Because the canine cubital (elbow) joint is a complex joint, developmental abnormalities of this joint are a common cause for lameness in young dogs. Dysplasia involving the cubital joint includes a group of diseases such as fragmentation of the medial coronoid process, osteochondritis dissecans (OCD) of the medial humeral condyle, and ununited anconeal process (UAP), as well as incongruity in the joint. Additionally, humeral intracondylar fissures (HIFs) can occur either alone or in combination with other developmental abnormalities. The first diagnostic imaging modality chosen for evaluating developmental orthopedic disease in the canine elbow is typically radiography.

**FRAGMENTED CORONOID PROCESS**

The most common developmental disorder involving the canine elbow joint is medial coronoid process disease (MCPD), previously referred to as fragmented coronoid process (FCP). MCPD is a separate osseocartilaginous fragment, fissure, or abrasion involving the cartilage and subcondylar bone of the medial coronoid process of the ulna.

MCPD most commonly affects medium- and large-breed dogs; incidence is higher in male dogs. The most common breeds for which it is reported include Bernese mountain dogs, English and bull mastiffs, German shepherds, Irish wolfhounds, Rottweilers, and Saint Bernards. The etiology is not completely known, but several theories have been proposed. These theories include joint incongruity (dyssynchronous growth of the radius and ulna) in the early growing phase, genetics, abnormal development of the trochlear notch, and osteochondrosis. The cause is likely multifactorial. Regardless, the result is development and progression of osteoarthritis, particularly involving

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**Abstract**

Developmental orthopedic disease of the elbow is a common condition with complex causes that affects many large-breed dogs. Specific conditions include fragmented coronoid process, osteochondrosis, ununited anconeal process, and humeral intracondylar fissure. The most commonly used diagnostic technique is radiography, although computed tomography is sometimes needed.
the medial compartment (humeral–ulnar articulation) of the elbow.³

Dogs with MCPD often exhibit lameness as early as 4 to 12 months of age. The onset of lameness is often insidious and will vary from a mild to severe weight-bearing lameness that is worsened with activity.³ The affected leg is often held with the elbow adducted and the paw externally rotated. Joint effusion is rarely palpable, but pain can be elicited by direct palpation over the region of the medial coronoid process. Pain can also be elicited by supination of the antebrachium when the elbow is held in flexion.³ As osteoarthrosis progresses, the medial compartment of the elbow will become thicker and the elbow range of motion will decrease.²,³,⁵

Take-Home Points

- Developmental orthopedic disease of the elbow is most common in large-breed dogs.
- Radiology is usually the first-line diagnostic modality.
- Radiographic diagnosis of medial coronoid process disease requires a minimum of 3 views: neutral mediolateral, flexed mediolateral, and craniocaudal. However, medial coronoid fragments may not be apparent, and diagnosis may depend on secondary radiographic signs.
- Radiographic diagnosis of osteochondrosis requires the same 3 views; however, radiographic changes associated with osteochondrosis are best seen on the craniocaudal view.
- The primary radiographic finding of ununited anconeal process is a radiolucent line separating the anconeal process from the olecranon in dogs older than 5 months.
- The primary radiographic sign of humeral intracondylar fissures is a vertically oriented radiolucent line in the central region of the condyle of the distal humerus.

FIGURE 1. Positioning for (A) a neutral lateral, (B) a flexed lateral, and (C) a craniocaudal radiograph of the elbow joint. In the neutral lateral view (A), the elbow angle is 120°. In the flexed lateral view (B), the inside angle is approximately 45°. In the craniocaudal view (C), the elbow is internally rotated to achieve a straight craniocaudal view, identified when the olecranon is centered over the humeral condyle.
For radiographic diagnosis of MCPD, a minimum of 3 projections should be obtained: neutral mediolateral, flexed mediolateral, and craniocaudal (FIGURES 1–4). For the lateral projections, it is critical to ensure that the beam is directed down the axis of rotation of the elbow so that the humeral condyle is not obliqued. An additional 25° lateral/caudomedial view may help to outline the medial coronoid process.\(^1\)\(^6\)\(^8\)

It is well-documented that radiographs are not as sensitive for diagnosis as computed tomography (CT) because CT will allow direct visualization of the medial coronoid process. Nonetheless, radiography is still the primary screening tool for diagnosis of MCPD.\(^5\)\(^8\)\(^9\)

Radiographic identification of a medial coronoid fragment is not likely, but the following early changes of osteoarthritis and some of the small nuances...
**FIGURE 5.** (A) Lateral radiograph of a normal elbow and (B AND C) incongruent elbows. Panel B shows a wide humeroulnar joint, often seen when the ulna is shorter than normal or the radius is growing faster than the ulna. Panel C shows an incongruent arc following the curvature of the ulna to the articular surface of the radius, creating a step between the ulna and radial articular surfaces. The medial coronoid process is now elevated above the radial head. These findings are common in dogs with medial coronoid process disease and can be early indicators of elbow pathology.

**FIGURE 6.** Lateral radiograph of an elbow of a dog with (A) a normal medial coronoid process and (B-D) an abnormal medial coronoid process (lines). In panel B, the medial coronoid process is blunted, a common finding in dogs with medial coronoid process disease (MCPD). A distinct fragment is usually not visible. In panel C, the medial coronoid process has a convex shape, which is exaggerated in panel D. Although not as common, this shape change is abnormal and indicates underlying MCPD.

**FIGURE 7.** Lateral radiograph of a young dog with elbow pain and lameness. Notice the shape of the medial coronoid process (line), which is blunted and poorly delineated, a typical early finding in dogs with medial coronoid process disease.

Associated with MCPD can be readily seen on well-positioned radiographs:

- Incongruity or subluxation of the humeroulnar joint (FIGURE 5)
- Abnormal shape or lack of visualization of the medial coronoid process (FIGURES 6 AND 7)
- Periarticular osteophyte production associated with the medial coronoid process (FIGURE 8)
- Periarticular osteophyte production associated with the anconeal process (FIGURES 9 AND 10)
- Periarticular osteophyte production and subtrochlear sclerosis of the semilunar notch of the ulna (FIGURE 11)
- Periarticular osteophyte production and enthesiophytes on the medial epicondyle of the humerus

There is no clear consensus on treatment options for dogs with MCPD, and the choice of treatment depends
on the age of the patient as well as the severity of the radiographic changes.\textsuperscript{5,8} The earlier the diagnosis of MCPD and treatment, the less the progression of osteoarthrosis.\textsuperscript{1}

**OSTEOCHONDROSIS**

Osteochondrosis is an endochondral ossification disorder that results in failure of both ossification and vascular penetration of the epiphyseal cartilage.\textsuperscript{1,10} These failures lead to articular cartilage thickening and progressive necrosis and weakening of the cartilage, with the weakening leading to fissures and subsequent osteochondral flaps. The exposure of subchondral bone and presence of cartilage degradation products triggers synovitis and development of osteoarthrosis.\textsuperscript{1,10} Similar to MCPD, osteochondrosis is most common in male large-breed dogs (e.g., golden retrievers, Labrador retrievers, Bernese mountain dogs, Newfoundlands).\textsuperscript{1,7} Clinical signs are similar to those reported for MCPD and cannot be differentiated by physical examination.\textsuperscript{1} Lameness, the primary clinical sign, tends to become apparent around 4 to 8 months of age and is often bilateral. Prognosis varies from poor to good, depending on the severity of disease and presence of concurrent cubital abnormalities such as MCPD.

OCD is osteochondrosis in which the diseased cartilage is separated from the bone, resulting in a cartilage flap that mineralizes. Because OCD cannot be differentiated from other forms of elbow disease during a physical examination, radiographic evaluation should include the same 3 views obtained to aid in diagnosis of MCPD. Radiographic changes associated with OCD are best seen on the craniocaudal view (FIGURE 12). These changes include flattening of the medial humeral condyle with concurrent concavity at the articular margin. A true osteochondral flap/fragment (dissecans) may not be visible. Over time, however, osteochondral fragments can be vascularized by adjacent synovium, resulting in increased mineralization and increased size of the fragment, which increases their visibility.\textsuperscript{6} The lesion will have variable degrees of surrounding subchondral sclerosis and secondary degenerative joint disease, depending on the severity of the disease and the age of the dog. As described earlier, evaluation should include assessment of additional abnormalities, including cubital joint incongruity and changes with the medial coronoid process (FIGURE 13).

**UNUNITED ANCONEAL PROCESS**

UAP is failure of the anconeal process to unite with the proximal ulna during the first 5 months of skeletal maturation.\textsuperscript{1,4,11-13} The normal anconeal process should be fused with the ulna by 150 days of age; failure to ossify after this time is termed “ununited” and leads to joint instability and secondary degenerative joint disease.\textsuperscript{1,9}

![Figure 12](image12.png)

**FIGURE 12.** Lateral and craniocaudal radiographs of the elbow with medial coronoid process disease. The arrows outline osteophyte formation on the medial coronoid process.
UAP is most common in large-breed dogs in which the anconeal process develops from a secondary center of ossification. Commonly affected breeds include German shepherds, Great Danes, Newfoundlands, Black Russian terriers, Saint Bernards, Basset hounds, greyhounds, and cane corsos. A small-breed dog that is overrepresented is the Pomeranian. Most small-breed dogs do not have a secondary ossification center, and therefore UAP does not develop. The most common hypothesis for development of UAP is asynchronous growth of the radius relative to the ulna in the early growth phase (up to 4 to 5 months). The asynchrony in bone growth results in increased pressure on the anconeal process by the humerus and prevents bony union of the ossification center. Other theories for the development of UAP include failure of endochondral ossification, underdevelopment of the trochlear notch of the ulna, or growth plate trauma associated with rapid or prolonged periods of growth in large-breed dogs.

The following 5 stages of UAP in growing dogs have been proposed:

1. The anconeal process is not fused but is firmly attached. The separation line on the radiograph is incomplete, and the anconeal process is in a normal position.
2. The anconeal process is not fused and moves slightly to create a small cranial gap. The joint is usually incongruent with a shorter-than-normal ulna. Radiographs show a complete zone of radiolucent separation, but the anconeal process appears to be in a normal position (FIGURE 14).
3. The anconeal process is not fused, and there is a complete radiolucent separation zone but no signs of

FIGURE 9. Lateral radiographs of (A) a normal anconeal process and (B AND C) an anconeal process with osteophyte development. In panel B, the changes are more subtle but show small osteophytes on the dorsal surface of the anconeal process (arrow), one of the easier locations on which to identify osteophytes. In panel C, the changes are much more severe, showing marked osteophytosis on the dorsal aspect of the anconeal process (arrow).

FIGURE 10. (A) Neutral lateral and (B) flexed lateral radiographs of a dog with subtle osteophytes on the dorsal surface of the anconeal process (arrow). These osteophytes are not seen on the neutral lateral view but are easier to identify on the flexed lateral view.
joint incongruity or MCPD (FIGURE 15).

4. The anconeal process is not fused and is completely loose. The joint is incongruent with a short ulna. The radiolucent line on the radiograph is wide, and there is resorption of the anconeal process. At this stage, the extended lateral and flexed lateral views should confirm mobility of the anconeal process.

5. Similar to stage 4, the anconeal process is not fused, and there is an FCP and a reverse joint incongruity (i.e., radius is abnormally short) (FIGURE 16).

Dogs with UAP typically show variable, progressive lameness that begins around 5 to 12 months of age, although some dogs may not show lameness until later in life.1-4 Dogs with UAP experience pain and crepitus during palpation and when the elbow is moved to near the limits of its range of motion.4

The primary radiographic finding of UAP is a radiolucent line separating the anconeal process from the olecranon in dogs older than 5 months.6 Because this finding can be unilateral or bilateral, both elbows should be radiographed. The radiolucent line may be sharply margined or of varying width and irregularity. Although UAP can be easily seen on the flexed lateral view, neutral lateral and cranio-caudal views are also advised to screen for incongruity as well as secondary degenerative joint disease. By obtaining neutral lateral and flexed lateral views, it is possible to check for mobility of the UAP. In the neutral lateral view, if the UAP is mobile, the gap with the UAP will be wider than on the flexed lateral view. On the flexed lateral view, there is less pressure on the UAP, allowing the UAP to return closer to the ulna.1

Treatment for UAP will depend on the stage of the disease and the age of the dog. The treatment of choice is an ulnar osteotomy to relieve pressure of the humeral condyle on the anconeal process. Osteotomy combined with lag screw fixation of the anconeal process has been reported to provide the best outcome.1-4 Successful resolution of clinical signs and healing of a UAP is more likely for dogs younger than 6 months of age at the time of surgery.1

**HUMERAL INTRACONDYLAR FISSURE**

HIF was previously referred to as incomplete ossification of the humeral condyle. This developmental cubital abnormality, which is characterized by a midsagittal fissure in the humeral condyle, is most commonly seen in spaniels and spaniel crosses but has been reported in other medium- and large-breed dogs, including brachycephalic breeds.6,15 The fissure weakens the humeral condyle and predisposes the dog to a condylar fracture.15 This fracture will be a Y- or T-type fracture in the humeral condyle in 50% of affected dogs, or the fracture may be limited to the lateral (35%) or medial (15%) condyle.16 HIF can also cause elbow pain and lameness without a complete fracture of the condyle.15

Mineralization of the humeral condyle progresses from 2 centers of ossification, which are separated by a thin cartilaginous plate until they unite at 8 to 12 weeks of age. Because the location of the HIF is at the location of this cartilaginous plate, HIF was originally referred to as incomplete ossification of the humeral condyle.16 However, the incomplete ossification theory does not completely explain the clinical findings in all dogs and, at least in some dogs, HIF is thought be a stress fracture.15 In addition to incomplete ossification and humeral stress fractures as potential causes of HIF, conformational abnormalities are also thought to contribute to the development of HIF by altering the...
weight-bearing forces, which can lead to failure of the condyles to fuse in young dogs or increased stress at this location in older dogs, leading to a humeral intracondylar fissure.\textsuperscript{15}

Dogs should be examined for 1 of 3 possible presentations: a weight-bearing lameness (no complete fracture), an acute non-weight-bearing lameness (complete fracture), or an incidental finding of HIF. Because HIF is often bilateral, both elbows are routinely radiographed, although clinical signs may be unilateral.\textsuperscript{6,15,16}

**FIGURE 12.** Cranio-caudal radiographs of (A) a dog with a normal elbow and (B) a dog with osteochondritis dissecans of the medial humeral condyle (arrow). There is a radiolucent defect in the articular margin surrounded by sclerosis (B) compared with the normal elbow (A).

**FIGURE 13.** (A) Lateral and (B) cranio-caudal radiographs of a young dog with lameness and elbow pain. (B) Notice the radiolucent defect at the articular margin of the medial humeral condyle surrounded by sclerosis (arrow), typical of osteochondritis dissecans. (A) This dog also has evidence of medial coronoid process disease (asterisk), indicated by the blunted and abnormally shaped medial coronoid process with secondary degenerative joint disease.
The primary radiographic sign of HIF is a vertically oriented radiolucent line in the central region of the condyle of the distal humerus. The line can extend from the subchondral bone margin distally to the supratrochlear foramen proximally (FIGURE 17). The line is best seen on a craniocaudal view. It has been reported that a 15° craniomedial-to-caudolateral projection will position the fissure parallel to the x-ray beam, thereby facilitating visualization. However, rotation of the condyle more than 5° away from this projection will result in an inability to see the fissure because the x-ray beam will no longer be tangent to the fissure. In addition to identification of the fissure, other...
radiographic changes include a periosteal reaction at the level of the lateral epicondylar crest resulting from instability and stress from a nondisplaced fracture. When a complete condylar fracture is seen in a young dog with a breed predisposition to HIF, the contralateral elbow should be radiographed to look for underlying HIF that may have predisposed to the fracture. Because HIF can be difficult to identify on radiographs, the preferred diagnostic test is CT, which can readily demonstrate the HIF as well as the secondary changes, often including regional sclerosis and bone remodeling (FIGURE 18).

HIF (incomplete or no fracture) and lameness are generally treated with a transcondylar screw placed from medial to lateral to bridge the fissure, strengthen the condyle, and reduce the risk for a complete fracture. Complete fractures are typically repaired by double plating. Approximately 18% of dogs with HIF diagnosed as an incidental finding experience fracture within 14 months of diagnosis (5 to 24 months). Because surgery is not without risk and considerable expense and the rate of fracture is relatively low, it may be prudent to monitor dogs with HIF that have no clinical signs at least until the dog reaches 2 years of age rather than prophylactically repairing the humeral condyle.

SUMMARY

Developmental orthopedic disease of the elbow is a common abnormality with a complex etiology, seen in many large-breed dogs. CT is considered the gold standard for evaluating the elbow joint, but radiography is still a valuable first-line diagnostic imaging test. Understanding the more subtle radiographic changes will help lead to an early diagnosis so that therapeutic intervention can be instituted before severe osteoarthritis develops.

References


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