Section One: History of Terminology

Osteoarthritis of the elbow has been recognized by veterinarians for many years to be a developmental disease syndrome in young dogs. It was not until the middle 1950s, however, that progress was made toward defining specific pathologic etiologies, with the elucidation of the problem of "ununited anconeal process." Originally thought to be analogous to patella cubiti in humans, (13) the true nature of these ectopic sesamoid bones was soon realized, (3) thereby categorizing an initial cause of elbow osteoarthrosis. In the early 1960s the term "elbow dysplasia" was offered as an alternative to the term ununited anconeal process, since it was believed by some to better describe the generalized osteoarthrosis syndrome that involved the entire elbow joint of animals afflicted with that disease. (2) Thus for several years the term "elbow dysplasia" was used synonymously with ununited anconeal process in the veterinary literature. (6, 10, 14) In spite of the recognition by multiple authors that secondary degenerative joint disease of the elbow in young dogs did, indeed, occur in joints having intact anconeal processes. In 1966 Ljunggren and co-workers correctly pointed out this misuse of terminology and redefined the syndrome of elbow dysplasia, describing the three causes then known for its development: ununited anconeal process, ununited medial epicondyle, and patella cubiti. (9) Corley further refined terminology by describing elbow dysplasia as "a descriptive term applied to a developmental abnormality of the elbow joint that is manifested as an early osteoarthritis with or without an ununited anconeal process." (4) His definition has been respected by many subsequent authors. (7, 8, 11)

More recently, numerous conditions, both congenital and developmental, have been described that might be incorporated under the heading of elbow dysplasia as defined by Corley. (1, 5, 12) The frustrations of dealing with the term elbow dysplasia as a definitive diagnosis in a computerized records system and the subsequent inability to decipher epidemiologic features of specific causes of elbow osteoarthrosis have been aptly demonstrated by Hayes and co-workers. (7) While a review of all the causes of elbow dysplasia far exceeds the scope of this discussion, several causes of the syndrome will be reviewed in the following pages. An understanding of this evolution of terminology will hopefully aid the reader who is interested in reviewing the veterinary literature on these topics.

Section Two: Ununited Anconeal Process

History, Incidence, and Prevalence

The term ununited anconeal process is generally used to describe a failure of the center of ossification of the anconeal process of the ulna to fuse completely with its parent structure. Originally described as an ectopic sesamoid bone in the canine elbow (patella cubiti) in 1956, (34) ununited anconeal process has at various times been referred to in the veterinary literature as elbow dysplasia, (17) congenital detachment of the processus anconaeus, (37) and nonunion of the processus anconaeus in the dog. (15) Cawley, in 1959, coined the term ununited anconeal process, which remains in use today. (18) As is common with
most diseaseentities, ununited anconeal process had apparently afflicted dogs for many years prior to its recognition, the condition having been documented retrospectively in the skeleton of a bassett-saluki cross who died in 1936. Unfortunately, much of the early veterinary literature and data concerning the disease are to be found under the diagnostic heading of elbow dysplasia, a descriptive term applied to any developmental abnormality of the elbow joint resulting in early secondary degenerative joint disease. While various authors recognized the existence of elbow dysplasia both with and without concurrent ununited anconeal process, distinct clinical categorizations were not made early on in the literature. Indeed, often the ultimate cause of the reported elbow dysplasia was an unrecognized osteochondritic lesion or ununited coronoid process. Bearing this in mind, it still seems relatively safe to say that ununited anconeal process is a developmental, noninflammatory joint disease (possibly genetic in nature) characterized by a partial or complete separation of the anconeal process from the proximal end of the ulna. The disease generally presents itself as an intermittent, unilateral, subtle to severe forelimb lameness of gradual onset. When occurring bilaterally (approximately 30% of all cases), lameness may shift from one forelimb to the other. While the age of onset of clinical symptomatology will vary (4 months-3 years), the average animal manifests clinical signs early in life. Males are apparently affected more frequently than females, with one report stating a 2:1 ratio. The disease characteristically affects large and giant breeds of dogs and has been reported in the Saint Bernard, Great Dane, Irish wolfhound, Great Pyrenees, Newfoundland, bull mastiff, French bulldog, Labrador, Afghan, pointer, and weimeraner. It has also been reported in two achondroplastic breeds, the bassett hound and dachshund. A disproportionate number of cases have been reported in the German shepherd with several early reports citing its occurrence in closely related animals. Such incidences in conjunction with one early report postulating a genetic mode of inheritance for elbow dysplasia in the German shepherd have led others to implicate a genetic predisposition for ununited anconeal process in that breed. While it would appear that the German shepherd is at risk for developing elbow dysplasia in general, as is the Saint Bernard and the bassett hound, a genetic predisposition as yet unproven.

**Chronologic Development**

The anconeal process is a sharp-edged, slightly hooked piece of bone that forms the proximal end of the trochlea of the ulna. Upon elbow extension beyond 45°, this process fits into the olecranon fossa between the humeral epicondyles and in conjunction with the collateral ligaments and other soft tissue structures confines elbow movements to a sagittal plane. It is a completely intracapsular structure, its only soft tissue attachments (and therefore blood supply) inserting proximocaudally at the point of insertion of the elbow joint capsule in that region. With pathology, the degree of malunion may range from complete separation from its bony attachments to apparent anatomical normalcy (the process in actuality being held in place by a fibrous bridging callus) or any stage in between. While the chronologic development of the anconeal process has not been documented in all dogs, it is believed that in many of the smaller breeds (e.g., beagle) it either develops directly as an extension of the proximal ulna itself or originates from a small, separate center of ossification that rapidly unites with the parent structure.

**FIG. 85-1** Lateral radiographs of the elbow of a 10-(A), 12-(B), 16-(C), and 20-(D) week-old male German shepherd illustrate the normal ossification of the anconeal process. (Van Sickle DC: Ununited anconeal process. In Selected Orthopedic Problems in the Growing Dog. American Animal Hospital Association. 1975)

**FIG. 85-2** Histology of the ossification of the anconeal process of the German shepherd dog corresponding to Figure 85-1. Histology at 10 (A), 12(B), 16(C) and 20(D) weeks.

In direct contrast to this, however, a separate center of ossification has been documented in the German shepherd, Saint Bernard, weimeraner, vizsla, Afghan, English pointer, greyhound, bassett, and dachshund. The distinctness of the ossification center and the interval of time before eventual synostosis formation are related to the initial size of the cartilaginous anlage. Using the German shepherd as a model, Van Sickle has documented that up to 11 weeks of age the anconeal process is cartilaginous and not visible radiographically. At 12 weeks +/-1 week, a single or multiple density appears in the region of the anconeal process that enlarges or coalesces into a single anconeal ossification center by 12 to 18 weeks. The larger dogs with large anconeal processes require a longer time for osteogenesis. A thin perpendicular dark line between the anconeal ossification center and the diaphysis of the ulna is a physeal plate. By 16 to 24 weeks of age the dark
physeal line has been replaced by a dense thin white line indicating unification of the anconeal process with the ulnar diaphysis (Figs. 85-1 and 85-2). Thus, in most breeds, a diagnosis of ununited anconeal process prior to 20 to 24 weeks of age would appear premature (Fig. 85-3).

**Presenting Signs**

Clinical signs of the disease generally do not appear until 5 to 9 months of age, at which time the animal is usually presented for an intermittent unilateral forelimb lameness of slow onset and progression that is exacerbated by exercise. Affected animals have been reported to manifest a characteristic stance in which their front paws point laterally and their elbows are abducted, with a characteristic abduction or "winging out" of the elbow when gaited. Upon physical examination, some crepitus may be noted while placing the limb through a range of motion, and the animal may experience mild to moderate discomfort upon hyperflexion and hyperextension. Some of the more chronically affected animals exhibit lateral swelling of the joint capsule in the area of the anconeus muscle, a result of chronic synovitis, osteoarthrosis, and joint capsular thickening. Deep digital palpation of the anconeal process through the anconeus muscle with the elbow in flexion may likewise result in the dog exhibiting pain. A small percentage of animals will remain asymptomatic until 18 to 36 months of age, by which time there is significant evidence of degenerative joint disease and chronic muscle atrophy upon both clinical and roentgenographic examination. With close questioning, one is often able to elicit history of previous episodes of lameness that resolved spontaneously. The cause for presentation usually relates to hyperextension injury with fracture of an osteophyte or shearing of a previously nondisplaced process. Several disease entities may occur concurrently with a symptomatic ununited anconeal process, or, alternatively, lameness may be due to panostitis, osteochondritis, ununited coronoid process, ununited mediopalmarcondyle, or elbow subluxation secondary to physeal disturbances, and the ununited anconeal process may, in fact, be clinically silent. One recent study has strongly suggested that hip dysplasia and ununited anconeal process occur in close association within the same animal, and ultimately alluded to in the earlier literature. Thus, lameness in these animals may relate to soft tissue trauma due to forelimb sparing of dysplastic hips, or in fact the dysplasia may make these animals more prone to trauma of bony forelimb structures (including the anconeal process). Radiography of the elbow in a flexed position will demonstrate the lesion. (See Figs. 85-4, 85-10, and 85-11)

**Etiology**

Several etiologies have been proposed for the development of ununited anconeal process depending on the breed of dog afflicted. There has been a discussion whether or not the condition is inherited or is associated with other developmental diseases such as hip dysplasia or osteochondrosis of the humeral head. While the disease prevalence within certain breeds is high enough to suggest a genetic disease, it is not proven. A logical biomechanical etiology for the physeal fracture is based on force and moment. This theory is supported by the biologic fact that the fracture begins at the ventral portion of the physis adjacent to the articular epiphysial cartilage of the trochlear notch where tension is the greatest, while compression maintains the integrity of the structure dorsally; and the collagen of the fibrous bone marrow in the ventral portion of the fracture is arranged parallel to the lines of tension.

While ununited anconeal process has been documented to occur with premature closure of the distal ulna in a large breed dog, it is generally believed that shearing forces relating to physeal growth disturbances with secondary elbow subluxation are
probably of major significance only in the achondroplastic breeds.

Some authors have implicated fracture of the synchondrosis secondary to a spontaneous avascular necrosis of the anconeal process, while more recently ununited anconeal process has been described as resulting from a basicendochondral ossification defect of the physeal plate, a form of osteochondrosis. Regardless of underlying etiology, the ultimate sequence is fracture of the physis of the developing process, with a failure of synostosis formation and the interposition of a fibrous union. Theresultant changes in joint mechanics, in concert with joint exposure to subchondral bone and cartilage fibrillation products due to abnormal wear of the loose or free-floating body, result in the release of chondroitin sulfates, producing a chemical synovitis and resultant secondary osteoarthrosis. Chronic low-grade osteoarthritic pain occurs, with an acute, exquisitely painful episode nonresponsive to medical therapy a logical sequel to a sudden dislodgment of the process.

**Pathology**

To understand the gross pathology, it is necessary to know the radiographic progression of the disease. There may be minimal initial displacement of the anconeal process because the fracture separation may extend slowly up through the physis. If the radiograph is taken within 3 weeks of the initial biomechanical insult, there is usually a dark radiolucent area extending 3 mm to 4 mm into the ulnar diaphysis (Fig. 85-4). This area represents osteonecrosis of the trabecular bone due to disruption of the diaphyseal blood vessels. The anconeal process may show little alteration since its blood supply is separate and comes from the dorsal periosteum (Fig. 85-5). If the trauma is so severe as to result in complete separation of the anconeal epiphysis from the ulnar diaphysis and there is no secondary attachment of the anconeal process to the synovial membrane, the anconeus can undergo complete osteonecrosis.

Grossly, ununited anconeal process is recognized by a disruption of the articular cartilage of the semilunar notch in the area of the physis (Figs. 85-6 through 85-8). There may be some thickening of the joint capsule, and a small degree of marginal cartilaginous osteophytosis may form at the lateral edges of the articular cartilage of the trochlear notch. In chronic cases of ununited anconeal process, the changes of secondary osteoarthrosis are readily apparent. The joint capsule is extremely thick, the articular cartilage of the ulnar trochlear notch and the humeral trochlea is gone and the underlying bone is eburnated, marginal osteophytosis is present, and, if the anconeal process is loose it will be enlarged and bulbous owing to continual remodeling. In some cases the anconeal process may become ankylosed in the trochlea of the distal humerus.

Histopathologically, the physeal fracture begins with the disruption of the articular cartilage and extends dorsally through the physis, eventually breaking through the dorsal cartilaginous model of the ulna. The rate of the physeal splitting can vary; hence, a ventral endosteal callus of vascular collagenous tissue arranged parallel to the underlying articular cartilage may be present. Since ununited anconeal process is an intra-articular fracture, there is no osteogenic contribution from the articular cartilage, and the healing is largely endosteal (Fig. 85-9). This can result in rapid healing (3 weeks) if the condition is diagnosed early during partial splitting and the limb is immobilized. When a complete physeal fracture occurs, the ulnar and anconeal ends of the fracture are constantly moving against each other during locomotion, resulting in a fibrocartilaginous surface that eventually undergoes endochondral ossification and results in eburnated articular surfaces. The movement between the fracture fragments results in the formation of a bony spur on the dorsal surface of the anconeal process and ulna. With time, another angular spur will form on the cranial edge of the proximal radius. These are the hallmarks of the final stage of ununited anconeal process, namely, secondary osteoarthrosis.
Treatment

If the detachment is only partial and the animal is young, strict confinement with immobilization has reportedly resulted in fusion in a small number of cases. In the acutely affected young animal with minimal osteoarthritic change, most authorities would agree to elective surgical intervention. A common method of management is removal of the ununited process. While most animals experience a mild residual decrease in range of motion as a result of elbow arthrotomy, it does not significantly affect their ability to function. One report of 16 dogs treated in this manner demonstrated a return to full use of the limb an average of 4 weeks postoperatively, with arthritic changes remaining static and good elbow stability on the average follow-up of 19.5 months. Many surgical techniques employing the lag screw principle (Figs. 85-10 and 85-11) have been described in the literature for replacement of the ununited anconeal process; the average time to union post surgery is 6 to 8 weeks. If the bone stock of the process is initially such that stable fixation is impossible or if nonunion persists for longer than 6 to 8 months postosteosynthesis, the process may be removed. To achieve any reproducible degree of success, however, surgery should be reserved for the young animal with an anatomical anconeal process and minimal osteoarthrosis. In a dog who has an significant pathologic deformity of the process or who manifests obvious signs of osteoarthrosis upon initial presentation, medical therapy is seemingly the rational approach.

Surgical reduction of the process in such cases would seem unwarranted due to the chronic nature of the disease and the degenerative changes in the process. While removal of the free fragment may relieve symptoms for a while, it is the opinion of many that within 2 to 3 years thereafter the animals once again manifest clinical signs of disease related to the chronic instability produced by progressive weight bearing. For these animals, salicylates remain the first line of defense, followed by nonsteroidal anti-inflammatory agents. Corticosteroids are the final mode of medical therapy prior to arthrodesis.

FIG. 85-7 Sagittal section of specimen shown in Figure 85-6. The fracture is evident, as well as the fibrous marrow reaction adjacent to the articular cartilage.

FIG. 85-8 The histopathology of the specimen shown in Figure 85-7. Note the apparent viability of the anconeal process and the fact that the fracture had not proceeded through the dorsal cartilage model.

FIG. 85-9 The pathogenesis of ununited anconeal process. (A) The fibrous reaction adjacent to the articular cartilage of the ulna is evident, with the marrow collaganeous fibers arranged along the lines of tension. (B) The physeal fracture is evident. (C) The cartilage of the collateral ligament is forming. (D) The eburnated bone of the ulnadiaphysis is evident as osteoarthritis develops. (Van Sickle DC: Ununited anconeal process. In Selected Orthopedic Problems in the Growing Dog American Animal Hospital Association, 1975)

FIG. 85-10 Lateral radiographs of the elbow in a 6-month-old German shepherd. (A) An ununited anconeal process. (B) The elbow immediately postoperatively after lag screw fixation. (C) Four months postoperatively after bony union. (Courtesy of Dr. M.R. Herron)
Section Three: Ununited Medial Coronoid Process

History, Incidence, and Prevalence

A great majority of the earlier reports discussed above contain references to cases of elbow dysplasia that exhibited either medial-compartment or generalized osteoarthrosis, unexplained by the three working diagnoses at hand, and thus were categorized merely as variants of elbow dysplasia. Singular accounts of these oddities had been the rule until a more thorough understanding of osteochondrosis and particularly its relevance to the medial compartment of the canine elbow joint were brought to light by Olsson and others. A more complete categorization of this enigmatic syndrome of elbow dysplasia was then made possible. Whereas for years ununited anconeal process was thought to be the main cause of secondary osteoarthrosis in the elbow joint of young dogs, osteochondrosis of the medial humeral condyle and ununited medial coronoid process are now considered to be the most common causes of canine elbow arthrosis as reported by several authors in various countries.

The term ununited medial coronoid process of the ulna was originally used to describe a partial or total failure of the medial coronoid process to unite to its parent structure, thereby resulting in one or multiple bony fragments of various size remaining loosely attached at the medial radio-ulnar articulation within the elbow joint. It is felt by some that the word ununited implies that the process was once united to the ulna by a synchondrosis or separate center (or centers) of ossification and has subsequently become separated in some fashion. This terminology becomes somewhat more compromised in light of reports by several authors who have confirmed by surgical exploration the presence of osteoarthrosis in elbows free of any underlying pathology other than obvious erosions and fissures in the cartilage of otherwise intact medial coronoid process. Furthermore, one report describes a similar yet possibly distinct finding of hypoplasia of the coronoid process in which the entire thickness of the articular cartilage over the coronoid process was necrotic, with no germination cells remaining to reinitiate the growth of the process. In light of the foregoing data, the term fragmented coronoid process has been offered by some as an alternative.

In any event, ununited coronoid process can be considered to be a developmental (and possibly inherited) form of osteoarthrosis in which the basic underlying defect relates to an abnormal medial coronoid process of the ulna. Its a disease of young, rapidly growing large breed dogs as has been described in the rottweiler, Labrador, golden retriever, Newfoundland, German shepherd, Bernese mountain dog, Saint Bernard, Old English sheep dog, flat-coated retriever, chow, and Airedale. It has likewise been described in the bearded collie, sheltie, and one mixed-breed animal. While there seems to be an adequate predisposition for males to simultaneously develop osteochondritis dissecans and ununited coronoid process of the elbow joint, a sexual predilection in males for ununited coronoid process alone as yet remains unproven. Onset of lameness in affected animals has occurred as early as 3 months of age and as late as 10 years. Ununited coronoid process has manifested itself as an asymptomatic incidental finding in elbow luxations and fractures as well as in elbow subluxations secondary to physeal arrest of the radius or ulna. In a series of Labrador retrievers exhibiting a combined retinal and skeletal dysplasia, ununited coronoid process has been reported to develop from a separate center of ossification that has been described as hypoplastic and remaining separated from the ulna by a plate of cystic, necrotic cartilage. It has likewise been reported in dogs with hip dysplasia and osteochondritis dissecans of the shoulder.

While ununited medial coronoid process remains the sole cause of osteoarthrosis in many canine elbows, it nonetheless has been described to occur concurrently with ununited anconeal process, and in one series it has reportedly been accompanied by osteochondrosis of the distal medial humeral condyle in 19 of 19 affected animals. In yet another report of 58 animals with either generalized or medial-compartment osteoarthrosis of the elbow, 40 animals were confirmed at surgery to have ununited coronoid process, while 15 had only osteochondritis dissecans and 3 had both ununited coronoid process and osteochondritis dissecans! Thus it would seem that the separation of the two disease entities either radiographically or upon surgical exploration is by no means an easy task and that the categorization of pure symptomatology for either disease is difficult at best. The frequency of concurrent lesions (particularly that of osteochondritis dissecans) would seemingly lend credence to the theory of a similar underlying etiology, however.
Presenting Signs

Animals generally present at 5 to 6 months of age with an acute or chronic intermittent weight-bearing lameness of one or both forelimbs. These animals have a tendency to stand with the affected forelimb externally rotated (supinated) from the elbow distally. Often a history of osteoarthritis pain can be elicited: the animals seem to be stiff in the affected joints after rest, with lameness exacerbated by prolonged exercise or changes in weather. On physical examination, the dogs generally exhibit pain when the limb is placed through a full range of motion, and there is minimal to moderate joint distension and capsular thickening. Deep palpation in the area of the coronoid process is generally equivocal. Local anesthetics placed intra-articularly have been reported to decrease the amount of lameness only slightly (their efficacy is probably a function of the degree of osteoarthrosis and the number of extra-articular structures involved in the degenerative process).

Radiographic evaluation of affected elbows should include cranial-caudal, lateral (flexed and extended), medial oblique, and lateral oblique projections, which, if negative, should be repeated in 4 to 8 weeks if the dog remains symptomatic. Generally, the initial radiographic changes are manifested at 6 to 7 months of age and consist of medial compartment disease evidenced by erosions and roughened, irregular condylar margins with or without bony spur formation. Occasionally, a free fragment may be seen in the medial joint compartment lying between the radial and ulnar articulations. However, owing to the frequent simultaneous occurrence of ununited coronoid process and osteochondritis lesions, as well as the limited ways in which the medial joint compartment of the elbow can respond to any given insult, radiographic diagnosis of a singular ununited coronoid process or osteochondritis dissecans lesion should be made with some hesitancy. As in other osteoarthritic disease processes, the extent of the radiographic changes often shows no correlation with the age of onset, duration of lameness, or degree of affectation clinically. However, a generalization has been offered that the degree of osteoarthrosis is greater in the lone ununited coronoid process lesion than in an elbow with a singular focus of osteochondritis dissecans.

Chronologic Development

The elbow joint is a composite joint of complex structure. The humeroradial interface provides the major weight-bearing articulation, with the humeroulnar articulation acting primarily as a stabilizing force by restricting motion to the sagittal plane. The ulnar trochlear notch flares distally into the medial and lateral coronoid processes, both of which are articulating structures that act to increase the joint contact surface area between the antebrachium and the humeral condyles without contributing significantly to weight bearing. Abnormal articulation between the humerus and coronoid process (whether a result of hypoplasia and abnormal wear or partial to complete detachment with fragmentation) will result in cartilage degeneration with its resultant release into the joint of chondroitin sulfates and other breakdown products producing synovitis and effusion. Continued changes in the articular cartilage and eventually in the subchondral bone can lead to a loss of normal articular contour, predisposing the joint to further abnormal movement and perpetuation of the vicious cycle. Thus, the ultimate result is generalized osteoarthritis superimposed on the focal osteoarthritis due to the medial compartment instability and chronic irritation. As in many other forms of osteoarthritis, the degree of muscle tone apparently plays a role in the progression of the disease process; in one study, it was found that those animals with well-developed musculature (regardless of therapeutic modality) at follow-up seemed to move more easily than their less active and poorly conditioned counterparts.

Treatment

Numerous surgical approaches have been described for exploration of the medial compartment of the elbow. Transolecranon osteotomy and triceps tenotomy have been advocated, as has osteotomies of the medial epicondyle of the humerus. Olsson originally used a medial approach combined with transection of the pronator teres and flexor carpi radialis in...
conjunction with desmotomy of the radial collateral ligament, as have others.\(^{(44,47,53)}\) Several modifications of this approach have been documented.\(^{(40,50)}\) Regardless of approach, thorough inspection of the medial joint compartment is mandatory, since complete retrieval of multiple fragments of the coronoid process is essential (Fig. 85-13); likewise, inadequate exposure would preclude distinction of a coronoid process attached by a fibrous union from a fully attached but exhibiting only degenerative changes in its overlying cartilage. Furthermore, inspection of the medial condyle of the humerus frequently reveals either osteochondritis dissecans or erosion and fibrillation of the opposing cartilage; the size of this "kissing lesion" is proportional to the degree of looseness and size of the free coronoid fragment.\(^{(42,47)}\) Curettage of any areas of chondromalacia, eburnation, or osteochondritic lesions should be carried out simultaneously. Synovectomy has been recommended in joints manifesting synovial hyperplasia.\(^{(38)}\)

![FIG. 85-13 Intraoperative view following medial elbow arthrotomy demonstrates an ununited medial coronoid process.](image)

To date, the results of surgical intervention in this disease process have been equivocal. Part of the problem relates to a paucity of reliable follow-up information on animals with singular ununited coronoid process lesions that are treated surgically. Certain trends or correlations may be made. While the time to recovery after surgery averages 3 to 4 months,\(^{(38,40-42)}\) one author reports that five of nine animals affected with both osteochondritis and ununited coronoid process and treated medically were fully recovered within 6 months of initial presentation.\(^{(42)}\) It would appear that if any generalizations are to be made, young animals with minimal radiographic changes of osteoarthrosis treated surgically seemingly fare better than older animals or animals in whom a moderate amount of osteoarthrosis is present prior to surgery. One author relates the degree of resolution postoperatively to be determined by the animal's age at presentation, the degree of osteoarthrosis, and the condition of the cartilage at surgery.\(^{(38)}\) The possibility of any given surgical approach ultimately resulting of itself in degenerative osteoarthrosis in the elbow has been addressed by only one author, who also presented the only control group of medically treated animals.\(^{(42)}\)

**Section Four: Ununited Medial Epicondyle**

There exists in the dog a pathologic entity described as ununited medial epicondyle. The humerus of the dog develops from five principal centers of ossification that ultimately organize to form two major epiphyseal growth plates (physes) located near the proximal and distal humeral epiphysis.\(^{(56,58)}\) The majority of longitudinal growth of the humerus is thought to occur at the distal physis, the proximal epiphysis being primarily concerned with the ultimate development of the humeral head and greater and lesser tubercles. The medial epicondylar epiphysis eventually forms the medial epicondyle, a site of origin for many of the carpal and digital flexor muscle groups.\(^{(59)}\) Radiographically, the center of ossification of the medial epicondyle appears approximately 4 to 8 weeks after birth (depending on breed) and generally by 6 months of age has fused with the distal humeral epiphysis and metaphysis respectively.\(^{(56,58)}\) Thus, early disruption of either the centers of ossification or the epiphyseal plates will result ultimately in a congenital or developmental anomaly.

Originally described by Ljunggren and co-workers in 1966,\(^{(57)}\) the term ununited medial epicondyle was offered to describe a form of elbow dysplasia arising from an ununited caudal portion of the medial humeral epicondyle that was seen to occur in an 8-month-old German shepherd. The animal had presented for a progressive right forelimb lameness of 2 months duration. Pain was elicited upon flexion of the elbow joint and with direct digital palpation of the medial epicondyle. While there was noticeable soft tissue swelling in the area of the medial epicondyle, range of motion remained good. Radiographically, both elbow joints manifested 1.5 cm x 0.5 cm islands of bone lying caudal and distal to the medial epicondyles, which were treated by surgical excision of the free fragments and their attendant periosteum into two separate procedures 6 weeks apart. Histologically, both specimens revealed normal cancellous bone that had been united to the epicondyle by a fibrocartilaginous bridge. On 10-month postoperative follow-up the animal manifested intermittent right forelimb lameness (possibly related to incomplete excision of the fragment in the right limb), the left limb remained asymptomatic. No initiating traumatic incident was cited nor an underlying etiology offered. Similar to patella Cubits, this disease remains enigmatic owing to a paucity of reported cases.
Section Five: Patella Cubiti

The term patella Cubits was used early on in the medical literature to describe a sesamoid bone or ectopic site of ossification that developed within the triceps tendon. The condition was believed to have evolved either from an early injury to or an inherent developmental defect in the olecranon epiphysis of the ulna. Either process would theoretically lead to a divided epiphysis, part of which separated to form an isolated structure in the triceps tendon reminiscent of a patella. The term patella cubiti was first introduced into the veterinary literature by Stiern in 1956. Hedescribed an "infrequent condition involving the presence of one or more atypical sesamoid bones incorporated within the elbow joint or the extensor surface of the joint, which at surgery had attachments only to the triceps tendon." Inreality, Stiern presented a beautiful description in three German shepherds of what is now considered to be ununited anconeal process. It was not until 1966 that the term patella Cubitis was reintroduced by Ljunggren and Co-workers to describe one of the three basic forms of elbow dysplasia in the dog, all believed to be congenital fusion defects affecting the ossification centers of the elbow (i.e., ununited anconeal process, ununited medial epicondyle, and patella Cubits). The authors described a single case of patella Cubits occurring in a 5-week-old Doberman pinscher who had been bilaterally affected since birth. The animal had always been less active than its littermates, had walked at a later age, and had been rated on physical examination to have noticeably diminished olecranon prominences. The animal walked with a stilted gait in its forelimbs, with both elbows held in partial Sexton throughout all phases of the step. Mobile, bony masses were palpable in the triceps tendon proximal to its ulnar attachments. Radiography revealed patella-shaped structures caudal to the humeral condyles that were distinctly separate from the proximal ulna. The animal was followed through 23 weeks of age and the authors concluded that the deformity resulted from a separation of both the unossified proximal ulnar (olecranon) epiphysis and the ossified proximal ulnar metaphysis from the ulnar diaphysis at an early stage in bone development. This separation resulted initially in one and eventually in two separate patella-shaped bones becoming radiographically visible caudal to the humeral condyles. The condition is seemingly rare, since reports of other cases have not been referenced in the veterinary literature. The underlying etiopathogenesis remains speculative.

Section Six: Sesamoidal Fragments of the Elbow

Whereas ununited medial epicondyle and patella Cubits have received only cursory review in the veterinary literature (indicative no doubt of their infrequent occurrence), ununited anconeal process and ununited coronoid process have been topics of more detailed discussion in past years. More recently, however, attention has turned toward the categorization of other, less well defined etiologies of elbow dysplasia. Of most significance, perhaps, are those papers concerned with sesamoidal fragments both within and around the elbow joint and their relation to the development of chronic osteoarthrosis.

Numerous authors have mentioned the existence of varioussesamoidal fragments lying within those soft tissue structures that are intimately connected with the elbow. In general, most of these fragments have been regarded as incidental findings, with no clinical significance ascribed to them. They often receive notice in the severely osteoarthritic joint, in which one may be hard pressed radiographically to distinguish between sesamoid, osteochondral fragments, and osteophytic avulsion, rendering the categorization of such merely speculative. In the younger animal, free of secondary degenerative joint disease, the task becomes somewhat more clearly definable. In the current literature, four compartments of the elbow have received attention as areas in which sesamoidal fragments are routinely described: the cranial humeroradial articulation, the medial compartment, the lateral compartment, and the trochlear compartment, which houses the anconeal process. Of primary concern in the current discussion are the first three compartments of this composite joint.

Cranial Joint Compartment

Calcified bodies referable to the anterior humeroradial articulation have received little recognition in the veterinary literature. Generally considered benign incidental findings, they have been reported by one author as a cause of lameness in the Afghan hound. The animal manifested lameness of both forelimbs after exercise, with pain on flexion and extension of the elbow joint. No other radiographic abnormalities were noted. The dog was one of a litter of nine animals, three of which exhibited congenital malformation of the elbow joint with multiple proximal radial and ulnar deformities. Three other littermates and both parents were radiographically normal, while the two remaining animals were unavailable for evaluation.
The etiology remains unknown.

**Lateral Joint Compartment**

Similar to calcified bodies in the cranial compartment, sesamoid bones existing in the lateral elbow joint region have generally been regarded as incidental vestigial anomalies of a benign nature, purportedly lying within the annular ligament. More recently, however, a series of eight large breed dogs with lameness referable to a sesamoidal fragment attached to the ulnar collateral ligament and lateral joint capsule has been described. All eight animals were presented at 6 months of age for an intermittent forelimb lameness that progressively deteriorated. Affected animals manifested a tendency to exhibit cubitis varum, and their elbow joints were swollen with pain readily elicitable upon palpation of the lateral (ulnar) collateral ligament in the area of the herathral head. Crepitation was not manifested when affected limbs were placed through a range of motion. Anteroposterior and lateral radiographs generally prove unremarkable in this condition, failing to outline the sesamoid and showing minimal to no changes in the joint consistent with osteoarthrosis. An oblique film with the radius rotated approximately 50° from anteroposterior generally reveals a dense fragment of bone situated on the lateral side of the proximal head of the radius. A standard lateral approach between the tendons of origin of the extensor digitorum communis and lateralis generally reveals the 2 mm x 2 mm to 5 mm x 5 mm smooth, dense sesamoidal fragment, which is firmly adhered to the collateral ligament and joint capsule. Upon removal, the intermittent lameness decreased significantly in one week, with lameness resolving completely in five of eight animals. The authors postulated a mechanical lameness in which the fragment became interposed between humeroradial joint surfaces in the flexion phase of joint movement.

**Medial Joint Compartment**

While an increased interest in the medial joint compartment of the elbow has arisen in the last several years (referable to the elucidation of osteoarthrosis occurring secondary to ununited coronoid process and humeral condylar osteochondritis dissecans), little has been published concerning the frequency or significance of sesamoid bones occurring within that area. The existence of a calcified body lying just medial to the medial humeral epicondyle at the level of the joint space has been described as a primary cause of lameness in the dog. To date, the lesion has been found only in the Labrador retriever and English setter, with three of four animals symptomatic between 3 and 11 months of age. One animal exhibited bilateral pathology. All animals were presented for a mild forelimb lameness that deteriorated over time. Physical examination generally revealed minimal to no joint swelling, slight atrophy of shoulder musculature, and pain on passive extension and flexion of the elbow joint. Medial arthrotomy between the origins of the flexor carpi radialis and the flexor digitorum superficialis tendons allowed good exposure for retrieval of the calcified body, which was always intimately connected with the origin of the flexor digitorum profundus and inner connective tissues of the fibrous joint capsule. Upon inspection of the medial joint compartment, secondary changes of osteoarthrosis were minimal to nonexistent in all animals explored, except for an obvious thickening of the involved capsular tissues. Histology revealed a true bony fragment, the site of origin of which was undetermined. Most animals became clinically sound between the 7th and 21st postoperative day, with one dog manifesting slight osteoarthritis changes at 6-month follow-up. Some authors have implied that this is really a flap of cartilage from an osteochondritis dissecans lesion that has subsequently adhered down to the caudomedial joint capsule, but this seems unlikely owing to the osseous nature of the fragment and its often extra-articular situation.

It is apparent from the small number of cases presented and the clinical nature of the material that many questions remain to be answered in the study of sesamoid bones and their functional relationship to the elbow joint. Likewise, owing to the very nature of its composite structure and the number of insidious disease processes that have already been described to affect it, as well as the systemic diseases that may simultaneously exist to confuse accurate radiographic or clinical examination, further case studies are desperately needed to solidify the above-mentioned preliminary reports.

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SESAMOIDAL FRAGMENTS


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