Fractures of the Humerus

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ANATOMY

BONY ANATOMY IN THE MATURE DOG OR CAT

The humerus is enlarged proximally and forms a smooth articular surface that articulates with the scapular glenoid; this surface is termed the humeral head. Immediately adjacent laterally and anteriorly is the largest protuberance, the greater tubercle. Medially a much smaller lesser tubercle exists.

The proximal humerus tapers through the metaphysis and forms the diaphysis. The humeral diaphysis tapers to an isthmus, which is located approximately midshaft. The distal humerus enlarges through the metaphysis and forms the medial and lateral humeral condyles. The medial condyle is larger than the lateral one and occupies a position more in axial alignment with the diaphysis than the lateral condyle. The articulating surfaces of the humeral condyles are called the trochlea, which apposes the ulna, and the capitulum, which apposes the radial head. The humeral shaft is straight when viewed cranially; however, when viewed laterally it is S-shaped. Beginning proximally the diaphysis curves first caudally to midshaft then curves cranially as the diaphysis approaches the distal condyles (Figs. 22-1 and 22-2).

The normal humeral anatomy in the cat mimics that of the dog. The variations that exist are minor: the diaphysis is of a more uniform diameter than in the dog, diaphyseal curvature is less, the supratrochlear fossa is not completely penetrated, and finally the medial epicondyle possesses an epicondyloid fossa through which the ulnar nerve passes (Fig. 22-1, C).

BONY ANATOMY IN THE IMMATURE DOG OR CAT

The immature animal has three epiphyses of significance. The epiphysis of the humeral head may be separate from or confluent with the greater tuberosity epiphysis. The contact surface between the epiphysis and metaphysis forms an angle of...
approximately 102°, which allows the epiphysis to sit upon the metaphyses. Premature closure of any portion of this growth plate can result in accentuated caudal curvature of the proximal humeral diaphysis.

The greater tubercle epiphysis sits upon the growth plate. Most separations of this epiphysis occur simultaneously with separation of the humeral head epiphysis. Premature closure of this growth plate may result in a shortened humeral diaphysis or a straighter diaphysis.

The distal epiphysis is composed of the articulating portions of both the medial and lateral humeral condyles. The proximal surface of the epiphysis is concave and apposes the slightly convex metaphysis. Premature closure or cessation of growth may result in humeral shortening or bowing if the closure is asymmetric.

BLOOD SUPPLY TO THE HUMERAL SHAFT
In the mature dog or cat the major diaphyseal artery enters the bone in midshaft on the caudal surface. It is a branch of the collateral radial artery that branches from the caudal circumflex humeral artery. The immature dog or cat may have diaphyseal blood supply from vessels in muscles originating or inserting at either end of the diaphysis.(4)

FRAC TURES OF THE PROXIMAL HUMERUS
Fractures of the humerus in the dog occur throughout its length and some fractures may pose special problems of reduction and stabilization.(1-3,5) Fractures of the head of the humerus are usually seen in young dogs with open, growing physes. A complete Salter type I fracture of the proximal physis of the humerus is an uncommon injury but one that can usually be handled through closed reduction and stabilized by means of a soft padded dressing that coapts the humerus to the chest wall. A Velpeau sling may be useful for this type of fixation. Usually the splint must be in place only about 2 weeks to ensure a satisfactory end result. Occasionally the proximal epiphysis of the head of the humerus or of the greater tubercle may be split, requiring open reduction and internal fixation, usually with small Kirschner wires. The approach can be made in front of, through the middle of, or behind the deltoid muscle depending on the location of the fracture. Little dissection is necessary, since the tissue planes are usually adequately separated at the time of injury. Small Steinmann pins or Kirschner wires can be inserted through the proximal metaphyseal aspect of the anterior portion of the humerus and slid perpendicularly into the humeral head to maintain its position on the shaft of the humerus. If the greater tubercle of the humerus is involved, the pins may be directed from the tip of the greater tubercle down through the physeal line and into the metaphysis of the humerus. When using these internal fixation methods, no external immobilization is used postoperatively. It is, however, important to immobilize the animal by restricting its activity for 4 to 6 weeks.

FIG. 22-3 A transverse midshaft fracture of the humerus (A,B) was stabilized with an intramedullary pin (C,D).

FRACTURES OF THE SHAFT OF THE HUMERUS
INTERNAL FIXATION TECHNIQUES
Shaft fractures of the humerus occur commonly and may be transverse, oblique, spiral, or comminuted. Transverse fractures are adequately stabilized after open reduction with intramedullary fixation techniques. In some simple transverse midshaft fractures, closed reduction with intramedullary pinning can be accomplished. Most fractures, however, do require open reduction, since overriding is a common sequela of the fracture (Fig. 22-3). For simple midshaft fractures any form of intramedullary fixation may suffice (Fig. 22-4). Kuntscher nailing, single or multiple Steinmann pinning, as well as Rush pinning, have been used (Fig. 22-5). Plating techniques are usually reserved for comminuted fractures and those fractures that cannot be handled adequately with intramedullary fixation techniques (Fig. 22-6). Although plates have been applied successfully to all surfaces of the humerus, we have found the best results with plate placement on the cranial aspect of the shaft of the humerus (Fig. 22-7). The plate can be placed distally close to the medial condyle of the humerus and proximal to the greater tubercle if necessary. When making a surgical approach to the midshaft of the humerus, great care should be taken to adequately visualize and protect the radial nerve.
In general the incision is made so that the brachialis muscle can be mobilized fully, and protection of the nerve is accomplished by maintaining its contact with this muscle belly. A large-diameter Penrose drain is a useful protection and retraction instrument when looped around the belly of the muscle to help elevate the muscle and nerve during the manipulative processes. The deltoid tuberosity can be removed if necessary for exposure, or the deltoid muscle can be elevated from the tuberosity to allow exposure of the proximal aspect of the humerus (Fig. 22-8). Simple suturing techniques will allow the deltoid to reattach itself to the tuberosity. Elevation of the deltoid tuberosity or the muscle from the tuberosity does not seem to result in any untoward problems. Our experience with plates on the humerus indicates that most commonly plates fail by pulling out of the proximal fragment and not the distal one. Therefore, surprisingly few screws seem to be necessary to provide adequate fixation in a distal fragment. Six to eight vortices is the minimal number to be used in the proximal fragment. Additional bone stock can be obtained for screw purchase by aiming the screw toward the head of the humerus through the plate. In this way longer screws can be used and the purchase can be maximized. Also, triangulation of screws in the proximal portion of the humerus will help eliminate the problem of the plate pulling away from the proximal fragment (Fig. 22-8, C) Mobilization of the brachialis muscle is important, since when plating the cranial surface of the humerus the surgeon may be working on both sides of the muscle, depending on at what level of the plate he is inserting screws. The use of bone grafts, as with any comminuted fracture, will help speed union and give added insurance against loss of fixation. The cranial plate may also be used with long oblique comminuted fractures of the distal humerus (Fig. 22-9). Distal fractures involving the joint are plated on the caudal surface. (See Chapter 23.)
Most complications associated with internal fixation are those of improper technique. Many can be predicted at the time of surgery or by looking at postoperative radiographs (Fig. 22-10). If internal fixation is not adequate for whatever reason, additional support should be added in the form of external fixation. Although it is not usually needed, external fixation should be relied upon whenever the stability of the internal fixation is in doubt. It is far easier to further immobilize an injured leg to protect an inadequate fixation than to allow this internal fixation to fail and be faced with a reconstruction based on this failure. Reduction of elbow motion is a common sequela of all humeral fractures except those of the proximal end. Even midshaft fractures of the humerus often have decreased range of motion in the elbow several months or years following surgery. It is important to try to maintain elbow motion during the postoperative course and to enable the animal to make pain-free excursions of the elbow joint. Loss of approximately one half of the motion of the elbow joint may go unnoticed in normal activities of most animals. Therefore, the good results often related by the owner must be tempered by the knowledge of restriction of motion of the elbow joint.

Fig. 22-8 The two preoperative views show a proximal one-third comminuted humeral fracture (A,B) that was approached using an osteotomy of the deltoid tuberosity for exposure of the proximal humerus. The postoperative views show the application of a ninehole dynamic compression plate with one interfragmentary screw and a small wire to reattach the deltoid tuberosity (C,D). Note the moderate use of triangulation of the proximal screws to obtain purchase of the proximal fragment.

Fig. 22-9 This long oblique comminuted fracture in a Great Dane (A,B) was handled with interfragmentary compression with screws and a cranial plate (C). Some distal comminution was included into the fracture fixation with small Kirschner wires. The distal Kirschner wires were introduced from distal to proximal and do not enter the joint.

Fig. 22-10 This multiple fracture of the humerus (A) was treated with axial compression I of the distal fracture, but a gap remained at the proximal fracture site (a). This signaled the resulting complication of deformity (C) and eventual healing of the fracture with fatigue failure of the implant at 8 weeks postoperatively (D). A small gap represents severe problems when dealing with a weight-bearing extremity.

EXTERNAL FIXATION TECHNIQUES
Closed reduction and external fixation of fractures through the physis of the proximal end of the humerus represent the optimal form of treatment. Bandaging techniques such as the Velpeau sling or coaptation to the body wall for a period of 10 days to 2 weeks is sufficient. Often these fractures appear to be extremely stable upon reduction. Fractures of the shaft of the humerus can be immobilized through external fixation using coaptation techniques. A Schroeder-Thomas splint may be useful in cases where musculature will allow the ring of the splint to be close to the proximal joint surface. A Schroeder-
Thomas splint should not be used whenever the ring of the splint would act as a fulcrum at the Fracture site. In general such splints can be used for fractures of the distal half of the humerus. The more distal the fracture, the more the shape of the splint changes to counteract the forces of muscle pull. (See Chapter 15.) Body coaptation and spica casts that incorporate the entire chest wall can be used to immobilize comminuted fractures of the humerus. Most external fixation methods will not allow adequate traction for reduction of the fracture fragments but will permit them to coalesce and heal with slight shortening and overriding. The Schroeder-Thomas splint allows the greatest degree of traction and maintenance of length during healing. Fractures of the distal aspect of the humerus involving the humeral condyle can be immobilized in a right-angle Schroeder-Thomas splint. Reduction of the Fracture fragments should be checked radiographically to ensure adequate position, but immobilization of the joint with a Schroeder-Thomas splint is certainly not an optimal form of treatment. When using this method it is important to try to minimize the length of time the animal spends with his joint immobilized. In general, internal fixation following open reduction gives a more satisfactory result with fractures of the humerus, but surprisingly good functional results can be expected with external splints and casts. External skeletal fixation with a frame and half pins may be a good way to handle unstable fractures of the humerus. I would limit the use of such devices to fractures in which intramuscular rods or compression plates would not be indicated. Open Fractures or septic conditions would be primary indications for the use of external skeletal fixation (Fig. 22-11).

FIG. 22-11 A dog with a long oblique humeral Fracture (A) was referred to our clinic after open reduction and internal fixation with a pin and wire had failed. There was, in addition, the possibility of infection. At the time of open reduction a large avascular loose fragment was removed and an external skeletal fixation frame was made using cortical screws as half pins and a wire-reinforced acrylic budge (a). Minimal internal fixation in the form of an interfragmentary screw was used to connect the proximal and distal fragments. A cancerous bone graft was used in the face of infection. The animal, an unfriendly type (C), was allowed restricted use of the leg. The device was removed after follow-up radiographs at 5 months showed healing (D).

REFERENCES


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