ELBOW DISEASES IN THE DOG

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CLINICAL APPLIED ANATOMY OF THE CANINE ELBOW JOINT

SUMMARY
This large and complex joint is composed of the condylar joint (humero-radial and humero-ulnar joint) and the trochoid joint (proximal radio-ulnar joint). Both joints turn around axes, which are nearly vertical arranged. The osseus development of the canine elbow joint is finished at approximately 9 months of age. The different times between appearance and fusion of the epiphyses and apophyses are to consider clinically as weak points. Clinical interest should be on the form and dimensions of the joint cavities and their pouches as well as on the position of the injection. Last but not least, knowledge about the innervation and the supply with blood vessels is necessary to plan a surgical approach to the stifle joint.

INTRODUCTION
The elbow joint is a complex joint, because 3 bones: Humerus, Radius and Ulna are integrated. It can be divided into 3 different joints: the humero-radial and humero-ulnar joint, and additionally the proximal radio-ulnar joint. The first two joints are in form of a condylar joint and the last is built as a trochoid joint. The result of this combination is that two axes are nearly vertical to one another, and problems are to be expected. Clinically important is a coordinated development of these bones, because, if there is a small non-coordination, severe step-like arrangements of the articular surfaces result in pain and lameness (Brunnberg et al., 1999).

The articular surface at the distal end of the Humerus is divided Incisura trochlearis, which begins with the sharp Processus anconaeus and to the distal end with the elongated Processus coronoideus medialis ulnae.

RANGES OF MOTION
High ranges of motion (VOLLMERHAUS et al., 1994) can be diagnosed by movements in clinical examination.

Extension – Flexion: 100 – 140°  
Rotations: 50 (70- 80°)

Additionally, normal gait movements display a slight adduction and abduction. For chondrodystrophic breeds, we know a normal abduction of ca. 15° occurs in the forearm of the elbow joint.

DEVELOPMENT
The articular surfaces of the elbow joint must be built correctly, because a hinge joint (ginglymus) does not allow laxity. This means that the development of the 3 bones: Humerus, Radius and Ulna have to grow simultaneously within the first 6 months after birth. And from here, the first and severe clinical problems can arise.

These 3 bones are long bones or Ossa longa. But their growing is very different: Knowledge about the development of the articulating bone ends (Vollmerhaus and Roos, 1980; Roos et al., 1981) gives a basis to understand some malformations, fractures of the related bones and of some specific lines in X-rays of young dogs (Waibl and Brunnberg, 2003).

In general, long bones develop with primary and secondary ossification centers.

a) primary ossification centers appear in dogs prenatally from 40th day of pregnancy and are the bases of diaphyses (Evans, 1993).

b) secondary ossification centers appear in dogs (or cats) postnatally in the 1st to the 4th month and are the bases of epiphyses or apophyses.

Humerus: The Epiphysis distalis humeri bears 2 ossification centers, medial to that of the Trochlea and lateral to that of the Capitulum. Both fuse together in the 3rd month and if not, fractures may occur are to attend (Brunnberg et al., 2001). The epiphyseal cartilage to the diaphysis disappear in the 5th or 6th month. This distal epiphysis produces only 40 % of the length growth of the humerus.

In the 2nd month the apophysial ossification center appears of the Epicondylus medialis which fuses with the distal epiphysis in the 5th month, (Vollmerhaus et al. 1981; Brunnberg et al. 1985).

Radius: The ossification center of the Epiphysis proximalis radii appears at the end of the 1st or beginning of the 2nd month postnatal. The closure of the cartilage to the radial diaphysis is from the 8th to 10th months, which is much later than that in the distal end of the Ulna. This epiphyseal cartilage is less than 1mm thick and like a round cap over the diaphysis (Roos et al., 1981).

Ulna: The proximal end of the Ulna is without an epiphysis, but at the top there is the Tuber olecrani, an apophysis, which appears in the end of the 1st or beginning of the 2nd month. The closure of the flat cartilage with the diaphysis is in the 7th to the 9th months.

Much more interesting is the existence of an ossification center in the Processus anconaeus, which perhaps could be a special kind of an epiphysis. But until now, we were not able to finally decide about this ossification center, which appears in the end of the 3rd month postnatal and the closure should be finished in the 4th month. Later closures are suspected for incorrect development. Then, this special processus becomes a clinical problem, because it forms the proximal limit of the length (and the form) of the Incisura trochlearis.

To understand problems in the develope elbow joint, one has to regard the distal ends of the radius and ulna, too.

Because of the fact that the proximal epiphysis of the Radius has the a potential of growth of only 30 to 40 %, its distal epiphysis must produce 70 to 60 % of the length growth till the 9th month after birth (Riser, 1985).

In contrary to this, the Ulna is known as an one-epiphyseal bone. That means there exists only 1 epiphysis at the distal end, which produces 85 % of the bone length and the rest of 15 % is a general growth of the diaphysis and the olecranon. How
can these 3 bones grow simultaneously? It is a miracle and so problems are expected in step constructions of the articular surfaces. As an example, you know that problems in the (distal) epiphyseal cartilage of the ulna in the 3rd or 4th month result in a Radius curvus and lesions at the Procusus anconaeus and perhaps at the medial coronoid process.

**Joint capsule:** A joint with such a great range of motion and which includes the proximal radio-ulnar joint must have pouches. The cranial pouch is divided incompletely by the oblique ligament in a crano-lateral and a crano-median compartment. The caudal recessus, which is only reachable at the lateral side in the clinical inspection, is partly divided by the Processus anconaeus. Additionally, there are some small diverticula under the origin of flexion muscles at the caudomedial side.

Injections into the elbow joint are possible cranilaterally towards the joint cleft between the M. extensor digitorum communis and the M. extensor carpi radialis in caudo-axially direction. A second point is recommended into the caudo-lateral pouch beside the olecranon (Vollmerhaus,1999).

**LIGAMENTS**

According to the function of the elbow joint, different ligaments are necessary and to be consider in clinical diagnosing.

The most important leading ligaments are the Ligg. collateralia (lat. and med.). Each has 2 parts to reach the radius and ulna. The Lig. coll. lat. originates from a ridge near the Epicondylus lateralis humeri and is connected with the origin of the M supinator and the Lig. anulare radii. Often, there is a small cartilage integrated into this connection. It runs, now divided, to a small tuberosity of the radius (cranial part) and a little bit oblique to the cranial side of the ulna (caudal part).

The Lig. coll. med. begins at a small groove near the Epicondylus medialis humeri reaches proximally the radius and ulna. Near the joint cleft, it is connected with the Lig. anulare radii.

The Lig. anulare radii curves around the radial head from one coronoid process to the other. The rupture releases the proximal connection of radius and ulna.

The Lig. oblimum strechtes in medio-ditally direction the cranial pouch.

The Lig. olecrani originates caudally at the Epicondylus medialis humeri and runs to the axial side of olecranon proximal of the Prox. anconaeus. Its function can be as a slip cushion and to limit the extension angle of the joint. It is responsible that in diagnosing the caudomedial pouch of the elbow joint is not palpable.

The special function of the elbow joint with pronation and supination belongs to special muscles. The pronation is made by the M. pronator teres with help of the M. biceps brachii and the M. brachialis, which cooperate at the medial side. As an antagonist works the M. supinator, which is connected to ligaments of the joint.

The innervation of the elbow joint is realized by 4 macroscopic nerves: N. radialis, N. musculocutaneus, N. medianus and N. ulaniris. In addition there are microscopic fibers from the periosteum and the passing nerves (Stasyk and Gasse, 1999).

Special interest must be given to approaches to the joint. There are the courses of the nerves and blood vessels to consider. Most of the bigger vessels are hidden cranially and medially (Frewein et al., 1984) and less lie at the lateral and caudal side of the canine elbow joint.

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**Palpation**

The bony landmarks of the elbow joint (lateral and medial epicondyles), and olecranon are palpated. They should lie in the same plane when the elbow is moderately flexed. The presence of joint effusion can be best detected by palpating laterally between the lateral epicondyte and the olecranon, over the protruding anconeus muscle.

When examining the right elbow joint, the examiner stands in front of, or to the right of the animal. When flexing the elbow, the right hand grasps the metacarpus. The left hand grasps the humerus as proximal as possible, preferably in the region of the triceps muscle. The right hand lifts the antebrachium, flexing the limb only at the elbow joint.

When extending the shoulder joint, the left hand grasps the limb in the region of the olecranon and pulls forward as the right hand exerts pressure against the shoulder joint at the level of the greater tubercle.

**Examination**

The examination of the elbow begins by locating the palpable bony landmarks (lateral and medial epicondyles and olecranon); they should lie in the same plane with the elbow moderately flexed.

Displacement of these bony prominences is a clinical sign of a condylar fracture or elbow dislocation. With condylar fractures, the fractured fragment remains in the elbow joint while the major proximal fragment usually displaces sideways and distally. In immature dogs minimally displaced lateral condylar fractures may not be detectable by palpation.

This is followed by grasping the distal antebrachium with one hand, while the thumb or forefinger of the other hand is placed between the lateral epicondyte and olecranon on the anconeal muscle and process. The elbow is flexed, extended, hyperextended and hyperflexed.

The presence of pain or crepitation on overextension can be a clinical sign of an ununited anconeal process or intracapsular OCD in immature animals. In older animals, pain and crepitation during hyperextension and a limited range of motion are signs of elbow joint osteoarthritis.

The medial structures of the elbow (medial coronoid process, humeral trochlea) are examined by supinating the carpus with one hand and flexing it to a 90° angle. The thumb of the other hand is placed on the lateral epicondyle and olecranon on the anconeal muscle and process. Pain elicited during these manipulations is a clinical sign of a fragmented medial coronoid process or OCD of the humeral trochlea.

Regardless of the tentative diagnosis, radiographs must be made in the craniocaudal and mediolateral views. Additional positioning techniques are described with the various specific disorders. The most common disorders in the region of the elbow joint are:

- Fractures
- Luxations
- Disorders
- Ununited anconeal process
- Fragmented medial coronoid process of the ulna
- Osteochondritis dissecans of the humeral trochlea
- Distractio cubiti

**FRACTURES**

- Fractures of the olecranon
- Fractures of the anconeal process
- Fractures of the humeral condyle (humeral capitulum, humeral trochlea, Y-supracondylar fractures)

Fractures in the vicinity of the elbow joint usually affect the condyles of the humerus. In descending order of frequency: fracture of the humeral capitulum (lateral part of the condyle), Y-fractures, humeral trochlea (medial part of the condyle), and supracondylar humerus fractures. In small breed dogs, fractures most often result from minor trauma (e.g. falling from a bed, jumping from the owner’s arms). Clinical signs include severe lameness, pain, and elbow joint crepitation. The tentative diagnosis of fracture can be confirmed with the aid of radiographs in the mediolateral, and especially the craniocaudal projection. If uncertainty exists, the radiographic examination should be performed on the contralateral limb under identical conditions.

Operative repair of these fractures is indicated. The treatment principles are precise, anatomically correct reconstruction of the joint surface with interfragmentary compression with a lag screw. Where required, the condyle is also fixed proximally with a bone plate, Kirschner wire or Rush pin.

LUXATIONS

Aside from the rare congenital form, luxation of the elbow joint almost always results from trauma. Lateral luxation is the most common presentation, followed by medial and then caudal luxations.

The Monteggia fracture is a special form involving radial head luxation and ulnar fracture, and always requires surgical intervention. Internal fixation is performed on the ulna and the radius is repositioned.

Severe lameness accompanies elbow luxation. The limb is flexed at the elbow with the humerus adducted, while the antebrachium is medially rotated and abducted. The limb does not bear weight. Passive manipulation is extremely painful and the palpable bony landmarks are displaced. The diagnosis can be confirmed on mediolateral and caudocranial radiographics projection.

Most often these luxations can be treated by closed reduction under general anaesthesia. Surgical intervention is required for luxations older than 48 hours and/or with bony involvement (fractures fragments) and in cases in which spontaneous luxation occurs.

DISORDERS OF SKELETAL DEVELOPMENT (ELBOW DYSPLASIA)

UNUNITED ANCONEAL PROCESS

The growth plate of the anconeal process closes at the age of 16 to 20 weeks, if this fails to occur then the anconeal process is considered ununited. Delayed growth of the long axis of the ulna (short ulna syndrome) irritates the anconeal growth plate and prevents its closure. Fast growing, large breed dogs are most often affected, especially German Shepherds. In 1/3 of the cases the disease is bilateral. Signs include mixed lameness, abduction of the paw and antebrachium, and adduction and internal rotation of the elbow.

In addition to lameness and characteristic limb positioning the elbow is swollen (palpable laterally) and painful on extension. The tentative diagnosis can be confirmed by radiographic examination of craniocaudal and mediolateral projections. The flexed lateral projection is decisive, especially in immature dogs. It is important to avoid an incorrect interpretation because the growth plates of the radius, ulna and humerus are not yet closed.

The anconeal process should be reattached in immature dogs (less than 7 months of age) with either a screw and/or a Kirschner wire (wires). It is recommended that animals with severe distraction cubiti (short ulna syndrome) undergo proximal dynamic ulnar osteotomy. Depending on the clinical findings, it is possible to perform both procedures in combination. If the anconeal process successfully heals, the prognosis is good with respect to function and the avoidance of osteoarthritis.

In older dogs with radiographic signs of osteoarthritis, the anconeal process should be removed. Full return of joint function is unusual, and in most cases osteoarthritis progresses.

FRAGMENTED MEDIAL CORONOID PROCESS (FCP)

FCP is caused by delayed growth of the radius (short radius syndrome) and/or an elliptic deformation of the trochlear notch, which stresses the medial coronoid process and leads to fracture. Three forms can be distinguished: fissure, fracture, and broad avulsion of the coronoid from the radial head. Rapidly growing large breed dogs are most often affected, with Bernese Mountain Dogs, Swiss Mountain Dogs, Rottweilers and Retrievers being especially prone. Bilateral disease is not uncommon. Signs include a mixed lameness of sudden onset and abduction of the limb below the elbow. Swelling of the elbow joint can be detected on the standing animal by palpating laterally between the olecranon and the lateral epicondyle.

Radiographic findings on the standard view include incongruity, step formation, and osteophytes on the medial epicondyde, medial coronoid and area proximal to the anconeal process. Quantifying the degree of incongruity involves measuring the length of the trochlear notch and the distance from the tip of the anconeal process to the tip of the lateral coronoid process and creating a ratio from the two values. If the ratio is greater than 1.15, then the joint is considered ellipsoid (a sign of incongruity). The fragment is removed either by arthrotyomy or arthroscopy.

OSTEOCHONDritis DISSECANS OF THE HUMERAL TROCHLEA

OCD is caused by a disturbance of cartilage growth and a failure of normal cartilage development. The cartilage thickness exceeds the capacity of the deeper layer to be supplied by diffusion, leading to malnutrition and necrosis. The humeral trochlea is the predilection site in the elbow joint. Rapidly growing large breed dogs are most often affected, especially Rottweilers and Golden Retrievers. It is often the case that excessive calcium or energy is present in the diet. Bilateral affection is common. As is the case with FCP, a mixed lameness is present, and signs include abduction of the limb below the elbow, and swelling of the joint. Joint effusion can be detected by palpating laterally between the olecranon and the lateral epicondyle on the standing animal (further clinical diagnostics). Radiographic finding in the craniocaudal view include radiolucency in the vicinity of the humeral trochlea with subchondral sclerosis and possibel degenerative changes as describe with FCP.

The detached cartilage flaps are removed via arthrotyomy or arthroscopy; the lesion is curedtted or foraged with a small drill. Nutritional analysis should be performed and necessary corrections undertaken.

HUMERAL INTRACONDYLAR OCD (HIOCD)

HIOCD is caused by delayed ossification of the humeral condyle. After birth the distal humeral epiphysis grows up out of two centers of ossification: the lateral Capitolium (week 2) and
the medial Trochlea (week 4). Cranial and caudal the epiphysis is deeply hatched by the radial fossa. The epiphysis is oblique distally and caudomedial enlarged forming an apophysis plate for the medial epicondyle. In dogs the whole epi-/apophysis plate is closed in the fifth or sixth month. Rapidly growing dogs are involved. Signs include a mixed lameness of sudden onset. Swelling of the elbow can be detected and it is painful on extension. The tentative diagnosis can be confirmed by radiographic examination of craniocaudal projection.

The intracondylar gap is curretted or foraged with a small drill via arthroscopy. The Condyle should be fixed with interfragmentary compression with a lag screw.

DISTRACTIO CUBITI

Distractio cubiti of chondrodysplastic breeds (e.g., Basset, Pekinese, Dachshund) is caused by a genetic disorder causing premature closure of the distal ulnar growth plate that results in disturbed axial growth of the radius and ulna (short ulna syndrome). The consequences are: carpus valgus, supination of the paw, radius curvus, elbow joint incongruity (long radius, short ulna), fracture of the anconeal process and radial head luxation.

The treatment principle is a distal ulnar defect osteotomy to remove the bowstring effect and to allow radial remodelling, to allow the proximal end to shift proximally and re-establish elbow congruency and spontaneous healing of the anconeal process.

REFERENCES