elastic bandage to give support. This can be used for birds up to 500 grams and is very useful for young birds that will heal quickly.

In birds over 150 grams, Redig[1,2,7,13] has enjoyed good success using a modification of the Schroeder-Thomas splint for fractures of tibiotarsus and tarsometatarsus. An appropriate gauge wire, ranging from a paper clip to a coat hanger, is shaped into the usual structure except that the loop is positioned more in the vertical plane with the proximal bar bent away from the body in a 70 angle then bent back down to conform to the leg.

Intramedullary pins are recommended by Redig[3] by introduction into the proximal fragment and retrograde passage out the stifle. Additional rotational stability is provided with a schroeder-Thomas splint as described above. Roush[12] prefers having the pin exit through the hock joint rather than the stifle.

Redig[31] uses a through and through Kirschner device held with Hexcelite for midshaft tibiotarsal fractures.

3. Tarsometatarsus

This is the most commonly fractured bone in birds legs.[1] Prognosis for healing of midshaft fractures is good as long as the circulation is intact. Proximal and distal fractures have a worse prognosis because often the joint is damaged as well. Fracture repair can be achieved with coaptation splints or casts, intramedullary pins or type II K-E apparatus.[1]

MacCoy recommends lightweight plastic or fibreglass casts for fractures in birds over 400 grams.[1] Both the hock joint and phalanges should be included to provide rotational stability.[1] Roush[12] prefers splinting because of the proximity of the bone to the surface and the ease of immobilising the joint above the fracture.

4. Phalanges

Phalangeal fractures are usually too small for surgical repair. Good success can be achieved with bandaging the foot to a rubber ball or similar structure for 3-4 weeks. If only one digit is involved it may be possible to strap it to an adjacent digit for support, depending on the species and the position of the digit involved.

Leg Prosthesis

As a sign of use of human technology and its application in special cases, one report[29] describes the use of a leg prosthesis in a Bald eagle. This was a team approach involving a veterinarian, prosthetist and physiatrist to adapt and use a technique commonly used in human amputation management. The eagle was able to walk and perch once all modifications were made.

Avian Beak Repair

Repair of beak damage is an area that has attracted more attention recently. It is a cross between orthopaedic surgery, dentistry and soft tissue surgery.[22] Clipsham[22] has written an excellent article describing the anatomy,surgical principles and techniques.

Morris & Weigel[28] describe and provide excellent diagrams of a technique for methylmethacrylate beak prosthesis.

Summary

Internal and external fixation as well as splints and bandages are viable techniques for fracture repair in avian patients. The selection is based on similar principles used in other species.

Important criteria in the selection of a technique are the weight and size of a device, location of the fracture relative to the joints, the size of the bird, the skills of the surgeon, expense and condition of the patient.

Bone plates are really only suitable for large species.

Kirschner-Ehmer apparatus are useful in birds. Usually Type I and II patterns will be used on all but leg fractures in large birds where Type III may be required. The most commonly used for wing fractures is type Ia single bar splint with exoxy or acrylic for a connecting bar. Type II are preferred for leg fractures of tibiotarsus and distally.

In small birds coaptation splints and bandages are more successful than surgery.

References

1. MacCoy D.M.: Treatment of Fractures in Avian Species. The Veterinary Clinics of North America, Small Animal Practice, W.B. Saunders, Philadelphia , Vol 22: Number 1, Jan 1992, pp. 225-238.

2. Redig P.T.: Evaluation and Nonsurgical Management of Fractures. In Harrison G.J. & Harrison L.R.(ed)Clinical Avian Medicine and Surgery W.B. Saunders, Philadelphia, 1986, pp. 380-394.

3. Redig P.T.: Basic Orthopaedic Surgical techniques. In Harrison G.J. & Harrison L.R.(ed)Clinical Avian Medicine and Surgery. W.B. Saunders, Philadelphia, 1986, pp. 596-598.

4. Altman R.: Fractures of the Extremities of Birds. In Kirk, R.W. (ed.) Current Veterinary Therapy VI. W.B. Saunders, Philadelphia, 1977. pp.

5. Redig P.T.: A clinical review of orthopaedic techniques in the rehabilitation of raptors. Proceedings Annual Meeting Association of Avian veterinarians, San Diego, 1983, pp. 34-39.

6. MacCoy D.M.: Techniques of fracture treatment in birds and their indications: External and internal fixation.Proceedings1st International Conference on Zoological and Avian Medicine, Oahu, 1987, pp 549-563

7. McCluggage D.M.: Application of splints, bandages and collars. Proceedings Annual Meeting Association of Avian veterinarians, Seattle, 1989, pp. 315-318.

8. Orosz S.E.: Surgical anatomy of the humerus in selected avian species. Proceedings Annual Meeting Association of Avian veterinarians, Seattle, 1989, pp. 324-332.

9. Orosz S.E.: Surgical anatomy of the avian carpometacarpus. Journal of the of Avian Veterinarians Vol 4 No 1, Spring 1990, pp. 40-45.

10. McKibben J.S. & Harrison G.J.: Clinical Anatomy. In Harrison G.J. & Harrison L.R.(ed)Clinical Avian Medicine and Surgery W.B. Saunders, Philadelphia, 1986, pp. 31-66.

11. King AS & McLelland J.: Birds Their Structure and Function. Bailliere Tindall, London, 1984.

12. Roush J.C.: Avian Orthopedics. In Kirk R.W. (ed): Current Veterinary Therapy VII. Philadelphia, W.B. Saunders, 1980, pp. 662-673.

13. Redig P.: IME 79. A recently developed modification of the Kirschner Splint. Assoc Avian vet News 2:10, 1981.

14. Degernes L.A. & Lind P.J.: Methyl Methacrylate bone cement in avian orthopedics. Proceedings Annual Meeting Association of Avian veterinarians, Seattle, 1989, pp. 268-273.

15. Kuzma A.B. & Hunter B.: Avian fracture repair using intramedullary bone cement and plate fixation. Proceedings Annual Meeting Association of Avian veterinarians, Seattle, 1989, pp. 177-181.

16. Bush M et al: The healing of avian fractures: a histologic xeroradiographic study. J Am Anim Hosp Assoc, 1976, vol 12, pp. 768-773.

17. Putney D.L. et al: Methylmethyacrylate fixation of avian humeral fractures: a radiographic study. J Am Anim Hosp Assoc, 1983, vol 19, pp. 773-782.

18. Borman E.R. et al: Use of acrylic bone cement in avian orthopedics. J Am Anim Hosp Assoc, 1978, vol 14, pp. 603-604.

19. Redig P.T. & Roush J.C.: Surgical Approaches to the long bones of raptors. In Fowler M.E. (ed): Zoo and Wild Animal Medicine, Philadelphia, W.B. Saunders, 1978, pp. 246-253

20. MacCoy D.M. & Redig P.T.: Surgical approaches to and repair of wing fractures. Proceedings 1st International Conference on Zoological and Avian Medicine, Oahu, 1987, pp 564-577

21. Coles B.H.: Avian Medicine and Surgery. Blackwell Scientific Publications, Oxford, 1985.

22. Clipsham R.: Surgical beak restoration and correction. Proceedings Annual Meeting Association of Avian veterinarians, Seattle, 1989, pp. 164-176.

23. Gaines J.: Alternative IM pins. AAV Today. 2:2, 1988, pp. 101.

24. Doyle J.: Orthopedic suggestions. AAV Today. 2:2, 1988, pp. 101.

25. Rosskopf W.J.: Splints for Tibiotarsal Fractures. AAV Today. 1:4, 1987, pp. 173.

26. Lind P.J. et al: Fracture repair in two owls using polypropylene rods and acrylic bone cement. AAV Today. 2:3, 1988, pp. 128-132.

27. Rosenthal K. et al: Stifle luxation repair in a Moluccan Cockatoo and a Barn Owl. Journal of the of Avian Veterinarians Vol 6 No 4, Spring 1992, pp. 235-238.

28. Morris P.J. & Weigel J.P.: Methacrylate beak prosthesis in a Marabou Stork. Journal of the of Avian Veterinarians Vol 4 No 2, Spring 1990, pp. 103-106.

29. Richter N.A. et al: Use of a leg prosthesis in a Bald eagle. Journal of the of Avian Veterinarians Vol 4 No 2, Spring 1990, pp. 109-112.

30. Lind P.J. et al: Bone cement/Polypropylene rod orthopedic technique. Journal of the of Avian Veterinarians Vol 3 No 4, Spring 1989, pp. 203-206.

31. Redig P.T et al: Of pins, bone cement and hexcelite in the repair of avian fractures. Proceedings Annual Meeting Association of Avian veterinarians, Phoenix, 1990, pp. 355-359.

32. Garcelon D. & Bogue G.L.: Raptor Care and Rehabilitation, Walnut Creek, Alexander Lindsay Museum, 1977

33. Orosz S.E.: Variations in the anatomy for fracture repair of the long bones of the pelvic limb in selected species. Proceedings Annual Meeting Association of Avian veterinarians, Phoenix, 1988, pp. 275-277.

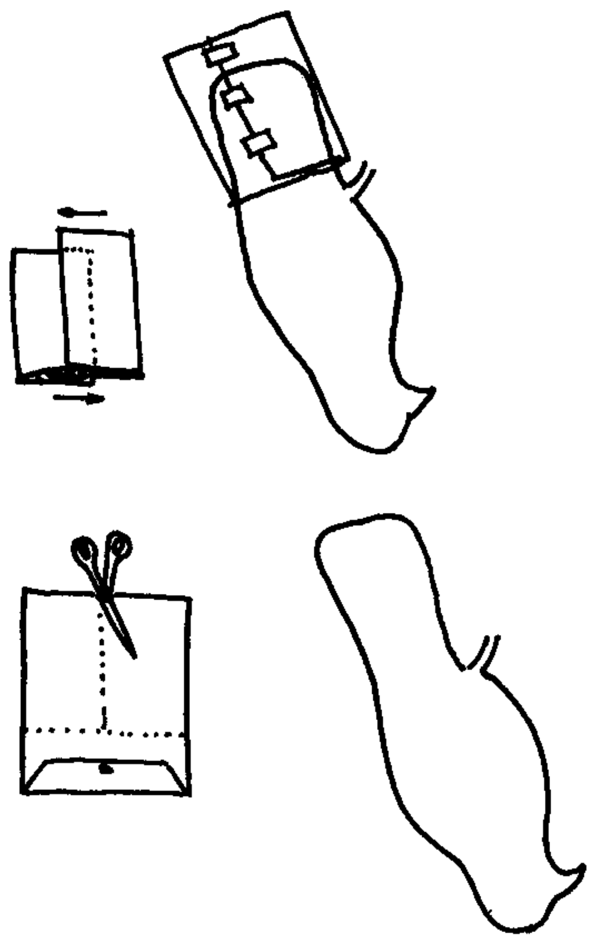

Figure 1:
Tail sheath (after Garcelon and Bogue, 1977)

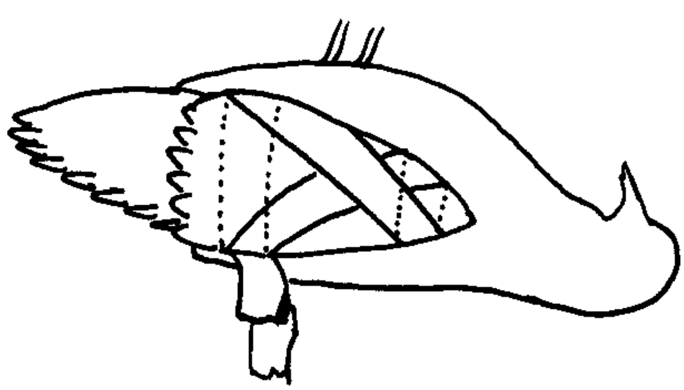

Figure 2: Figure of 8 bandage (after Garcelon and Bogue, 1977)

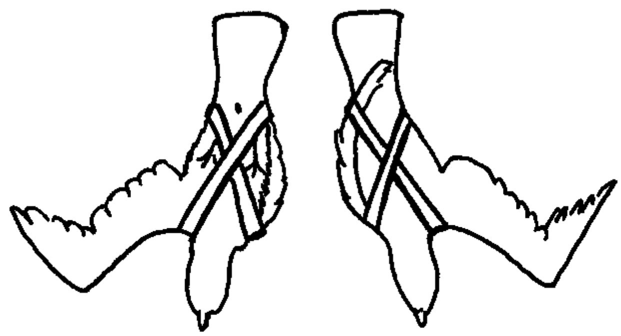

Figure 3: **Bandoleer bandage (after MacCoy, 1992)**

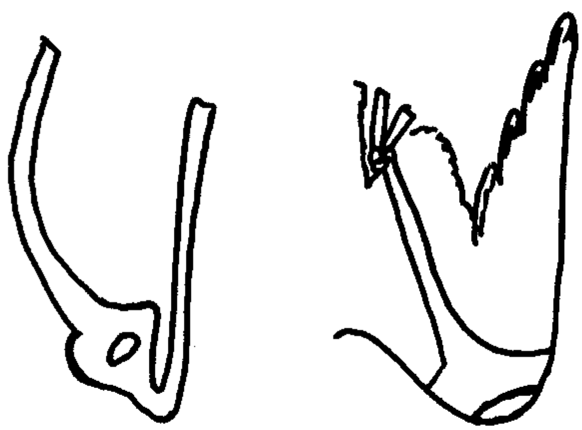

Figure 4: **Braille (after MacCoy, 1992)**

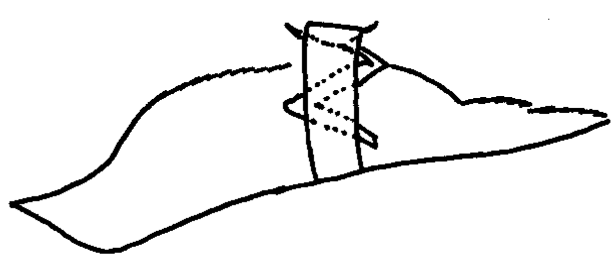

Figure 5:
Encircling tape bandage of femur (after MacCoy, 1992)

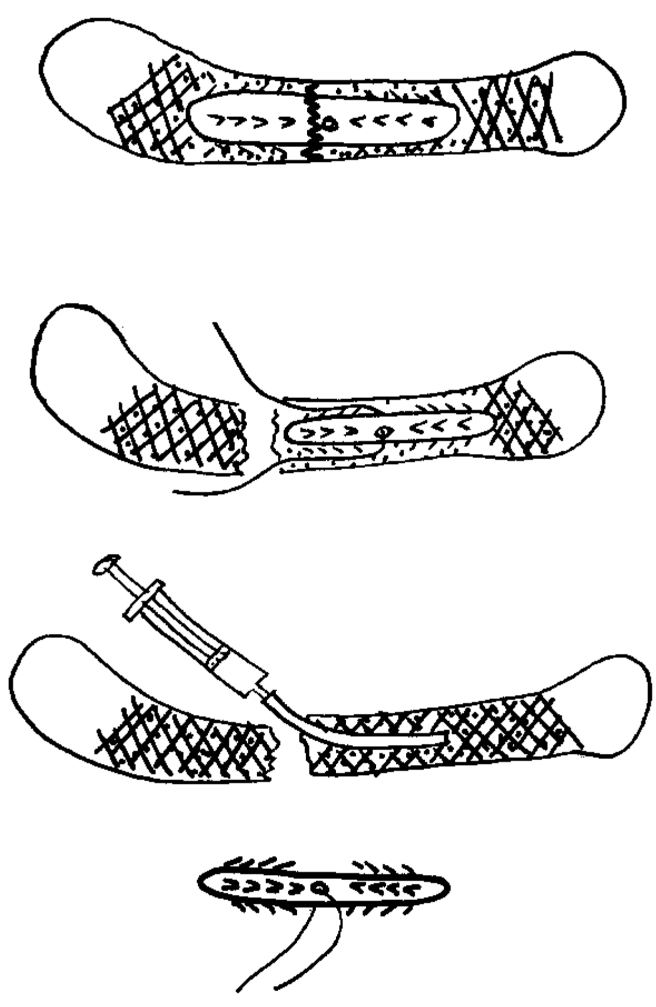

Figure 6: **Polypropylene rod & bone cement (after Degernes, 1989)**

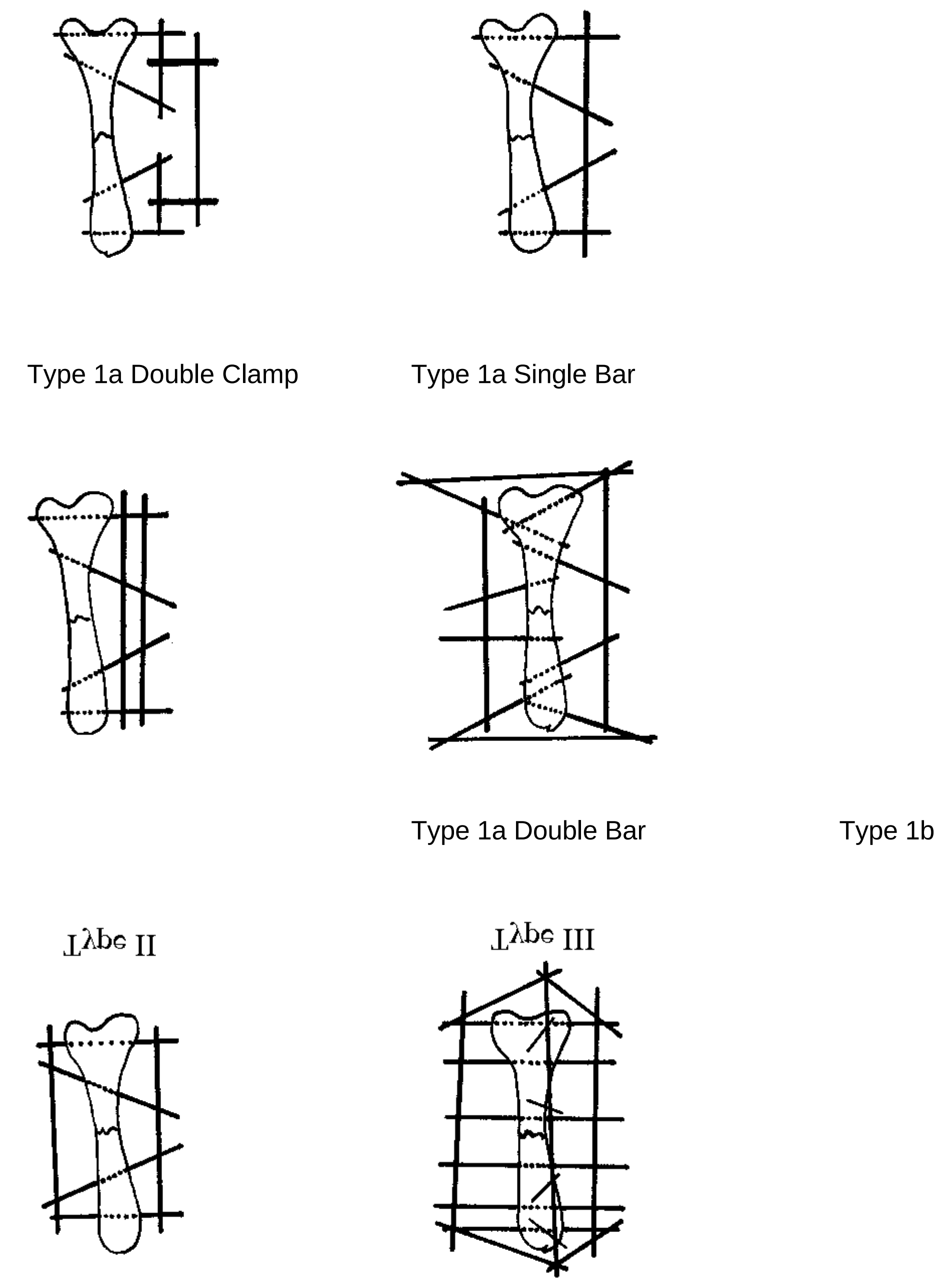

Figure 7: Kirshner Splint (after MacCoy, 1992)

Fracture Site	Recommended Management	Prognosis
Coracoid		
- closed	Bind wing to body	Excellent
- distracted	IM Pinning	Fair
Furcula/Scapula	Bind wing to body	Excellent
Proximal Humerus		
- closed	Bind wing to body	Excellent
- open, comminuted	IM Pinning	Fair
Distal Humerus		
- closed	Bind wing to body	Good
- open	IM Pinning	Good
- open, comminuted	IM Pinning	Fair
Proximal Radius		
- closed	IM Pinning	Good
Midshaft Radius		
- closed	Figure 8 bandage	Excellent
	Braille	Excellent
	Bind wing to body (small birds)	Excellent
- open	Figure 8 bandage	Excellent
Distal Radius		
- closed	Figure 8 bandage	Excellent
	Braille	Excellent
	Bind wing to body (small birds)	Excellent
- open	Figure 8 bandage	Excellent
Proximal Ulna		
- closed	Figure 8 bandage	Good

Fracture Site	Recommended Management	Prognosis
Midshaft Ulna		
- closed	Figure 8 bandage	Excellent
	Braille	Excellent
Distal Ulna		
- closed	Figure 8 bandage	Excellent
	Braille	Excellent
Proximal Radius/Ulna		
- closed	Transarticular	Fair
	Kirshner	Good
- open, comminuted	IM pinning	Fair
Midshaft Radius/Ulna		
- closed	Modified Kirshner with plastic rod	Good
- open, comminuted	Figure 8 with minimal internal fixation	Fair
Distal Radius/Ulna		
- closed	Modified Kirshner with plastic rod	Good
- open, comminuted	Figure 8 with stiffener	Fair
Carpometacarpus		
- closed	Figure 8 with stiffener	Good
- open	Figure 8 with stiffener*	Fair
Proximal or Mid-Femur		
- closed, simple	Bind to body	Good
	Cage rest	Good
	IM pinning if over 400gm	Good
Distal Femur		
- closed	Modified transarticular	Good
	Kirshner	Good
Proximal Tibiotarsus		
- closed	IM pinning	Excellent**
	Transarticular	Excellent**
	Kirshner	Excellent**

Fracture Site	Recommended Management	Prognosis
Midshaft Tibiotarsus*		
- closed	IM pinning & Schroeder-Thomas	Good**
	Finger Plate	Good**
Distal Tibiotarsus		
- closed	IM pinning & Schroeder-Thomas	Good
	Tape Splint (small birds)	Good
- open	IM pinning & Schroeder-Thomas	Fair
	Tape Splint (small birds)	Fair
Metatarsus		
- closed	Tape splint	Good
	Schroeder-Thomas splint	Good
	Boston	Good
- open	Tape Splint	Fair
	Schroeder-Thomas splint	Fair

* Attempts at primary union usually result in a non-union. It is better to allow time for soft tissue to repair, then use open reduction & repair.

** These cases are often lost because of development of pressure necrosis on the opposite foot.

*** In comminuted fractures use the following guidelines:

With one butterfly fragment internal fixation is usually successful

With two or more fragments external fixation alone is preferred.