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Humeral fractures in dogs

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KEY POINTS

- Humeral fractures in dogs are common. They represent approximately 10% of all limb fractures. They usually result from motor vehicle accidents, falls, gunshots, or minor traumas.
- There are three classic patterns for humeral fractures: approximately 20% of humeral fractures are physeal fractures in immature dogs; approximately 50% of humeral fractures are diaphyseal fractures resulting from a major trauma, and half of these fractures are comminuted; and approximately 20% of humeral fractures are condylar fractures in adult dogs, secondary to incomplete ossification of the humeral condyle.
- Most humeral fractures need surgical repair. Condylar fractures are ideally repaired with bone screws providing interfragmentary compression. Stable diaphyseal fractures can be repaired with intramedullary pins and cerclage wires, and unstable diaphyseal fractures should be repaired with bone plates, interlocking nails, or external fixators.
- Early postoperative physical therapy helps maintain range of motion of the elbow and limb function. Physical therapy, in our experience, plays an important role in the success of the treatment of humeral fractures in dogs.

INTRODUCTION

Humeral fractures are common in dogs. In a recent epidemiological study of 30,140 fractures in dogs, humeral fractures represented 34% of the forelimb fractures and 10% of all fractures (1). Humeral fractures affect dogs from a broad variety of breeds and ages. They may involve the proximal part of the humerus (humeral head, greater tubercle), the humeral shaft (diaphysis), the distal part of the humerus (humeral condyle, medial or lateral epicondyles), or a combination of these areas.

This article covers the etiology, signalment, clinical signs, diagnosis and treatment of humeral fractures in dogs. The clinical information is based on previous reports (2–7) and on a retrospective case-control study of 243 humeral fractures in dogs treated at the Veterinary Teaching Hospital of the College of Veterinary Medicine at North Carolina State University (NCSU), between September 1983 and November 1995.

Three classic presentations for humeral fractures are seen. First, young, immature dogs have humeral condylar fractures induced by a minor trauma, usually after a fall from a height of 3 feet or less (5). Second, adult dog victims of vehicular trauma have humeral fractures, usually involving the humeral diaphysis. Third, adult dogs of several predisposed breeds have humeral condylar fractures after a minor or unknown trauma. These fractures are secondary to incomplete ossification of the humeral condyle (IOHC) (8). The breeds affected include cocker spaniels (8–11), springer spaniels (4, 10, 12), Brittany spaniels (8, 9), Cavalier King Charles spaniels (4, 12), Labrador retrievers (13), and, rarely, mixed-breed dogs (8).

Signalment

Humeral fractures are seen in all breeds. In our case series, 52 breeds were represented. Brittany spaniels, Great Danes, cocker spaniels, and Labrador retrievers were at increased risk for humeral fractures **(Table 1)**, and miniature poodles were at decreased risk for humeral fractures (odds ratio: 0.14, confidence interval: 0.01 to 0.95). Likewise, 58 breeds were represented in a report of 189 humeral condylar fractures, and English and French bulldogs,

Table 1
Breed distribution and predisposition for humeral fractures treated at NCSU between 1983 and 1995

Breed	*Humeral fractures**	*Hospital population*	*Odds ratio*	*95% confidence interval*
Brittany spaniel	7	170	6.31	2.75 to 25.6
Great Dane	7	387	2.83	2.69 to 14.1
Cocker spaniel	32	1,941	2.68	1.22 to 6.24
Labrador retriever	32	2,628	1.94	1.31 to 2.86
Mixed-breed dogs	49	7,425	†	†
German shepherd dog	14	1,388	†	†
Golden retriever	10	1,962	†	†
Boston terrier	6	371	†	†
Beagle	5	392	†	†
Chow-chow	5	395	†	†
Rottweiler	5	696	†	†
Yorkshire terrier	5	458	†	†
Other breeds (< 5 dogs)	66	18,076	†	†
Total	243	36,289		

*Five or more individuals represented.

†Not significantly different from the general population of dogs with humeral fractures.

Figure 1 *Mediolateral and craniocaudal radiographs of the humerus of a 15-week-old male beagle.*
(a) *A lateral condylar fracture (Salter IV fracture) was caused by an unknown trauma. The fracture was repaired with a 3.5 mm bone screw providing interfragmentary compression, a washer, and a Kirschner wire 1.6 mm in diameter.*
(b) *Six weeks after surgical repair, the fracture has healed.*

Yorkshire terriers, and miniature schnauzers were at increased risk (7). In that study, the size of the dogs did not seem to be a factor predisposing to humeral condylar fractures (7).

Three-quarters of the humeral condylar fractures in pups occur between 3 and 5 months of age (7). There is no age predisposition for humeral fractures after vehicular trauma; the median age is 4 years. The median age at the time of condylar fracture for cocker spaniels with IOHC is 6 years, and the range is 2 to 11 years.

No sex predisposition is apparent for humeral condylar fractures in pups. For all humeral fractures treated at NCSU, the risk of fracture was higher in intact males (odds ratio: 2.43, confidence interval: 1.87 to 3.16) and lower in castrated males (odds ratio: 0.62, confidence interval: 0.40 to 0.94) and spayed females (odds ratio: 0.35, confidence interval: 0.24 to 0.50). Intact and castrated male cocker spaniels are three to five times more likely to sustain a humeral condylar fracture secondary to IOHC than female cocker spaniels.

Weight does not seem to affect the occurrence of humeral fractures. One study found that cocker spaniels with humeral condylar fractures tended to be heavier than control cocker spaniels (8); however, another study has shown otherwise (14).

Etiology

In pups, most humeral fractures are condylar fractures. Of these, 78% are Salter IV physeal fractures **(Figure 1a)**, 16% are Salter II, 3% are Salter I **(Figure 2a)**, and 3% are Salter III physeal fractures (15). Physeal fractures also occur at the proximal humeral physis and usually are Salter I or II fractures. This fracture distribution is due in part to the relative softness of the physeal cartilage compared with the surrounding bone and soft tissues and to the asymmetric load placed by the radial head on the lateral side of the humeral condyle. In one report, 20% of humeral fractures (20/107) were physeal fractures (2).

Falls and motor vehicle accidents are thought to lead to humeral fractures by overloading the humerus. The humeral condyle may fracture after falls because, when the elbow joint is extended, the anconeal process contacts

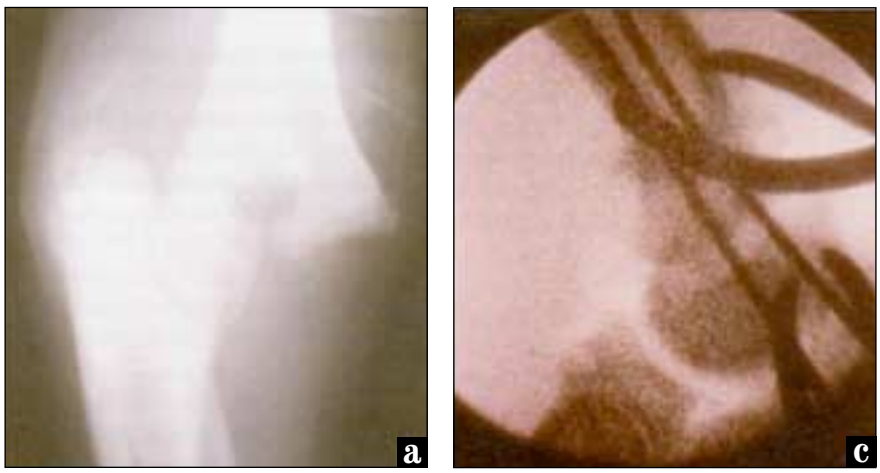

Figure 2 (a) *Craniocaudal radiograph of the elbow joint of a 4-month-old male German shepherd chow-chow crossbred dog. A Salter I fracture of the humerus is present, with a large, associated soft-tissue swelling.*
(b) *A caudal approach to the humerus, including a tenotomy of the triceps tendon, has been performed. The fracture has been reduced, and two Kirschner wires 1.6 mm in diameter have been placed as intramedullary cross-pins.*
(c) *Intraoperative pictures of the humerus, made with a portable fluoroscope, are taken to assess wire placement.*
(d) *Mediolateral and craniocaudal radiographs made 4 weeks later. The fracture has healed.*

Figure 3 *Mediolateral and craniocaudal radiographs of the elbow joint of an 11-year-old castrated male cocker spaniel.*
(a) *A right lateral condylar fracture was caused by an unknown trauma.*
(b) *The fracture was repaired with a 4.5 mm bone screw providing interfragmentary compression.*
(c) *On the left side, only a faint 2 mm notch can be seen at the apex of the concavity of the humeral condyle, on the craniocaudal view.*
(d) *On a CT scan of the left elbow, a notch is present on the caudal aspect of the condyle and the adjacent bone is sclerotic.*
(e) *Six months later, a minimally displaced lateral condylar fracture of the left condyle has occurred, unbeknown to the owner.*

the caudal aspect of the supracondylar region of the humerus and, with violent hyperextension or torsion of the limb, the anconeal process may act as a wedge leading to the separation of the medial and lateral aspects of the humeral condyle (5). Of the dogs with humeral fractures treated at NCSU, 58% had a major trauma: 38% had vehicular trauma, 11% fell from a height of more than 3 feet, and 9% had gunshot trauma.

In dogs with IOHC, a fibrous plane, originating at the cartilaginous regions separating the medial and lateral sides of the humeral condyle before 10 weeks of age, is present across the humeral condyle (8). This fibrous plane is thought to weaken the condyle and predispose affected dogs to humeral condylar fractures **(Figure 3)**. The pathogenesis of IOHC may be related to the pathogenesis of the fragmentation of the medial coronoid process, since most dogs with IOHC also have a fragmented medial coronoid process (16). Of the humeral fractures treated at NCSU, 22% were due to IOHC (8).

Rarely, humeral fractures are pathologic. A dog treated at NCSU had a humeral fracture secondary to a fibroblastic osteosarcoma. A humeral condylar fracture secondary to the presence of an aneurysmal bone cyst has been reported in a dog (17).

Clinical signs

Of the dogs referred to NCSU with humeral fractures, 84% were non-weight bearing, 4% were toe-touching, 4% were weight-bearing lame, and 2% had intermittent lameness. The degree of lameness of the remaining 5% could not be determined from the review of their medical record. Dogs with IOHC may have chronic humeral condylar fractures with a small amount of fragment displacement. These dogs are lame, but usually will bear weight on the affected limb. Concurrent thoracic injuries, such as pneumothorax and pulmonary contusions, were found in 31% of the dogs with appendicular fractures caused by vehicular trauma. Radial nerve injuries or brachial plexus avulsions infrequently complicate humeral fractures.

Diagnosis

Humeral fractures are suspected after physical examination and should be confirmed with mediolateral and craniocaudal radiographs of the humerus. In growing dogs, the contralateral humerus may be used as a control. In dogs less than 1 year old, 75% of the humeral condylar fractures are lateral, 16% are intercondylar, and 9% are medial condylar fractures **(Figure 4)** (7). However, in dogs with IOHC, only 34% of the humeral condylar fractures are lateral, 14% are medial condylar fractures, and 51% are intercondylar fractures (8). Even though 93% of the dogs with IOHC were initially referred for unilateral humeral fractures, all dogs were affected bilaterally, as evidenced by the presence of a radiolucent line across the contralateral humeral condyles **(Figure 3 c, d)** and, ultimately, the contralateral humeral condyle fractured in 25% of these dogs **(Figure 3e)**. Bilateral humeral condylar fractures are rare in dogs without IOHC. After vehicular trauma, most humeral fractures involve the humeral diaphysis; approximately 50% of these fractures are comminuted, 25% are transverse and 25% are oblique (2).

Treatment

Preoperatively, the dogs should be cage-confined and concurrent systemic problems should be addressed immediately. Spica splints can be placed around the fractured legs, but their benefits are questionable. Soft, padded bandages should be avoided because, while they increase the weight of the extremity, they do not limit

Figure 4 *Fractures of the condylar region:* **(a)** *intercondylar,* **(b)** *lateral condylar,* **(c)** *medial condylar, and* **(d)** *supracondylar fracture.*

movement of bone fragments and may actually act as a fulcrum at the fracture site. The treatment distribution of the dogs seen at NCSU was: 170 (70%) dogs had internal fixation, 34 (14%) had a combination of internal and external fixation, 7 (3%) had external fixation, 2 had an arthrodesis of the elbow joint, 6 were treated conservatively, 9 were amputated, 8 were euthanased and 7 had treatment declined.

Conservative management

A minority of humeral fractures can be managed conservatively when the fracture is minimally displaced and non-articular and occurs in young, growing dogs. An extended lateral splint (spica splint) or a Velpeau sling can be placed for 2 to 3 weeks, potentially to decrease movement at the fracture site.

Surgical repair

Most humeral fractures must be repaired surgically because of articular involvement, instability, difficulty restricting fragment motion, or likelihood of loss in range of motion of the elbow with prolonged immobilization or prolonged absence of weight bearing. The surgical approaches to the humerus are difficult because of the close proximity of several neurovascular bundles and the presence of large muscle masses. The surgical methods for repair of humeral fractures include Kirschner wire, bone screw, intramedullary pin and cerclage wires, interlocking nail, external fixator, and plate fixation.

Condylar fractures

Humeral condylar fractures should be repaired with internal fixation, preferably with a bone screw providing interfragmentary compression **(Figure 1b)**. A second screw, or a Kirschner wire, should be placed through the supracondylar portion of the fractured fragment whenever sufficient bone length is present, because the second point of fixation prevents rotation of the fragment. A craniolateral surgical approach is generally used to repair lateral condylar fractures, a medial approach is used to repair medial condylar fractures, and a caudal approach is used to repair intercondylar fractures (3, 6).

In pups less than 5 months old with intercondylar fractures, the osteotomy of the olecranon may be contraindicated and a tenotomy of the triceps muscle may be used as an alternative (18). Surgical reduction of the fractured fragments should be anatomical to avoid any mechanical restriction in the range of motion of the elbow joint and to avoid the development of degenerative joint disease of the elbow joint, secondary to joint incongruity or to the presence of exposed subchondral bone. Because rigid fixation is necessary for primary bone healing, bone screws should be used whenever possible.

In very small dogs, Kirschner wires may be used as an alternative to the screws (19, 20). For lateral condylar fracture repair, the fracture is reduced and a drill hole is started a few millimeters distal and cranial to the lateral epicondyle and is aimed at the medial epicondyle. Metal implants should not penetrate the elbow joint. Screw placement may be difficult, and cannulated screws or portable fluoroscopes have been used to facilitate implant positioning.

Non-articular physeal fractures

Non-articular physeal fractures are treated with dynamic intramedullary cross-pinning, using Kirschner wires or small diameter intramedullary pins **(Figures 2** and **5)**. Tension-band wires or bone screws can be used if the remaining growth potential is minimal. Growth deformities of the humerus resulting from proximal or distal humeral physeal fractures are rare.

Humeral diaphyseal fractures

The surgical approaches to humeral diaphyseal fractures are lateral, medial, or caudal. Laterally, the radial nerve must be protected during fracture repair. The radial nerve and the brachialis muscle can be retracted proximally or distally to provide access to the cranial and lateral aspects of the humeral diaphysis **(Figure 6 b, c)**. Medially, the median and musculocutaneous nerves and the

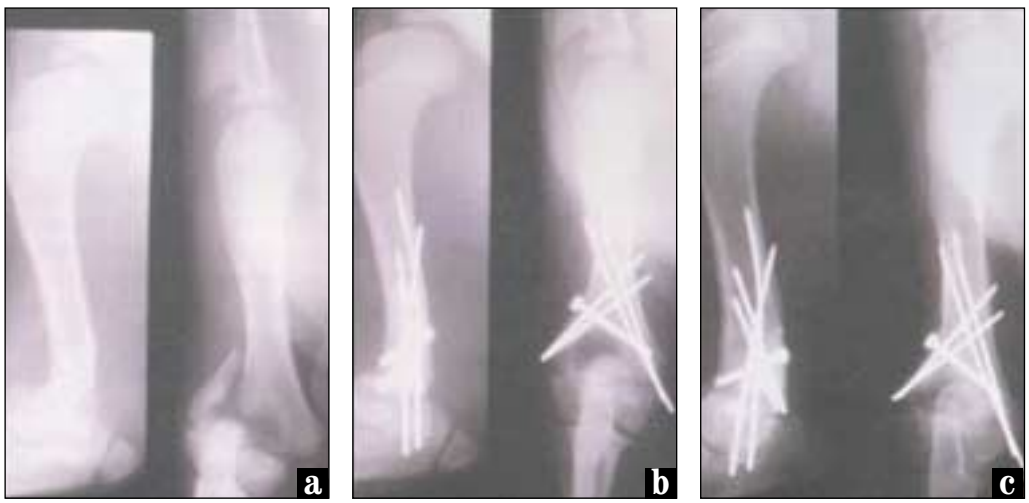

Figure 5 *Mediolateral and craniocaudal radiographs of the humerus of a 10-week-old male Dalmatian, after vehicular trauma.*
(a) *A Salter II fracture of the distal humeral physis is present, with a moderate amount of lateral displacement.*
(b) *The fracture has been repaired with multiple Kirschner wires used as cross-pins and a 2.7 mm bone screw placed in the metaphysis. The bone screw does not bridge the distal humeral physis.*
(c) *Four weeks later, the fracture has healed.*

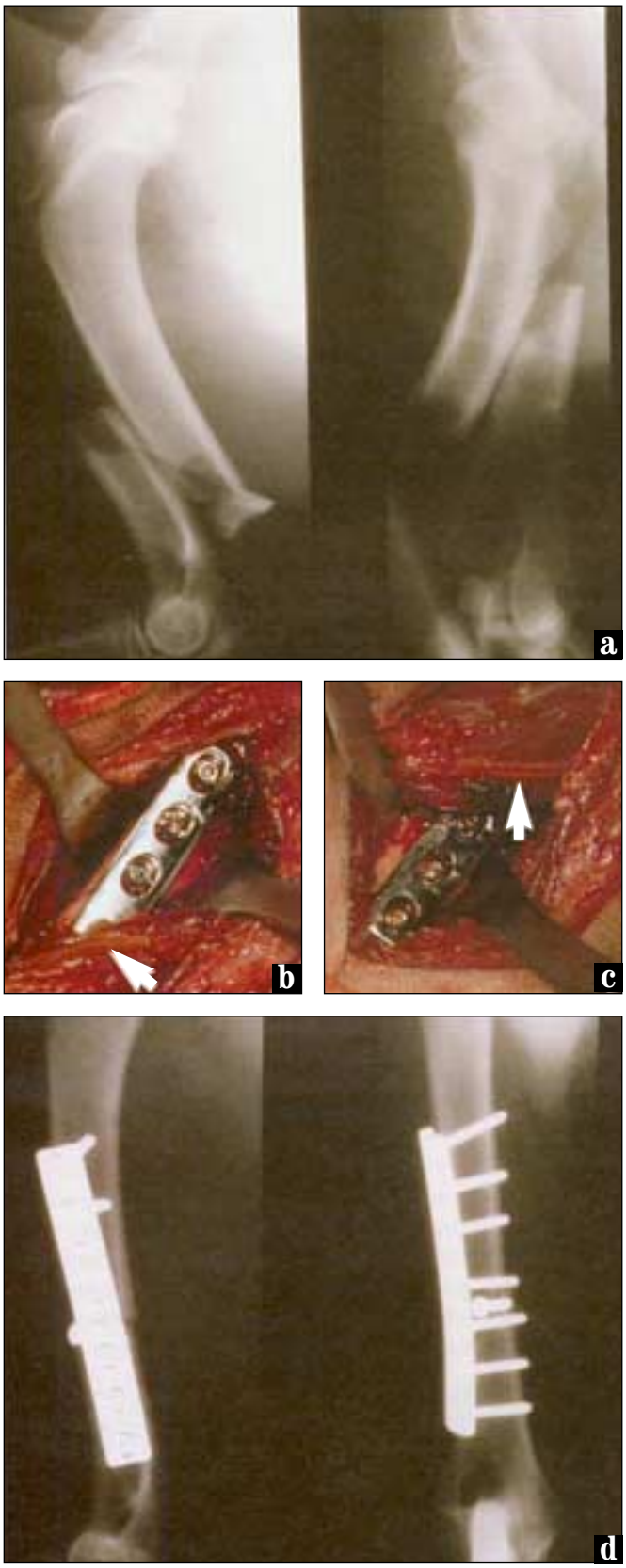

Figure 6 *Mediolateral and craniocaudal radiographs of the humerus of an 11-month-old male Siberian husky crossbred dog, after vehicular trauma.*
(a) *A three-piece, oblique, diaphyseal fracture is present. A craniolateral approach to the humerus has been performed. The radial nerve and the brachialis muscle* (arrows) *can be retracted caudally* **(b)** *or cranially* **(c)** *to expose the proximal and distal aspects of the seven-hole 3.5 mm dynamic compression plate, respectively.*
(d) *Postoperatively, the fracture reduction is good. On the day after surgery, the dog was bearing weight on the operated leg.*

brachial artery and vein must be protected during repair. If complex reconstruction of the supracondylar region is necessary, a caudal approach can be used by performing an osteotomy of the olecranon or, in young puppies, a tenotomy of the triceps muscle, by reflecting the triceps muscle proximally, thus exposing the caudal and distal part of the humeral diaphysis **(Figure 2b)**.

Intramedullary (IM) pinning without additional fixation should be limited to simple fractures in small and medium-sized breeds. Because repairs with pins and cerclage wires can only succeed when the bone is reconstructed anatomically, pin fixation may not be possible with complex fractures. Because IM pins should fill 60% to 70% of the medullary cavity, IM pin fixation is most often contraindicated in large and giant dog breeds.

Closed placement of the IM pin is attempted only when fracture displacement is small and when the fracture is inherently stable, such as a greenstick fracture in young dogs. With open treatment, the IM pins can be introduced in normograde or retrograde fashion. Normograde insertion starts on the proximal aspect of the crest cranial to the greater tubercle, without entering the shoulder joint. The pin is directed distally and medially, the fracture is reduced, and the pin is seated in the medial aspect of the humeral condyle, avoiding the elbow joint.

The pin position should be evaluated on a craniocaudal radiograph immediately after surgery. Since IM pins do not provide rotational stability to the surgical repair, most IM pin fixations must be complemented with cerclage wires or external skeletal fixators

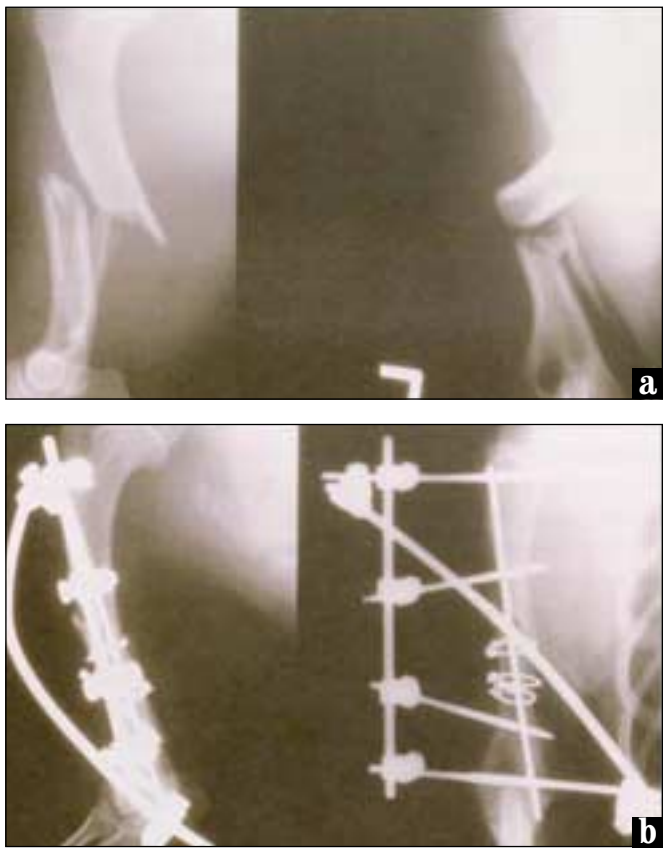

Figure 7 *Mediolateral and craniocaudal radiographs of the humerus of a 12-year-old male Jack Russell terrier.*
(a) *A comminuted diaphyseal fracture is present.*
(b) *The fracture has been repaired with an intramedullary pin, three cerclage wires, and a bilateral external fixator with a curved bar connecting the medial aspect of the distal pin to a proximal pin. The medial part of the distal pin was cut 4 weeks later, transforming the external fixator into a unilateral fixator.*
Nine weeks later, the fracture had healed, and the external fixator was removed.

Figure 8 *Mediolateral and craniocaudal radiographs of the humerus of a 9-month-old female Rottweiler, after probable vehicular trauma.*
(a) *A long oblique diaphyseal fracture is present.*
(b) *The fracture has been repaired with an interlocking nail 8 mm in diameter, four 4.5 mm bone screws, and three cerclage wires.*
Eight weeks later, the fracture had healed.

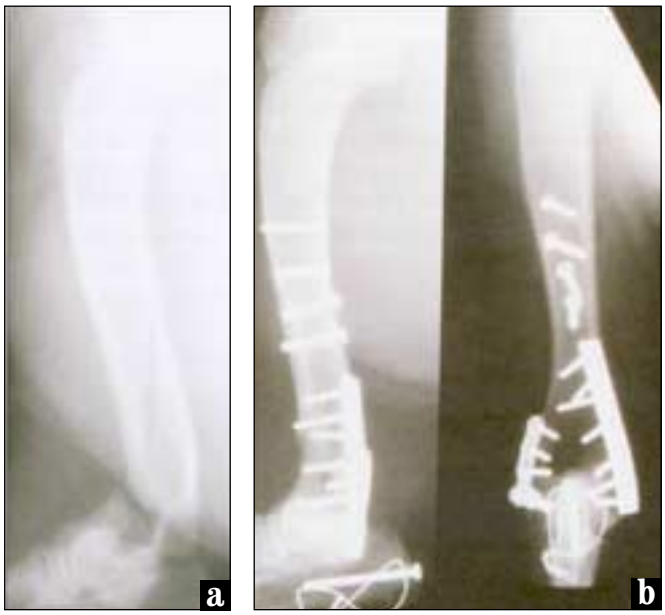

Figure 9 *Mediolateral and craniocaudal radiographs of the humerus of a 7-month-old male Labrador retriever crossbred dog, after vehicular trauma.*
(a) *Supracondylar fracture is present, with several fissure lines visible in the proximal fragment.*
(b) *Postoperatively, the fracture has been repaired with a caudolateral 2.7 mm T-plate, a caudomedial 2.7 mm dynamic compression plate, and four bone screws. An osteotomy of the olecranon was performed to approach the caudodistal part of the humerus. The osteotomy was repaired with a 3.5 mm bone screw and a tension band wire.*
Ten weeks later, the fracture had healed.

(Figure 7). Cerclage wires, Kirschner wires, and bone screws can be used in addition to IM pin fixation for the repair of humeral fractures.

External skeletal fixators may be used to treat fractures either alone or in combination with an IM pin when IM pin fixation would not provide enough stability. This method makes possible the use of IM pins and cerclage wires to repair humeral diaphyseal fractures in large and giant breeds. Two or three half-pins are placed laterally, proximal to the fracture site. Distally, a full pin is placed across the humeral condyle, and an additional half-pin can be placed from the lateral epicondyle proximally, toward the medial cortex. A curved connecting bar joins the proximal pins and the medial aspect of the transcondylar pins (21). The frame stability and durability can be enhanced with the use of predrilled, positive profile threaded pins **(Figure 7)**. A connecting bar can join the IM pin and the proximal pins, forming a tie-in configuration. In a report of 14 humeral fractures treated with tie-in configuration, all fractures healed, leading to good or excellent results (22).

Interlocking nails (INs) have been used to repair humeral diaphyseal fractures. The nail is placed in the humeral diaphysis in normograde fashion, two bone screws fix the nail to the proximal bone end, and one or two bone screws fix the nail to the distal bone end **(Figure 8)**. INs are ideal to repair comminuted diaphyseal fractures because, compared with plate fixation, the duration of surgery is decreased, surgical trauma is low, and nail fixation is very stable biomechanically. Newer nails with screw holes closer to each other will make the use of INs possible for more proximal or distal diaphyseal fractures. The preliminary results of IN fixation of humeral fractures are encouraging: an early study reported 85% success after seven repairs, and a recent study reported 92% good to excellent results in 19 dogs (23, 24).

Bone plates can be placed on the medial, cranial, lateral, caudolateral, and craniomedial surfaces of the humerus for fracture repair. Cranial placement of the plate is most appropriate for proximal diaphyseal fractures. Mid-diaphyseal fractures can be stabilized with a plate placed on the medial or lateral surfaces **(Figure 6)**. With lateral plate placement, the surgical approach is less technically demanding, but plate contouring is more difficult. Supracondylar fractures are best stabilized with two plates placed on the caudomedial and caudolateral surfaces of the humerus **(Figure 9)**, exposed with a caudal approach including an osteotomy of the olecranon. Although technically more difficult than IM pin fixation, plate fixation of humeral fractures allow a rapid return to function. The results of plate fixation of humeral fractures have been highly successful (2).

Postoperative management

Control radiographs are made immediately after surgery. For condylar or supracondylar fractures, a soft, padded bandage is then placed on the limb and left in place for 3 days to avoid swelling. No bandage is placed after surgical repair of diaphyseal and proximal humeral fractures. The dogs are given analgesics for 1 to 5 days, as needed.

Physical therapy is a crucial part of the postoperative management of humeral condylar fractures. Loss in range of motion of the elbow joint is very likely after humeral fracture in dogs, especially when the dogs are immature, when original or surgical tissue trauma is severe, when the fracture involves the condylar or supracondylar region, or when neurogenic injuries are present. Even in the presence of adequate fracture healing, loss in range of motion in the elbow joint will limit weight bearing, and limited weight bearing will in turn lead to further loss in range of motion. Physical

therapy should start early because it is easier to maintain range of motion than to regain it once it is lost.

The owners should be instructed on how to perform the physical therapy. Practically, physical therapy sessions should take place twice daily starting on the first postoperative day or as soon as the soft padded bandage is removed. A typical session includes cold packs in the first two postoperative days, or hot packs thereafter, gentle distal-to-proximal finger massage of the traumatized and edematous areas, and passive range of motion of the carpal, elbow, and shoulder joints. Leash walks may replace physical therapy as soon as the dog is bearing weight. Walking up steps and inclines may help to maintain range of motion of the elbow joint because it requires additional flexion of the joint, compared with walking on a flat surface.

Postoperative re-evaluation should be performed 2 weeks after surgery in immature dogs and 4 to 6 weeks after surgery in adult dogs provided that the dog maintains a good range of motion in the elbow joint.

Treatment complications

The complications of humeral fractures include loss in range of motion of the elbow joint, loss in fracture reduction and malunion, infection, iatrogenic neurologic deficits, and, for articular fractures, degenerative joint disease of the elbow or shoulder joints. The failure rate after repair of humeral condylar fractures tends to be higher in dogs with IOHC than in other dogs, potentially because of the bone sclerosis of the condyle **(Figure 3d)**. In dogs with loss of reduction, additional surgical repair may be necessary. Some dogs with untreatable condylar fractures will adapt and recover the use of their limb, albeit with a lameness, 4 to 12 weeks after surgery. Arthrodesis of the elbow joint and amputation of the forelimbs can be considered if the forelimb remains non-functional or painful after surgical repair or conservative management.

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