I. CLOSED IM PIN INSERTION – TIBIOTARSUS

A. For treatment of fractures of the tibiotarsus a single IM pin may be inserted to provide axial alignment and bending support. The pin is inserted in a method analogous to insertion of an intraosseous cannula.

B. Grasp the tibiotarsus firmly with one hand on the proximal part and one on the distal. Bend the bone over the edge of the table until it snaps creating a fracture roughly in the center of the bone. It breaks easier if the bending is done with a sharp, hard, quick movement to make the bone snap.

C. Pluck the feathers surrounding the cranial aspect of the stifle joint and palpate the structures associated with this joint. You should be able to palpate the cranial cnemial crest that will be a landmark for pin / cannula insertion.

D. In a live bird, the area is prepared for an aseptic procedure using chlorhexidine and warm saline gauze sponges.

E. Normograde IM pin placement closed technique.

1. Hold the stifle in flexion with the left hand (for right handed people) using the thumb and forefinger to feel the lay of the tibiotarsus.

2. Insert the 1/8” Steinmann pin in a manner similar to insertion of an IM pin into the tibia of a dog or a cat starting between the cranial cnemial crest (analogous to the tibial tuberosity) and the caudomedial prominence of the plateau. Rotate the pin and advance it until it penetrates the plateau into the medullary canal.

NOTE: YOU WILL ALSO USE THIS PIN FOR THE FEMUR AND HUMERUS SO DO NOT CUT BOTH ENDS OFF BEFORE YOU GET TO THE HUMERUS FIXATION SECTION.

3. Once the pin is inserted in this normograde manner, the most difficult part will be aligning the fragments so the pin can be inserted into the distal segment.

4. Try to align the fracture ends without making a surgical approach. Use ZEN (“Use the force, Luke”) to assess the alignment of the pieces and advance the pin into the distal segment (BE THE BONE).

5. Advance the pin until you encounter SLIGHT resistance. Do not advance farther as you will likely penetrate the tarsus.

6. If properly placed, when the chuck with pin attached is rotated, the foot should rotate too. However, this can occur if the pin is periosteal and not intramedullary.
7. Make a mini-surgical approach as described below to make sure the pin is properly placed.

F. Normograde IM pin placement open technique.

1. Once you feel the pin is in place OR you have tried unsuccessfully 2-3 times to get the pin into the distal segment, make a mini-surgical approach to the fracture.

2. Make an incision on the medial aspect about 1 cm long (just long enough to allow you to look at the ends of the bone). Once the incision is through the skin, use hemostats to bluntly dissect through soft tissues. As in mammals there is little soft tissue on the medial aspect of the tibiotarsus but when there is a fracture there can be a lot of tissue swelling, making it appear as if there is a lot of tissue.

3. Use small forceps or hemostats to find the ends of the fracture and make sure the pin is properly placed.

4. If you were unable to place the pin closed or if you missed the distal segment, exteriorize both fracture ends. If you did place the pin correctly, back it out proximal to the fracture so you can practice and compare the closed technique with the open technique. The pin should be within the proximal segment. Advance the pin so only a small amount extends beyond the fracture end. Many recommend cutting the trochar tip off the pin to minimize the risk of penetrating the distal cortex. In this lab, we will need to use the pin again so DO NOT cut the tip off the pin.

5. Toggle the ends of the fracture on top of each other and slowly, carefully advance the pin into the distal segment. Again, advance it to where slight resistance if felt.

G. Retrograde placement of an IM pin in the tibiotarsus.

1. Make the mini approach as described above.

2. If the pin is NOT in the proximal segment, remove it.

2. With the fracture exposed, flex the stifle so the pin will not go up into the femur. Retrograde the pin into the proximal segment out the proximal tibiotarsus. Normograde placement is preferred to avoid injury to the patella and distal femur since a pin placed retrograde proximally can exit the proximal tibiotarsus more caudal and lateral.

3. Once the pin exits the proximal tibiotarsus, back it out proximally to a point where only the very tip is exposed at the distal end of the proximal fracture fragment.

4. Toggle the fracture together and advance the pin as described above.

II. PLACEMENT OF AN OFF-WEIGHT-BEARING SLING - LEG

A. Following placement of the IM pin, support the leg with an off-weight-bearing sling to prevent rotation of the distal segment and excess movement at the fracture.
B. Using adhesive or masking tape, apply a tape stirrup to the foot such that it continues on the lateral side of the bird. This tape will be wrapped around the bird’s body and if it is on the medial side, this will not be possible.

C. Wrap the tape around the lateral side of the affected leg pulling it into flexion (not too tightly).
   a. Continue the tape over the dorsal midline
   b. Down the contralateral side of and cranial to the contralateral leg
   c. Continue across the ventral abdomen and the affected foot.
   d. Continue by making a second wrap around the body, this time caudal to the contralateral limb.
   e. By having one wrap cranial to the opposite leg and one caudal, it is difficult for the sling to slip cranially or caudally.

II. INTRAOSSEOUS CANNULA – ULNA

A. The dorsal aspect of the distal ulna and the proximal carpus is prepared as above for insertion of an intraosseous cannula.
   1. If the needle is inserted ventrally, it will pass through the ulnar carpal bone, which is difficult and results in more damage to the joint.
   2. If the needle is inserted from the end of the carpus, it will pass through the alula as well causing more damage to the bone and joints.

B. The needle is inserted into the dorsal aspect of the distal ulna.
   1. Three prominences are palpable; the distal radius, the extensor process of the carpometacarpus, and the distal ulna.
   2. The distal ulna is identified as a crescent shaped raised area proximal to the extensor process of the carpometacarpus.
      a. Note: the bone over the leading edge of the carpus is NOT the ulna; rather it is the extensor process of the carpometacarpus and must be avoided.
   3. Needle insertion is initiated at the prominence of the distal ulna.

C. Bend the carpometacarpus downward (adducted) to open the space between the distal ulna and the ulnar carpal bone for pin insertion. The needle must be started 2-4 mm deep to the crest or it will come out the bone lateral (dorsal) to the ulna and not be advanced into the medullary canal.

D. Insert the needle through the soft tissue at an acute angle until it contacts bone (only a few millimeters)

E. Twist the needle until you feel it engage the bone, and then flatten out the angle of insertion to be in line with the lay of the ulna.
F. Advance the needle until it is in the medullary canal of the ulna. With proper placement, you may feel the needle point scrape / grate along the inner surface of the cortex of the bone.

G. Confirm placement:

1. Use a 3 cc syringe attached to the IOs needle and aspirate to check placement. If flashback is visualized, placement is confirmed. In this manner a bone marrow sample may also be obtained.

2. If there is no flashback following aspiration, slowly inject 1 cc of heparinized saline and try again. (use water in the lab) If blood-tinged fluid is retrieved, placement is confirmed.

3. For ulnar cannulae (not applicable to other bones) placement can be confirmed by injecting 1-3 cc saline while visualizing the cutaneous ulnar vein. If properly placed, when saline is injected, this vein will blanch temporarily following injection.

4. If the above fail, you may inject 3 cc saline, which should cause swelling of the muscles in the antebrachium if the needle is NOT within the canal.

5. Some birds have pneumatic ulnae. If you aspirate air, do not use this site because the fluid will go into the air sac and lung.

H. Once you have confirmed placement, you may suture the needle in place. A butterfly tape is placed on the needle and two nylon sutures used to secure the tape to the skin.

III. OPEN IM PIN INSERTION WITH EXTERNAL SKELETAL FIXATION OF THE ULNA – RADIUS AND ULNA

A. Use the same wing as the one in which you placed the intraosseous catheter. Remove the catheter.

B. Pluck the secondary feathers from the lateral (dorsal) aspect of the antebrachium. Do not pluck the primary flight feathers. Also remove the feathers from the carpal joint. Some of the feathers will have already been removed in preparation of the IOs catheter.

C. Break the radius and ulna over the edge of the table as close to mid-diaphyseal as you can.

D. Make a mini approach at the fracture site to expose the ends of the broken radius and ulna. Make a small incision between the two bones so you can access both through one incision.

E. First you will place a non-threaded 0.035 K-wire retrograde from proximal to distal in the radius. It will exit at the carpus. The distal radius has a slight bend as it articulates. Because of this bend, the pin will exit the radius and not enter the joint. In some birds with fracture of both the radius and ulna that produce excess callus, the callus can fuse the radius and ulna preventing supination and pronation. In many birds precision flight is not needed and in those, pinning the radius may not be necessary. In raptors and other birds that require precision flight, pinning the radius often results in less callus formation and reduces the risk of synostosis between the radius and ulna.
1. Put the 0.035 “ K-wire in the pin chuck and tighten it. Insert the pin in the distal segment of the radius and advance it by rotating it.

2. Advance it until it penetrates the distal radial cortex and exits the skin at the carpus.

3. Remove the chuck and replace it at the end of the pin exiting the radius at the carpus.

4. Back the pin out until it is at the fracture with only 1 mm or less exposed.

5. Reduce the fracture and advance the pin into the proximal segment. Advance the pin until you feel resistance.

6. Do not advance the pin through the proximal cortex or it will be in the elbow joint.

7. Cut the pin at the carpus as short as possible and cover it with skin so the tip is not protruding.

F. You will place a 3/32” non-threaded Steinmann pin into the ulna normograde from proximal to distal. Because of the ulna has a joint on each end it is best to normograde the pin from proximal to distal to avoid being close to or through a joint, which will cause ankylosis.

1. Place the pin in the chuck and tighten it with the key.

2. Begin the insertion of the pin between the second and third flight feathers distal to the elbow joint. The ulna has a curve and if the pin is started to proximal it will exit the bone before it gets to the distal end.

3. Begin the insertion with the pin nearly perpendicular to the surface of the ulna until it just starts to engage bone.

4. Once it begins to engage bone, change the angle so that it is being inserted parallel to the ulna. Keep rotating the pin so the trochar tip cuts into the bone while the angle of insertion is being changed. If the pin completely penetrates the near cortex before the angle is changed, it will break the cortex.

5. Once the pin has penetrated the near cortex and is oriented in line with the ulna, advance the pin by pushing and rotating the pin slowly and carefully. Advance the pin until resistance is encountered distally.
   a. Be careful to stop when you feel resistance
   b. Do not penetrate the distal cortex or it will compromise joint function

6. It is best not to remove the pin and replace it with one that has a blunted end. This may make the hole in the cortex larger and compromise stability.

7. Cut the pin as short as possible at the elbow joint. If possible, pull the skin over the cut end
of the pin. (Note: do not cut the pin if you intend to use it to tie into an external fixator: see method for Tie-In Fixator on the Humerus below)

G. IM pins generally will not prevent rotation at the fracture site. With a two bone system like the radius and ulna, there will be less rotation compared with a single bone; however, there will still be some rotation. To stabilize against rotation, one option is to use a figure 8 bandage. Because this type of bandage will immobilize the joints proximal and distal to the fracture (elbow and carpus) it is not necessary to wrap it to the body as well. Many birds, however, will droop the wing due to pain/discomfort for a few days after surgery. If that occurs, then it will be necessary to add a body wrap.

IV. FIGURE 8 BANDAGE AND BODY WRAP – TO PREVENT ROTATION

A. Typically a wing wrap will have 3 layers: cast padding, roll gauze, and Vetrap. Each layer is applied in the same manner. In the end, only the Vetrap should show (no cast padding or gauze should be exposed).

B. Place the end of the material on the dorsal aspect at the leading edge of the wing so the roll is directed toward the medial aspect of the carpus.

C. Wrap the material around the ventral aspect of the carpus to the cranial edge of the carpometacarpus and over onto the lateral aspect of the wing.

   a. This will create a loop of bandage material around the ventral aspect of the carpus crossing on the dorsal aspect of the wing with the roll directed now toward the distal, lateral humerus.

D. Wrap the material over the dorsal aspect of the distal humerus, into the axilla (as far proximal as possible to engage the distal humerus, NOT JUST FEATHERS).

E. Wrap the material under the ventral aspect of the more distal portion of the wing to come along the cranial edge over to the dorsal surface at the level of the phalanges.

F. Wrap the material to overlap with the starting point.

G. Continue this figure 8 pattern for 2-3 more wraps.

H. In order to immobilize the shoulder joint for humerus fractures (which a Figure 8 bandage alone will NOT do) wrap the material around the bird’s body.

   a. Be careful to NOT wrap too tightly or you can compromise the bird’s ability to breathe.
   b. Also be careful NOT to allow the bandage to cut into the propatagium, which is a common complication with figure 8 bandages in birds.
   c. As with the off-weight bearing sling, one wrap should go cranial to the opposite wing and one caudal to it to prevent the bandage from shifting in a cranial or caudal direction.

V. EXTERNAL SKELETAL FIXATION USING TUBING AS THE CONNECTING SYSTEM– TO PREVENT ROTATION
A. Different things can be used for the connecting system for an external fixator. We now have partially threaded, positive profile threaded pins for acrylic fixators. These pins have a rough shaft to bond with acrylic cement. Cement holds by a cohesive bond, not adhesives. It will break away from a smooth surface.

B. The fixation pins can be connected using tubing and filling the tubing with the cement when it will still flow. In the lab we will use a 1/4 “ Penrose drain.

1. Use the four 0.045 or 0.062” threaded pins for acrylic fixators and place 2 in each the proximal and distal segments on the lateral/dorsal side perpendicular to the bone.
   a. The angle of pin insertion is not important. Because the pins are threaded, insert them in a clockwise direction, not rotating back and forth.
   b. Place the pin in the chuck and pass it through the skin over the mid-diameter of the ulna. Use the pin to slip cranial and then caudal to identify the middle of the ulna.
   c. Try to insert the pins in the middle of the ulnar diameter. Again, the angle may change if the fixation pin hits the IM pin.

2. It is ideal to place one pin as close to the fracture as possible and the second pin as far from the fracture as possible for the best stability.

3. Pre-drilling is not necessary with avian bone. Because the pins are threaded, start insertion by rotating the pin back and forth but once it starts to engage bone you need to thread clockwise.

4. After you completely penetrate the near cortex, allow the pin to go where it wants to go. It may hit the intramedullary pin and if you try to force it where you want it to go, it may break the near cortex. Let it pass by the IM pin even if it changes the angle of the pin.

4. Thread the pins completely through the far cortex. It will get easier once you are in the medullary canal then more difficult again when you start to cut into the far cortex.

5. All of the trochar tip should be through the bone so the bone is completely engaged by threads and not just the trochar tip. The body will wall off the sharp tip.

6. Try to insert all pins parallel to each other. This may not be possible because of the IM pin. The advantage to using the Penrose drain is that it is flexible enough to zigzag as needed to engage all pins.

7. Push the tubing over all 4 fixation pins. Try to hit the middle of the Penrose with each pin. After the Penrose is over the pins, push them down close to the skin surface but leave enough space to be able to cut the fixation pins once the fracture has
healed.

8. Try to open the Penrose. It is often flat at this point. Pull up on the side farther from the body to recreate the tube.

8. Mix the cement and when it is still thin, disassemble the catheter tip syringe and fill the barrel with cement. You may need to add more liquid monomer.

9. Allow the cement to run down the side and not completely fill the syringe transversely so the air can be expelled from the tip. Replace the plunger and expel the air.

10. Place a hemostat on one end of the Penrose drain.

11. Connect the tip of the syringe to the tubing and inject the cement. While injecting, PMMA might ooze from the fixation pin holes. DO NOT try to clean it up. It will just make things worse. Once it begins to solidify, it will be easy to remove from the feathers or skin.

12. It takes 10-15 min for the cement to become hard. While it is curing, fold the bird’s wing and hold it close to the body as the bird would if it were perching. Hold BOTH wings, one in each hand, so you can feel for symmetry to keep rotational alignment in tact.

13. Cut the excess length of the fixation pins as close to the acrylic bar as possible. The cut ends can be covered with tape or caps of PMMA cement.

14. Using this technique it is usually necessary to bandage the wing to the body for a few days because it will often droop and the bird may stand on it and soil it. However, once the bird will hold the wing up, a bandage is no longer needed minimizing bandage morbidity. Rehabilitation can begin at this point.

IV. OPEN IM PIN INSERTION WITH ANTIROTATIONAL FIGURE 8 WIRE – FEMUR

A. Pluck the feathers from the dorsal midline to the stifle along the lateral aspect of the thigh of the contralateral leg to the one with the tibiotarsal fracture. Break the femur mid-diaphyseal. It will be best to make the fracture as transverse as possible. This technique is most applicable to transverse fractures. The antirotational figure 8 wire will prevent rotation with an IM pin.

B. Make a surgical approach to the fracture.

C. Isolate the proximal and distal segments and free about 1 cm from the soft tissue attachments.

D. Load a cut piece of a K-wire used previously as a fixation pin, sharp end out, into the pin chuck and create a hole cranial to caudal (or caudal to cranial) through the proximal and distal segments about 0.5 cm from the fracture ends.

E. Pass a strand of 24 ga wire through each hole. There will be two pieces of wire, one in each
segment.

F. You will pass the 1/8” IM pin normograde from proximal to distal through the trochanteric fossa.

1. Load the 1/8” pin into the chuck. Insert the pin at the proximal end of the femur. Walk the pin from lateral to medial until the pin drops off the greater trochanter into the trochanteric fossa.

2. Insert the pin into the trochanteric fossa down the shaft of the femur. It is best to insert the pin normograde to avoid the sciatic nerve. When a pin is inserted retrograde it can come out close to the sciatic nerve causing compromise.

3. Advance the pin to the fracture, reduce the fracture, and continue advancing the pin into the distal segment until you meet resistance. Again, be careful not to penetrate the distal femur and advance the pin into the joint.

4. At this point you will create the figure 8 antirotational wire. Cross the two wires you placed in the proximal and distal segments so they create the figure 8. You will be making two knots, one on each side.

5. Use wire twisters to tighten the figure 8 wire alternating sides. You do not have to make this super tight. Its function is to prevent rotation. Over tightening can cause iatrogenic fractures.

6. Try to have one twist at the cranial aspect of the femur and the other twist at the caudal aspect. Cut the twists at three twists from the bone. You can leave the twists up or carefully bend them over. If you leave them up, they are stronger and will be covered by a fibrous tissue cap. If you bend them over, do it carefully. With cerclage wires we leave them up because they are not as secure when bent over but because we are only preventing rotation, it is acceptable in this application.

7. Test the tightness by rotating the distal leg internally and externally to see if there is motion at the fracture. If there is, tighten the wires more. If not, it is tight enough.

8. Close the surgical site and cut the pin at the greater trochanter as close as possible to the skin. Pull the skin over the end of the pin and a suture can be placed if needed to keep the pin from protruding.

V. OPEN IM PIN INSERTION – HUMERUS

A. Break the humerus of the wing contralateral to the wing your broke the radius and ulna as you broke the other bones. Try to break it mid-diaphyseal.

B. Make a skin incision on the lateral aspect of the humerus beginning at the middle and extending distally for about 2-3 cm.

   a. THE RADIAL NERVE CROSSES OVER THE LATERAL ASPECT OF THE DISTAL HUMERUS SO BE CAREFUL NOT TO CUT IT.
b. Because of the location of this nerve, fractures in this region can damage the nerve.

c. It is vital to assess pain perception in the extremity before attempting fracture repair.

C. Identify the ends of the fracture.

D. Place the 1/8” IM pin retrograde through the proximal segment

   a. The pin should exit the deltid crest of the proximal end of the humerus.
   b. Adduct the wing during placement so if the pin advances too far it does not penetrate the chest cavity.

E. Pull the pin out of the proximal humerus so the tip of the pin is just barely visible at the fracture end. Again, some prefer to cut the pin off so when the pin hits the distal cortex it will not penetrate it. This is more acceptable when a pin is place retrograde than normograde because it does not need to be removed and replaced.

F. Reduce the fracture and advance the pin into the distal segment until slight resistance if felt.

G. At this point you can close the incision (only skin sutures are needed because there are only tendons here and there is little subcutaneous tissue).

H. Using two pliers/pin benders/wire twisters/old needle holders bend the pin as close to the skin as possible 90 degrees so that it is perpendicular to the lay of the humerus.

   a. Use one at the base of the pin where the pin enters the skin to apply counter pressure
   b. Use the other farther away and bend up while applying downward counter pressure with the other wire twister.
   c. If you do not do this, you will likely cause iatrogenic fracture to the proximal humerus because it is too fragile to withstand the pin bending force.

VI. Tie-In Fixator on the Humerus

A. The IM pin in the humerus that has been bent will be incorporated into an external skeletal fixation device. Acrylic cement will be used as the connecting system.

B. Insert four 0.045 or 0.065” positive profile threaded pins for external fixators transversely into the bone as fixation pins.

   a. One close to the proximal end and one close to the distal end of the humerus.
   b. One close to the proximal fracture end and one close to the distal fracture end.
   c. When using positive profile threaded fixation pins the angle of insertion is not important.
   d. Try to insert all pins parallel to each other, but again, it may not be possible with the IM pin in place.

C. Mix the acrylic putty according to the directions.

   a. If the pins are long enough, you can bend them over 90° so they will act as re-bar. This will prevent the cement from sagging while it cures.
D. Roll the putty into a bar that you will use to connect all 5 pins.

E. Apply the cement onto all 5 pins making sure it does not lay on the skin and leaving enough room between the cement and the skin to allow the pins to be cut when the fracture has healed.

F. It takes 10-15 min for the cement to become hard. While it is curing, fold the bird’s wing and hold it close to the body as the bird would if it were perching. Hold BOTH wings, one in each hand, so you can feel for symmetry to keep rotational alignment in tact.

G. Once the cement has hardens, cut any pins protruding through the cement off and cap the sharp points.

H. Apply a Figure 8 Body Wrap bandage in order to immobilize the joints proximal and distal to the fracture.

I. With a Tie-In Fixator the wing only needs to be bandaged for a few days. Most birds will not hold the wing up for a few days after surgery due to pain. Once they will hold the wing up, the bandage is not needed because the repair should be very stable. At this point, controlled physical therapy can be instituted.