Avian bones are commonly described as thin and brittle with a large medullary canal. They have a high calcium content compared with bones of mammals and are more prone to shattering upon impact. Many bones (most notably the humerus and femur) are pneumatic and involved in respiration and humidification of air. In most locations, soft tissues are not strongly adhered to bones and in the distal extremities there is little soft tissue coverage. These factors contribute to the high incidence of open, comminuted fractures and make iatrogenic fracture during repair attempts a significant concern.

Bone healing in birds is not well understood but the rate of fracture healing appears to depend on the integrity of the blood supply, the presence of infection, the amount of displacement, and the degree of motion at the fracture site. It is likely that under conditions of rigid immobilization, primary bone healing occurs similar to that observed in mammals. When bone callus is involved in fracture healing, endosteal and periosteal callus contribute to stabilizing the fracture. Endosteal callus, even in pneumatic bones, contributes more to healing than periosteal callus. Clinically, avian bones seem to heal faster than mammalian bones with well aligned, stable fractures requiring about 3 wks.

Autogenous bone grafts are beneficial in avian fracture management. Because the humerus and femur are pneumatic, they are not viable sources of cancellous bone. More distal bones of the extremities are often small and narrow making them poor donor sites. In large birds and terrestrial birds, the tibiotarsus may provide adequate cancellous bone for grafting. More commonly, corticocancellous grafts are used in birds. These may be used for onlay grafting or cut into fragments and used around the fracture site or packed into cortical defects. The sternum and ribs are good sources of corticocancellous bone. To harvest bone graft from the keel, the pectoral muscles are elevated bilaterally exposing the carina sterni. A central portion is removed leaving a bucket handle remnant to which the pectoral muscles are reattached. When harvesting ribs, preserving the inner periosteum will maintain the air sacs and prevent subcutaneous emphysema.

The principles of fracture treatment in birds are similar to those established for mammals—rigid fixation, anatomic alignment, and minimal disruption of soft tissues and callus formation. Early return to function is critical to prevent ankylosis. This is especially important when normal limb function is required as for wild birds intended for release. Practical considerations in fracture management include cost of the materials, ease of application, required limb function required, patient's temperament, availability of equipment, and the surgeon's level of expertise.
Nonsurgical management of avian fractures is an important method of fracture treatment not addressed in this session. In avian orthopedics, internal fixation is often used in combination with external coaptation. This should be avoided as the negative aspects of both types of repair may be manifest. The surgical approaches to long bones of birds have been described (Orosz). When closing the surgical wound, the muscles may be loosely apposed to cover the fractured bone unless there is concern that this might restrict joint function. In these situations it is only necessary to close the skin.

Application of IM pins and orthopedic wires is familiar to most veterinarians and requires little specialized equipment. They are inexpensive, provide axial alignment and bending stability, and require minimal tissue exposure for insertion. They do NOT stabilize fractures against rotation and shear forces. For proper flight, rotational alignment is critical. External coaptation is frequently utilized in conjunction with IM pins to stabilize fractures against rotation and shear forces. This can result in impaired function from fracture disease. More appropriately stack pinning, cerclage or hemicerclage wires, or external skeletal fixation (ESF) are used to counter these forces. The most significant concern when using IM pins in avian patients is the possible damage to articular and periarticular structures. Even pins placed near a joint may stimulate production of sufficient scar tissue to inhibit normal joint function. If possible, pins are inserted so they do not enter or exit through or near a joint. If a pin must be placed through a joint, it is removed as soon possible. Following pin removal, the extremity is maintained in external coaptation to continue to stabilize the fracture until healing is complete. Cross pin and Rush pin techniques are used to stabilize metaphyseal fractures. Rush technique achieves a dynamic 3 point fixation which will counter major fracture forces. Orthopedic wires may be used as cerclage, hemicerclage, or interfragmentary wires to provide stability to the fracture.

Intramedullary polymer rods (polyvinylidene fluoride and polypropylene) have been used as an alternative to steel IM pins. They are inserted using a shuttle technique which does not damage articular structures and requires minimal surgical exposure. These pins are not as resistant to bending as steel and are frequently used in combination with transverse pins, ESF, external coaptation, or intramedullary polymethylmethacrylate (IM PMM) to add shear and rotational stability. A modification of this technique involves the use of threaded Steinmann pins which may be cut to an appropriate length and placed IM using a shuttle technique. These pins are stiffer and, when used with IM PMM, provide a cohesive surface bond with the PMM. These IM devices are not removed after fracture healing as they are completely within the bone.

Polymethylmethacrylate (Surgical Simplex-P, Howmedica, Inc., Rutherford, NJ 07070) is a nontoxic bone cement that produces a cohesive, mechanical friction bond with the interstices of the bone. Once the liquid monomer is mixed with the powered polymer, the reaction is exothermic, producing temperatures of >100° C. This results in osteocyte death but appears to be of little clinical significance. PMM may be used in pneumatic or marrow containing bones, as well as to incorporate fracture fragments into the repair of comminuted fractures. IM PMM may be used as a sole means of fracture support by injecting the cement into the medullary canal of both fracture fragments. While the cement is curing, the fracture is held in reduction. IM PMM is most commonly used in conjunction with some other means of support such as a shuttled threaded Steinmann pin, polypropylene rod, or with a bone plate.
Bone plate fixation of avian fractures has historically been discouraged. It was believed that the thin, brittle cortices would not provide adequate screw purchase. There are no studies on the screw holding strength of avian bones. Recently, bone plates have been used successfully in birds with or without IM PMM. Veterinary cuttable plates (#243.99 and 242.99, Synthes, 1690 Russel Road, Paoli, PA 19301) are well suited for treatment of avian fractures. These plates may be used with either 1.5 mm or 2.0 mm (243.99) or 2.0 mm or 2.7 mm (242.99) screws. They are lightweight, small, strong, have closely placed screw holes, and may be cut to an appropriate length. They can be stacked for added strength. Special care must be taken when inserting screws into avian bones. The drill bit must be straight and sharp, proper drill guides must be used so that screws are placed in the correct location within the hole of the plate, threads must be tapped carefully clearing the flutes frequently, and the drill and tap should be cleaned between screws. Screws must be inserted delicately to prevent iatrogenic fractures and stripping the threads.

The Kirschner-Ehmer splint is only one type of external skeletal fixation device. Because of the expense and weight of this type of fixator, they are rarely used in avian fracture management. Biphasic fixators utilize steel fixation pins and acrylic compounds to connect the fixation pins external to the body surface. ESF devices do not damage articular and periarticular structures, they require minimal surgical exposure, and they are light weight and allow early return to function. Their strength is a function of configuration and fixation pin placement. Depending upon the size of the patient, small Steinmann pins, Kirschner wires, injection needles, or spinal needles may be used as fixation pins. Nonsterile PMM (Technovit, Jorgensen Labs, Loveland, CO 80537), 5 min epoxy glue, Hexcelite cast material, and dental acrylics have been used for the connecting bar of biphasic fixation splints. With the exception of Hexcelite, these materials may be injected into flexible tubing which has been placed over the fixation pins. Placing the tubing over pins which are placed at different angles can be challenging. Alternatively, cement can be mixed to a dough consistency, then molded around the fixation pins while the fracture is maintained in reduction. To improve the bond between the pins and the cement, the pins are notched with a pin cutter or bent over and incorporated into the connecting system. Hexcelite (Hexcel Medical, 6700 Sierra Lane, Dublin, CA 94566) is a casting material that becomes soft and malleable when immersed in hot water and becomes rigid when it cools. Because of the severe consequences of fracture disease in birds, ESF has gained a prominent role in avian fracture management.

Epoxy putty is available at most hardware stores. It comes in a tube with the two components within the tube, one being as an outer rim and the other the central core. A portion is cut off and mixed with fingers. It is a modeling clay consistency and when mixed, the polymerization occurs. In about 5 minutes it becomes hard. This material is easy to work with and does not have the fumes PMMA does.

Tie-in external fixators combine an IM pin with an external skeletal fixator and are much stronger than either used alone or in combination without tying them together. An IM pin is inserted using standard technique. It is best to use a pin about 50% of the diameter of the medullary canal to allow the fixation pins to be inserted perpendicular to the IM pin. The fixation pins are inserted using standard technique using a pin size small enough to go perpendicular to the IM pin and past it to the trans-cortex of the bone. The IM pin is then bent at its exit from the
bone 90° so that it can be incorporated into the external connecting system. An acrylic or a traditional bar and clamps can then be used to connect the bent IM pin and the fixation pins. This construct is very stable.

Prognosis with avian fracture repair is somewhat dependent on the intended use of the bird. Pet birds and zoo specimens may function without the ability to fly with precision; however, with wild birds, hunting birds, and racing pigeons, anything less than perfection cannot be regarded as success. In many birds, some degree of leg dysfunction may be acceptable. In raptors, legs are important for obtaining food, in terrestrial birds they are necessary for survival, and in many species they are vital for successful reproduction.


