PROCEEDINGS

29th annual meeting of the

INTERNATIONAL ELBOW WORKING GROUP

May 17th 2015
Centara Grand Hotel & Convention Center
Bangkok, Thailand

WELCOME ADDRESS

Dear colleagues,

The board of the International Elbow Working Group **(IEWG)** is grateful to the organisers of the 40th World Congress of the Worlds Small Animal Veterinary Association (WSAVA) for the hospitality offered, to organise a seminar dedicated to elbow dysplasia (ED). It is the second time that the IEWG got the opportunity to dedicate a full day program to the different aspects of ED in large breed dogs at a WSAVA congress in Bangkok, Thailand and we like to thank the local organisers of the Thai Veterinary Association cordially.
The IEWG has been founded in 1989 by a group of veterinarians and dog breeders with a concern about ED. The purpose of this non-profit working group is to gather and exchange knowledge and experiences about hereditary elbow diseases regarding aetiology, diagnosis, treatment, and prevention and in particular discussing optimal screening procedures of the breeding stock. The screening protocol includes a standardised method of radiological film reading, a standardised method of scoring of the presence of the primary lesion or secondary osteoarthrosis as well as a standardized scoring form. An ED-certificate has been introduced and can be found in the proceedings of the IEWG; it gives insight not only into the identification of the dog, its owner and screeners, but especially also into the amount and direction of radiological views used for screening and the findings the final score was based upon.
All the aspects of concern of the IEWG are directed to diminish the incidence of the developmental disturbances of the elbow joint in growing dogs of numerous breeds, with a great impact on the quality of life for both the patient and its owner. Therefore the WSAVA recognised the IEWG as an affiliated group, and the IEWG is grateful for this mental support.

The IEWG can only accomplish its goal with the help of the organisers of the congress of the WSAVA who provided space in the main congress programme and a lecture room to have the meeting. We are grateful for the cooperation of an international team of world famous experts who accepted the invitation to give an update in their field of expertise, including Dr Palmer (USA), Dr Boroffka (NL), Dr Heng (USA, Malaysia), Dr Lau (Malaysia), Dr Vannini (Switzerland), and Dr Ondreka (Germany)

We invite all practicing veterinarians with special interest in canine orthopaedics to participate in this year conference of the IEWG or in one of the future meetings. All are welcome to read the proceedings texts of the past years at the web page of the IEWG (http://www.vet-iewg.org/joomla). See you at the IEWG- meeting!

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IEWG

CERTIFICATE OF ELBOW DYSPLASIA EXAMINATION

Examination based on IEWG standards

Logo National Kennel Club

Registration .nr. Examination: ED-XXX

National reg.scruteneer

Animal

Pedigree name

Breed

Registration nr

Tattoo

Microchip nr

Date of birth (day - month - year)

Sex: F (female intact) Fs (female spayed) M (male intact) Mc (male castrated)

Owner

Name

Address

Country, Zip (country, zip code)

Town

The undersigned agrees to the IEWG examination protocol, the rules of the national scheme and confirms that the dog submitted for examination is the one described above. Signature also means that the results of the examination will be registered and archieved as designated by the national Kennel Club, and are made available for official publication.

Signature owner / handler

Veterinarian

Name

Address

Country, Zip (country, zip code)

Town

Identification of the dog

Check tattoo: Correct Incorrect Absent Partly /unreadable

Check microchip: Correct Incorrect Absent Partly /unreadable (new tattoo/ chip number)

Radiographic views

Date radiographic examination (day - month - year)

Age (Years, Months)

Radiographic projections:

- Medio-lateral~45°
- Medio-lateral~90°
- Medio-lateral >120°
- Cranio-caudal-15°pronated
- Cranio-caudal
- Other: specify

Stamp / personalia veterinarian

The undersigned agrees that the examination was performend according to the valid IEWG protocol.
Furthermore the undersigned states that the identity of the above mentioned dog has been verified. The results of the examination will be registered and archieved by the national Kennel Club

Signature veterinarian

Results of the evaluation by the national ED-panel

Evaluation panel

Name

Address

Country, Zip (country, zip code)

Town

Radiographic evaluation

Date evaluated (day - month - year)

Primary lesions	NONE R L	UAP R L	FMCP R L	OC R L	INC R L	OTHER R L
						Affected
						Suspected

Secondary arthrosis

Arthrosis-score according to the IEWG protocols

- Grade 0
- Borderline
- Grade I
- Grade II
- Grade III

Space for sponsors !!!

Stamp / personalia evaluation panel

The undersigned agrees that the radiografic evaluation was performed according to the valid IEWG protocol.

Signature representative evaluation panel

Interpretation

Interpretation based on the current recommendations of the international Elbow Working Group (IEWG), an affiliate of the World Small Animal Veterinary Association (WSAVA)

Primary Lesions
- UAP Ununited Anconeal Process
- FMCP Fragmented Medial Coronoid Process
- OC Osteochondrosis or Osteochondritis dissecans of the medial humeral condyle
- INC Incongruency of more than 2mm between articular surface of Radius and Ulna

Other Lesions
- Avulsion medial humeral epicondyle
- Mineralisation medial collateral ligament/origin flexor muscles
- Other: .

ED grade, based on the secondary arthrosis
- **Grade 0** No signs of arthrosis
- **BL** Border Line. Undetermined changes
- **Grade 1** Osteophyte formation of less than 2 mm anywhere in the elbow joint
- **Grade 2** Osteophyte formation of 2-5 mm anywhere in the elbow joint
- **Grade 3** Osteophyte formation of more than 5 mm anywhere in the elbow joint

Note: The classification Grade 0 (or no detected primary lesion) does not imply that the animal is genetically sound. Based on the current scientific knowledge IEWG does not recommend breeding of arthritic animals or animals displaying a primary lesion!.

International Elbow Working Group Annual Meeting

Elbow Dysplasia in Dogs, Sunday May 17th 2015, WSAVA Congress, Bangkok Thailand.

Chairperson: Prof. Dr. H.A.W. Hazewinkel

08.30 – 09.15	Introduction, clinical investigation and force plate of patients with Elbow Dysplasia (ED) Prof. Dr. H.A.W. Hazewinkel
09.15 – 10.00	Break
10.00 – 10.30	Artroscopy; diagnosis and treatment of ED Prof. Dr. R.H. Palmer
10.30 – 10.45	Aftercare following surgery. Dr. K.L. How *Radiological investigation of the elbow joint*
10.45 – 11.10	Dog positioning for radiology Dr. S.A.E.B. Boroffka
11.10 – 11.30	Dog positioning for CT scanning Dr. S.F. Lau
11.30 – 12.15	Radiography for FCP, OCD, UAP and elbow incongruity, additional value of extra views or other imaging modalities Dr. H.G. Heng
12.15 – 13.45	Lunch
13.45 – 14.30	Treatment strategies in growing dogs and adult dogs with elbow disease Dr. R. Vannini
14.30 – 14.50	Ethiology of FCP Dr. S.F. Lau
14.50 – 15.15	Genetic background of ED Dr. J. Bell
15.15 – 15.45	Break
15.45 – 16.30	Explanation of grading according to IEWG and discussion of cases Dr. N. Ondreka
16.30 – 17.15	Interactive film reading session Dr. N. Ondreka & Prof. Dr. H.A.W. Hazewinkel

List of speakers

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ELBOW DYSPLASIA; introduction, clinical investigation and force plate evaluation.

Prof. em. dr. H.A.W. Hazewinkel, DVM, PhD, Dipl. ECVS, Dipl. ECVCN.

Introduction

Originally the term “elbow dysplasia” or “dysplasia articulationis cubiti” covered generalized osteoarthrosis of the elbow joint with an ununited anconeal process (UAP) by Corley et al, in 1968. These days UAP is just one of the different entities which are covered by the term “Elbow Dysplasia” which is here defined as the group of elbow dysplasias including 1) ununited anconeal process (UAP), 2) fragmented medial coronoid process (FCP), 3) osteochondrosis (OC) or osteochondritis dissecans (OCD), and 4) incongruity (INC) of the elbow joint. These four entities have in common that they all occur in the elbow joint (although OCD occurs also in other joints), that they are all seen in young growing dogs of 4-6 months of age (although they can be overlooked and reveal the first signs at mature age) of medium and large size, that they can cause lameness (but not in all cases these entities go together with lameness, and if so not always for the first time at young age), and that they will cause osteoarthritis (OA), (but that can vary per individual dog and perhaps even per breed).
Since developmental skeletal diseases, either due to genetic cause or due to nutritional influences or trauma, are frequently seen in this category of companion animals all three etiologies can be held responsible for the occurrence of ED. Here first definitions and a short indication of its etiology will be given of each of the primary entities of ED.

Primary lesions

In the screening programme according to the International Elbow Working Group (IEWG) these lesions are graded as absent (ED grade 0), suspected-present (ED grade 2) or obvious present (ED grade 3) See figure 1. We will distinguish the following primary lesions:

1. UAP: Separation in the cartilaginous bridge between the secondary ossification centre of the anconeal process and the olecranon, which can cause a partially or completely detached anconeal process, is referred to as ununited anconeal process (UAP). Etiology: When the humeral condyle increases in proportion (i.e, in diameter), the semilunar notch should widen equally by shifting the anconeal process in a proximal direction. However, when widening stays behind or at the same time the radius pushes the humerus in a proximal direction (in case of delayed ulnar growth in length) this can lead to a shift of the anconeal process off its origin when (i) the anconeal process is a secondary ossification centre (as it is in some but not all breeds) and (ii) it is not bony fused yet with the ulna (i. at the age of <5.5 months).

2. FCP or MCPD (= medial coronoid process disease) or MCD (medial coronoid disease or medial compartment disease): Fissuring of the medial coronoid process of the ulna with partial to complete separation (fragmentation) of the medial coronoid process from the ulna. Etiology: primary osteochondrosis of the subchondral bone with a fissure line between osteochondral cartilage and subchondral bone, possibly with secondary a fissure line in overlying articular

cartilage as described by Guthrie in 1992) and recently by Lau (2014, and Lau: this proceedings), although also chondromalacia at the medial coronoid process is considered part of this entity.

3. OC or OCD: Local thickening of growing epiphyseal cartilage of the distal humerus due to delayed endochondral ossification (i.e. osteochondrosis=OC), which may develop into a single or fragmented detached cartilage flap (i.e. osteochondritis dissecans = OCD).

"Kissing lesion": An abrasion of the articular cartilage of the humerus, sometimes extending into the subchondral bone (and radiological often slightly more lateral than the OC-lesion), is caused by a fragmented coronoid process at the opposite side as suggested by Morgan in 2000. This finding is graded as a "OCD-like lesion" since it is not always possible to distinguish it from OC/OCD (both in Fig. 1 at location "h").

4. Elbow incongruity (EI, INC): The subchondral bone of the trochlear notch of the ulna and of the radial head are not parallel to the opposing humeral subchondral bone. There are different forms of EI:

(i)The radius is longer than the ulna with a narrowing of the joint space between the tip of the anconeal process and the humeral condyle, a distally gradual widening of the joint space between the ulnar semilunar notch and the humeral condyle and the radial head proximal of the coronoid process of the ulna (this form of EI is typically seen in Bernese Mountain dogs, often together with a fragmented apex of the coronoid process (=FCP).

(ii)The longer ulna with a wider joint space between the proximal radius and the humeral condyle and the step between the more proximally located distal edge of the ulnar trochlear notch (i.e., the lateral coronoid process) and the radial head (and displacement of the distal humerus cranially). This can also be considered as an underdeveloped or too small trochlear notch (or part of traumatic short radius syndrome).

(iii)The alignment between the subchondral bone of the trochlear notch and the radial head is more elliptical than the circular contour of the humeral condyles described by Wind especially in German Shepherd dogs in 1986.

(iv)An incongruity of the radial-ulnar joint (not to be detected on plain radiographs) warrants computed tomography, but will only visualize the subchondral bone; this incongruity may play a role in avulsing the loosening of the medial coronoid process when weakened.

Developmental elbow luxation with lateral displacement of the (often hypoplastic) radial head with a comparative overgrowth of the radius (as seen in chondro-dysplasia in non-chondrodystrophic breeds) can be described as elbow incongruity although it is generally considered beyond the scope of the screening for ED.

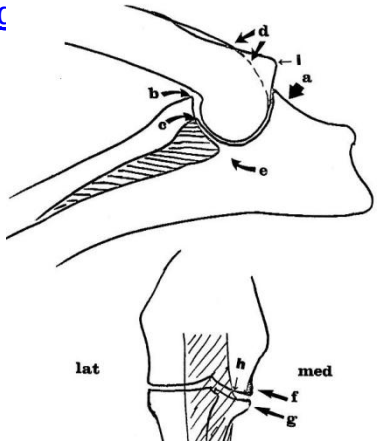
5. Osteoarthrosis (OA) is radiological characterized by new bone formation at the edges of the joint cartilage. In addition, enthesophytes (i.e. new bone formation at the sites of attachments of tendons, ligaments, and joint capsule, resulting from abnormal tension placed on the soft tissue attachments near, but outside the joint) can be formed; quit typical is the enthesophyte at the caudal margin of the humeral condyl (fig. 1, indicated by "i ") in case of more severe ED.

Regardless of the primary cause, the pattern of OA is similar. The different locations where osteophytes and enthesophytes are visible in case of OA are given in fig. 1 (a,b,d,f,g,and i). Both secondary signs (OA) and primary signs (UAP, FCP, OCD, INC) play a role in the final scoring for ED(fig. 1). An irregularity at the

dorsal margin of the anconeal process (in fig. 1 indicated with “a“), can by physiological in certain breeds (Lappalainen, *2014 in:* (http://www.vet-iewg.org/joomla under proceedings 2014)

6. Sclerosis, an alteration in normal bone architecture, i.e., a decrease in normal bone porosity, is depicted on a ML view of the elbow joint as an increase on bony opacity with loss of trabecular markings (a white area), within the trochlear notch just caudal to the lateral coronoid process (fig.1 at location “e”). Osteosclerosis is considered as one of the first signs of ED in young dogs, especially when the primary cause cannot be identified as in some cases of FCP. Since FCP often occurs bilaterally, the use of the opposite elbow joint for comparison will not always be of help to detect sclerosis. In a survey with 17 Labrador retrievers (6-16 months of age) with FCP and 17 without FCP as diagnosed by arthroscopy, radiographic density was objectively diagnosed and expressed as pixels: an extremely significant correlation between pixel intensity of the projection of the lateral coronoid process revealed in dogs with FCP (Burton et al, 2007). Microscopically, this area is characterised by reduced intertrabecular spaces (Wolschijn et al, 2004) in the medullary cavity of the ulna, either due to mechanical overloading or influence of e.g. MMPs, enzymes which play a role in OA.

Fig. 1 **Locations for grading of elbow OA (**http://www.vet-iewg



a. the proximal surface of the anconeal process
b. the cranial aspect of the radial head
c. the cranial edge of the medial coronoid process
d. the caudal surface of the lateral condylar ridge
e. sclerosis of the ulnar notch, at the base of the coronoid
f. on the medial surface of the medial epicondyle
g. at the medial edge of the medial coronoid process
h. indentation of the subchondral bone: OCD (-like) lesion
(i. spur formation is an enthesophyte, not part of OA)

Grading of Elbow Osteoarthrosis (OA)
Grading definitions:
Grade 0 OA: no signs of osteophytosis or osteosclerosis
Grade I OA: When at any of the locations listed a –h. osteophytes are present of < 2 mm, or presence of minor osteosclerosis
Grade II OA: When at any of the locations listed a-h osteophytes are present of 2-5 mm.
Grade III OA: When at any of the locations listed a-h osteophytes are present of ≥5 mm.

“Borderline OA” can be defined as increased radiographic density (sclerosis) in the ulna caudal to the trochlear notch. In addition, minimal changes at the dorsal border of the anconeal process which is considered as a normal edge and grouped under border line. This can be scored separately as ‘Borderline’ or as ‘Grade 1’.
In several countries the presence of a primary lesion such as UAP, FCP, OCD, or INC of > 2 mm, automatically results in a ED score 3; the suspicion of primary lesions results in a ED score 2.

Elbow dysplasia scoring	Radiographic findings
0 Normal elbow joint	Normal elbow joint, i.e. no evidence of INC, sclerosis or OA or any primary cause
1 Mild OA	*osteophytes are present of < 2 mm,* *or presence of minor osteosclerosis*
2 Moderate OA or suspect for primary lesion	*osteophytes are present of 2-5 mm.* *or presence of obvious osteosclerosis* *Step of 3-5 mm between radius and ulna (suspect INC)* *or Indirect signs of UAP, FCP and/or OCD*
3 Severe OA or evident primary lesion	*osteophytes are present of ≥5 mm.* *or step of >5 mm between radius and ulna (obvious INC)* or obvious presence of *UAP, FCP and/or OCD*

Clinical Investigation: It is of paramount importance to see the dog walking and trotting on a loose leash in a quiet surrounding before deciding at which leg the

dog is (the most) lame. Than the dog is put on the table and investigated (looking and superficial palpation) from proximal to distal comparing contours of muscles, bones and joints. On lateral recumbence the leg is meticulous investigated from distal to proximal (from nails to cartilage scapulae) with special attention for all joints (range of motion, crepitation, pain reaction). The elbow joint is flexed and extended several times with the thumb placed at the anconeal muscle for crepitation and a close look at the reactions of the dog for pain sensations.

In addition, pronation and supination is performed in different flexed positions and supination with the elbow extended to check for pain reaction. In addition the shoulder joint is investigated (extension and flexion) and flexion of the shoulder plus extension of the elbow joint (the latter to check the biceps tendon) is performed. Finally deep palpation of the long bones is performed for bone pain (like in panosteitis).

Typical signs of ED are: joint effluation in case of OA (especisally UAP), new bone formation at the caudolateral margin of the humeral condyle (in case of OA), pain upon extension (in case of UAP or incomplete humeral fractures) or flexion, supination and pronation at different angles (FCP, OCD), pain upon extension plus supination, decreased range of motion especially in flexion (in case of OA). Based on the clinical findings imaging techniques are to be considered (see presentations of Dr Boroffka, Dr Lau, Dr Heng and Dr Ondreka, this congress).

Force plate technique

Different techniques are in use to investigate in an objective way the locomotion of dogs affected with ED. One of these is the measurement of ground reaction forces. Rather than only evaluating the vertical force (Fz), the advantage of measuring also breaking and propelling ground reaction forces of the front legs give extra insight in the use of each (front) leg. The weight bearing of the dog occurs for 60% by the front legs and the function of the front legs is mainly breaking (Fy-) (rather than propelling = Fy+); consequently the breaking force and the vertical force are interesting to consider in dogs with front leg lameness. Breaking and propelling forces are unnatural, and thus less informative, when measured at a treadmill (Fanchon and Grandjean, 2007) with only a fair to moderate correlation of the data between force plate analysis (FPA) with or without treadmill could be shown in dogs with hind leg lameness (Böddeker et al. 2010). Breaking and propelling forces are totally missed when a force mat is used. The advantage of FPA is that there is only a small variation in repeated measurements allow to evaluate treatment modalities in case of lameness (e.g. medication, surgery) and that a symmetry index (SI= ratio affected side : contralateral side) is relevant for strictly unilateral pathology (Theyse et al, 2000); the disadvantage is that interpretation can be influenced when bilateral abnormalities are present (as in almost 70% of cases of ED) or when evaluating OA. Therefore real standardized conditions (body weight, pre-screening exercise, constant walking velocity, one handler) for FPA are of utmost importance.

FPA of seven dogs with unilateral FCP, was performed before, and 6 weeks and 6 months after surgical FCP-removal and Fz, Fymax and Fymin were determined for each dog and the SI was calculated (Theyse et al, 2000). The combination of the SIs of Fy-, Fy+ and the impulse of the vertical force (Iz) proved to be more

sensitive in determining frontleg lameness due to unilateral FCP, than the SI of the maximal vertical force (Fzmax). Fzmax returned to normal values 6 months after surgery for all seven dogs, whereas the other parameters showed persisting abnormalities in two of the seven dogs and the remaining 5/7 dogs had complete normalized SIs, this despite radiological progression of OA in 4/7 dogs at 6 months after surgery (Theyse et al, 2000). This demonstrates that in this study, there is no correlation between lameness and the radiological OA-grade, but there is correlation between the lameness and the presence or absence of the fragmented coronoid process.

References

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Arthroscopic Evaluation and Treatment of the Dysplastic Elbow.

Prof. Dr. R.H. Palmer, DVM, MS, DACVS.

Diagnostic imaging

Radiographs can be used to screen for elbow dysplasia though in cases of medial coronoid process (MCP) fragmentation, the fragment is seldom visualized; thus, secondary changes (subtrochlear sclerosis, abnormal contour of the MCP, osteophytosis, etc) are often used for evidence of disease. Computed tomography (CT) improves the diagnostic accuracy of many patients with elbow dysplasia.

Arthroscopy Basics

An arthroscopic system attaches a camera head to the end of the scope and projects images to a monitor.[1] Camera orientation is critical to maintain a point of reference within the joint. If the camera is right side up, the top of the projected image corresponds with the top of the field of view and one's ability to systematically evaluate the joint space is quite simple. If, however, the camera is sideways, the top of the projected image corresponds with the side of the scope's field of view and one's ability to systematically evaluate the joint is seriously compromised. Typically, an arthroscopic camera head is "right-side up" when the buttons are on top. Next, one must understand that the end of the typical arthroscope is beveled 30°. This bevel means that the image visualized from the scope is not as though one is looking through a pipe; rather it is as though looking through a periscope. One can rotate the scope to look around the joint. Next, one must appreciate the importance of depth of field when performing arthroscopic surgery. To understand this concept, imagine that you are looking at a friend across the room. As you move closer, a pimple on her ear lobe comes into view. As you get closer still, you can no longer tell to whom this pimple-covered ear belongs. As you get closer still, you can see only the pimple, but you have no context that it is attached to an ear or even that it represents a pimple. The ideal arthroscopic depth of field is close enough to visualize the lesion and far enough to have appropriate orientation. Finally, arthroscopic surgery requires proper fluid flow into and out of a joint. Ideally, the flow rate into and out of a joint allows distension of the joint and lavage to maintain a clear visual field. Too little flow and the joint is not adequately distended or lavaged to allow visualization. If the fluid flow into the joint drastically exceeds the flow out of the joint, fluid will extravasate into the surrounding tissues and, ultimately, collapse the joint.

Equipment needs

The following items are needed to perform diagnostic elbow arthroscopy: an arthroscopic camera with color monitor, a 1.9 or 2.4mm, 30°, short arthroscope with compatible cannula/blunt trocar and light source, lactated Ringer's bags and sterile administration tubing, and photo documentation system. Fluid ingress can be via gravity flow, pressure bag or fluid pump. To perform basic therapeutic elbow arthroscopy, the following instruments are needed: a blunt probe (or "switching stick"), a fine curette, right-angle blunt probe, small graspers, fine-tipped mosquito

hemostats, small arthroscopic osteotome, arthroscopic micropick, and mallet. A hand burr is also quite helpful. A power arthroscopic shaver is helpful for more advanced arthroscopic surgery.

Patient Preparation for Elbow Arthroscopy

The patient is clipped and prepared for open arthrotomy in the event that arthroscopy must be aborted. The dog is placed in dorsal recumbency with sandbags placed along the edge of the table to function as a fulcrum to distract the medial joint space.

Instrumenting the Elbow

After draping, the assistant abducts the limb firmly against a sandbag or similar fulcrum. Firm pronation of the elbow will further widen the medial joint space (Fig 1). A 3cc syringe and 22 gauge needle is placed into the joint distal and several millimeters caudal to the medial epicondyle. The needle should pass cleanly into the joint (if the needle must be angled to hit the joint, it should be re-inserted). Joint fluid is aspirated to confirm proper placement (Fig 2). The needle is left in place and lactated Ringer's solution is injected until the joint is distended and pressurized as detected by reverse pressure felt on the plunger (Fig 3). The position of the needle marks the desired location for the arthroscopic portal and the assistant must be careful not to alter the limb position. A #11 blade is advanced as a proximo-distally oriented stab incision though skin and fascia at the level of the needle (Fig 4). As the needle is withdrawn, the arthroscope cannula and blunt trocar are advanced through the stab incision and elbow joint capsule. The trocar is removed from the cannula and fluid should flow freely (Fig 5). The arthroscope is inserted into the cannula and the fluid ingress line is attached. Establishing an outflow (or egress) portal will allow joint lavage to clear the view (Fig 6). An 18 or 20-gauge needle is advanced along the deep edge of the medial epicondylar ridge and directed toward the anconeal process. Free flow of fluid and a clearing of the arthroscopic image confirm penetration of the joint. If gravity flow is used, a 10-drop/ml administration set is used. If a pressure-controlled fluid pump is used, relatively high pressures (60 to 70mm Hg) and low volume can be used in the elbow. Outflow tubing can be connected to the needle to direct outflow of fluid into a canister on the floor if desired. This instrumentation will allow diagnostic arthroscopy and image-capture documentation of the anconeal process, trochlear notch, coronoid process (lateral and medial aspects), radial incisure, radial head, and medial and central aspects of the humeral condyle (Fig 7).

For probing or treatment of the MCP, an instrument portal is established. First, a 22-gauge needle is passed into the joint at the same proximo-distal level as and ~ 1.5-2.0cm cranial to the scope. Fluid flow from the needle confirms intra-articular placement, but visualization of the needle at the level of the MCP with the surgeons hands spaced comfortably apart is essential before proceeding (Fig 9). The needle can be used at this time to loosen the fragment from its surrounding attachments, though this may require a stronger probe (Fig 10). A #11 blade is passed into the elbow joint along side the needle, Next, a mosquito hemostat is passed through the incision into the joint and gently opened to dilate the portal. A relatively large, clean portal will allow for free passage of instruments (without

need for a cannula) and free outflow of fluid (so that extravasation into the subcutaneous tissues is minimized).

MCP Fragment Removal vs. Subtotal Coronoid Ostectomy (SCO).

MCP disease may be present without identifiable fragmentation, thus preoperative computed tomographic (CT) scanning of the elbows can be helpful in the comprehensive evaluation of elbow dysplasia. Blunt probing of the MCP can be helpful in detection of in situ fragmentation. When fragmentation is present, fragment removal can typically be performed with hand instruments (blunt probe, curette, graspers, hemostats, fine osteotome, etc) and does not require a motorized shaver. Even when fragmentation is present, studies have shown that MCP pathology often extends into the intact MCP adjacent to the gross fragmentation. For this reason, subtotal coronoid ostectomy (SCO) may be indicated in some elbows. SCO can be performed with some combination of a curette, hand- or power-shaver, and osteotome.

Biceps Ulnar Release Procedure (BURP)

The multifactorial pathogenesis of MCP disease is thought to include concussion of the MCP against the radial head. This is theorized to result from strong tensile force of the biceps brachii muscle tendon uint upon its ulnar insertion. Tenotomy of this ulnar insertion via the BURP is one advocated treatment for selected cases of MCP disease. The clincial efficacy of the BURP has not been established to date. A detailed description of the procedure has been published.[2]

When to convert to a medial mini-arthrotomy

While arthroscopic surgery of the elbow has distinct advantages, the arthroscopic surgeon must be willing and able to convert the procedure to a mini-arthrotomy in instances when the treatment goals cannot be met arthroscopically. Instances where this conversion from arthroscopy to mini-arthrotomy may arise include:

- Hemorrhage or other technical challenge that prevents thorough diagnostic evaluation of the elbow.
- inability to remove an MCP fragment due to its size, location or other challenges,
- inability to perform complete BURP tenotomy,
- inability to safely perform a subtotal coronoid ostectomy (SCO) when indicated
- SCO has been performed, but the fragment cannot be retrieved arthroscopically.

A thorough understanding of the regional skeletal, muscular, nervous and vascular anatomy is required in order to safely and effectively perform a medial mini-arthrtomy of the elbow joint. Mini-arthrotomy preserves the integrity of the medial collateral ligament.

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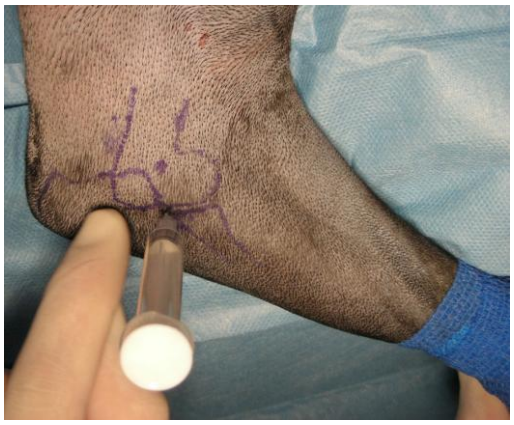


Fig 1 – Elbow is abducted against a padded bolster and pronated to “open” the medial aspect of the joint. A 22g needle and 3cc is advanced into the joint distal to the medial epicondyle.

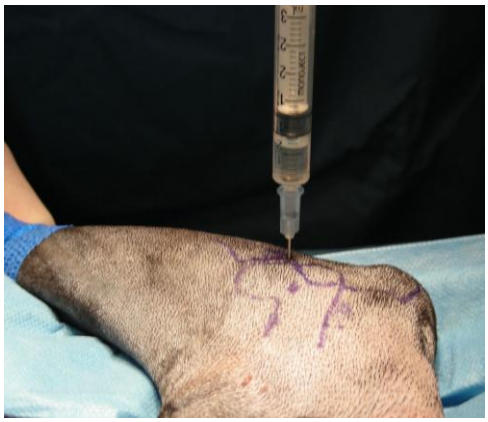


Fig 2 – Aspiration of joint fluid confirms intra-articular placement of the needle. The needle should enter the joint directly without appreciable angulation.

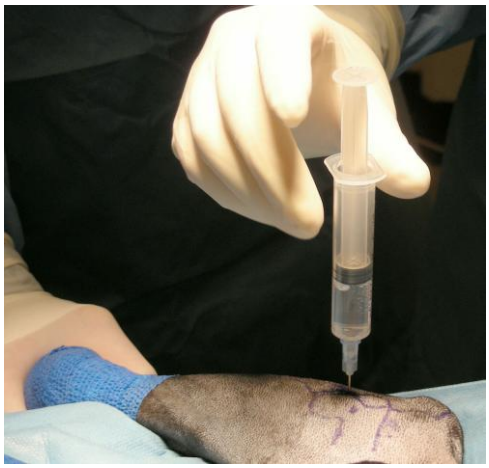


Fig 3 - The joint is distended with lactated Ringer’s solution or marcaine / epinephrine injected through the same needle previously used for joint fluid aspiration.

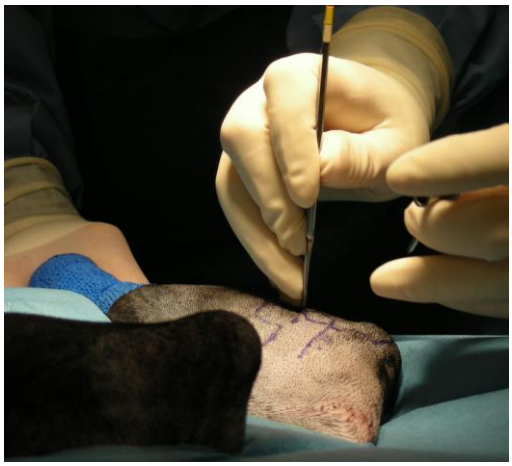


Fig 4 – A #11 blade oriented vertically is used to make a stab incision through skin and superficial soft tissues (ideally, joint capsule is not penetrated).

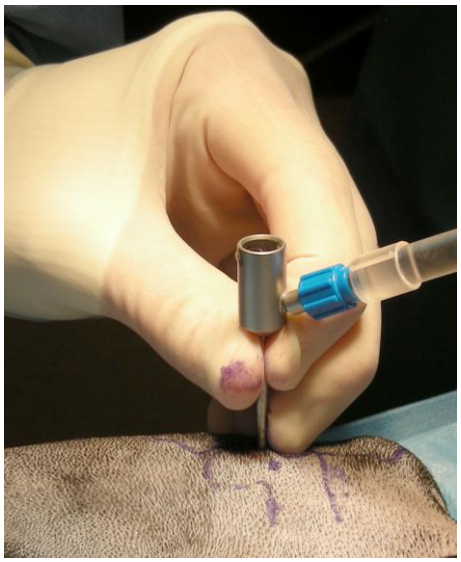


Fig 5 – A cannula (that matches the arthroscope) was placed through the stab incision along the same orientation at the original needle and the conical trocar was removed.

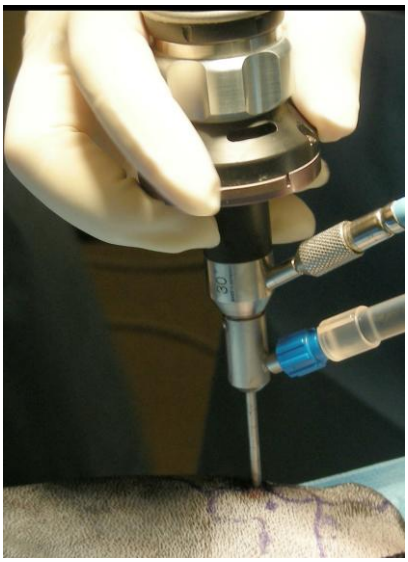


Fig 6 – Scope and camera head are passed into the cannula. Fluid inflow tubing is attached to the cannula and a light cable is attached to the arthroscope.

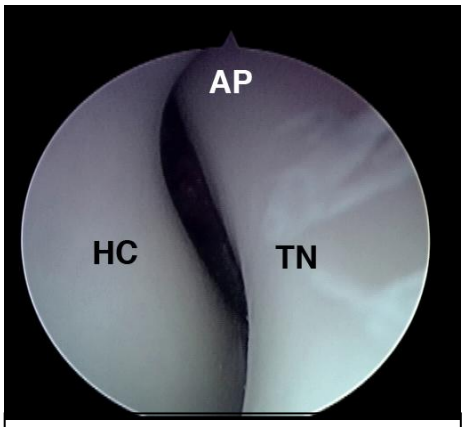


Fig 7 - Right elbow – arthroscopic visualization of humeral condyle (HC), anconeal process (AP), and trochlear notch (TN). "Notch" in image at 12:00 indicates the bevel of the scope is directed proximally.

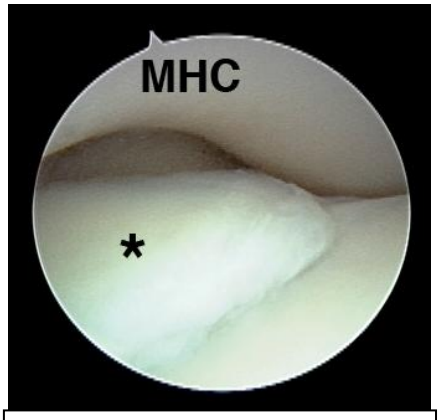


Fig 8 – Right elbow – arthroscopic visualization of medial humeral condyle (MHC) and fragmented medial coronoid process (*). "Notch" in image at ~ 11:00 indicates the direction of visualization through the scope.

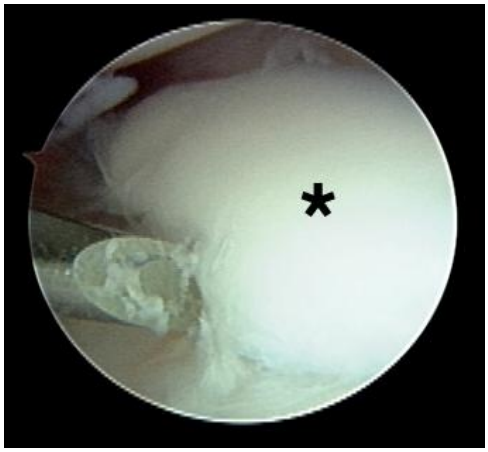


Fig 9 – Left elbow – Arthroscopic visualization of FMCP (*) and triangulation using a needle prior to establishing a full instrument portal.

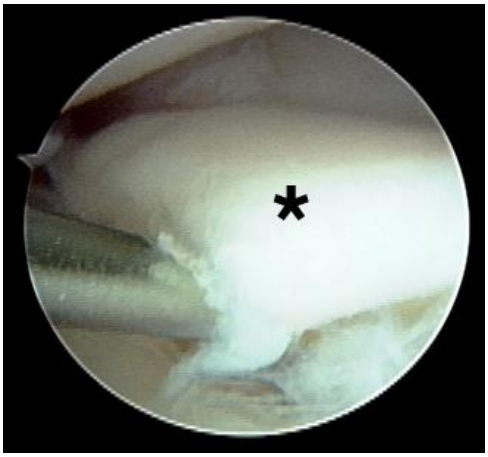


Fig 10 – Left elbow: arthroscopic visualization of FMCP (*) and triangulation using a needle to probe the fragment prior to establishing a full instrument portal for fragment removal with graspers or a hemostat.

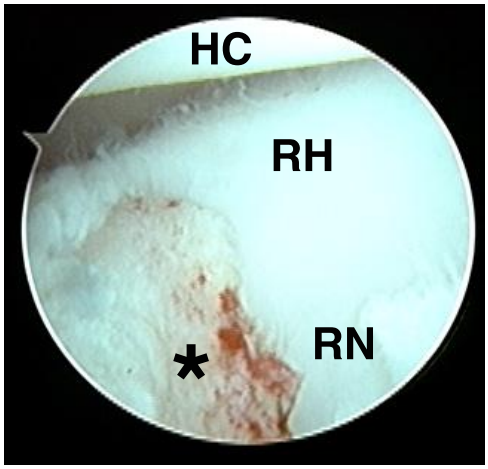


Fig 11 – Right elbow: Arthroscopic visualization following subtotal coronoid ostectomy (SCO) showing the humeral condyle (HC), the radial head (RH) , radial neck (RN) and ostectomy surface (*).

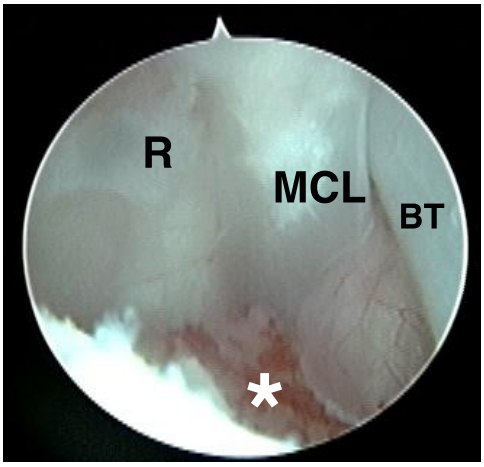


Fig 12 – Right elbow: Arthroscope is positioned down into SCO site (*). Removal of the tip of the medial coronoid process enhances the visualization of the relationship between the medial collateral ligament (MCL) and biceps tendon (BT) of insertion onto the ulna.

Aftercare following surgery.

Dr. K.L. How, DVM, NACAM Specialist in SA Surgery.

Dogs with Elbow Dysplasia [ED] that undergo surgery almost always have some degree of osteoarthritis. Postoperative management following elbow surgery is therefore best tailor made and composes of a combination of medical therapy, nutritional support and physical rehabilitation.
The Nonsteroidal Anti-Inflammatory Drugs [NSAID's] are the main drugs used in osteoarthritis and can be given for longer periods of time. Side effects involving the gastrointestinal tract, platelets and kidneys must be monitored in cases of long term administration. Corticosteroids are very strong anti-inflammatory drugs, but are not used routinely because of the risk of cartilage damage and progressive joint destruction.
Platelet-rich plasma, stem cell therapy, hyaluronic acid, polysulfated glucosaminoglycan, chondroitin sulfate and glucosamine sulfate/hydrochloride are used frequently, but evidence is not always sufficient for their recommendation for routine use in dogs. Omega-3 fatty acids have been proven to have anti-inflammatory effects in dogs and are available as a supplement or added in commercial diets.
Postoperative bandaging is not indicated after arthroscopy. Soft-padded bandage however can be used for 24 to 48 hours after open procedures or after significant extravasation of fluid during arthroscopy.
Activity must be restricted in the first 10 to 12 weeks after surgery. The first 3 weeks only very short [5 to 10 minutes] walks on the leash, several times a day. Depending on the progression walks can be extended accordingly. Physical therapy can help restoring the limb function without overloading the operated leg.
Besides exercise restriction the importance of weight management cannot be overestimated. Keeping the animals weight at the low end of the normal range slows the progression of degenerative joint disease.
Client education must also emphasize that surgery and post operative management in ED are no curative procedures, but are to improve joint function and slow down osteoarthritis. Many affected dogs however will have progressive osteoarthritis despite surgery. Medial compartment syndrome can be a deleterious condition that causes severe lameness and discomfort in ED patients. Lameness due to OA (lame after rising, especially after heavy exercise before the rest period) should be differentiated from lameness which increases during exercises and which warrants a careful examination of biceps tendinitis.
In cases in which advanced degenerative joint disease doesn't respond to therapy, corrective techniques as SHO, PAUL, CUE, joint replacement, arthrodesis or salvage procedures are possibilities.

Dog Positioning for Radiology of the Elbow.

Dr. S.A.E.B. Boroffka, PhD, Dip ECVDI and Prof. Dr. R.M. Kirberger, BVSc DVSc MMedVet(Rad) DipECVDI .

Normal Radiographic Anatomy of the Canine Elbow

The elbow joint has a complex articulation and knowledge of normal anatomy is important. In the mediolateral view, the normal elbow appears as two concentric, parallel rings. The larger ring is a continuous arc formed by the trochlear notch, lateral coronoid process, and articular surface of the radial head, whereas the smaller circle represents the narrowest part of the trochlea humeri articulating with the trochlear notch. The width of the humeroradial joint and humeroulnar joint should be nearly equal. The medial coronoid process (MCP) articulates with the widest part of the trochlea humeri. The MCP is superimposed with the radial head and proximal ulna and tapers cranioproximally at 45º from the ulna with a slightly concave contour. The apex of the MCP should appear as a sharp point superimposed with the proximal physeal scar of the radius. Trabecular detail of the trochlear notch should be clearly visible. The anconeal process of the ulna has a slightly concave margin and partially obscured by the medial epidondyle on extended and standard mediolateral views. Uni- or bilateral lateral sesamoid bones within the tendon of origin of the supinator muscle may be present on craniocaudal views.

Radiography of the Elbow

Radiographs are the routine imaging modality practitioners use to diagnose elbow dysplasia. As early osteophytic changes and pathology associated with medial coronoid disease may be subtle, optimal imaging techniques are essential to improver diagnostic accuracy. Standard film screen techniques should use slow (detail) screens and short scale contrast techniques. High quality, properly positioned radiographs remain the most cost-effective method of diagnosing elbow dysplasia. Radiographs should be obtained with a non-grid table-top technique, low kVp and high mAs exposure, with detailed film screen combination and tight collimation. Digital imaging is more forgiving regarding image quality assuming the correct look up tables are used and standard exposure principles are applied. Remember to collimate to the joint and not to over collimate on digital systems.

Radiographs are usually taken in lateral or sternal recumbency. They may also be made in dorsal recumbency or with horizontal beam radiography but these are not described here. Standard radiographic projections of the elbow include the 90° flexed mediolateral and craniocaudal views. True lateral positioning is important with the x-ray beam centered at the medial epicondyle. For the craniocaudal view, the x-ray beam should be angled 10-15° toward the humerus to best display joint surfaces. The standard mediolateral view (90° flexion) provides good overall evaluation of the MCP and joint congruence but the anconeal process is often obscured by the medial epicondyle. Maximally flexed mediolateral projections (45º inside angle) have the highest sensitivity for UAP and early osteophyte formation and are also recommended for routine screening. However, this view does not contribute to the evaluation of fragmented medial coronoid process (FMCP) when

compared to other views. The craniocaudal view is useful for evaluating the medial aspect of the joint for osteochondrosis (OC) or kissing lesions of the trochlea humeri, but fragments of the MCP are rarely demonstrated in this view. A supplemental view that may be useful to highlight OC or FCP lesions is the craniolateralcaudomedial oblique projection because it reduces superimposition with the ulna.

Standard Views

Mediolateral extended

For a mediolateral extended (ML extended) view the patient is positioned in lateral recumbency lying on the affected limb. The upper limb is retracted caudally and the head and neck are slightly extended. The angle between the humerus and radius and ulna is 120 degrees. The beam is centered on the medial epicondyle. This view optimizes the following:

- evaluation of elbow incongruity
- osteophytes on the cranial aspect of the joint and lateral epicondylar crest
- medial coronoid process that is superimposed on the radial head

Craniocaudal

For a craniocaudal (CrCd) view the patient is positioned in sternal recumbency ensuring the humerus, radius and ulna are in a straight line. The head is elevated and retracted away from the affected limb. A thin foam pad under the elbow may prevent rotation. The beam is centered on the joint space just distal to the prominent medial epicondyle. This view optimizes the following:

- medial humeral condyle osteochondral defects (kissing lesion)
- osteophytes on the medial humeral epicondyle
- distinguishing the supinator long tendon sesamoid from a FMCP

Mediolateral maximally flexed

For a mediolateral maximally flexed (ML flexed) view the patient is positioned in lateral recumbency lying on the affected limb. The upper limb is retracted. The distal antebrachium is pulled towards the neck so that the angle between the humerus and radius and ulna is <45 degrees. The carpus should not be elevated to maintain the elbow in a true lateral position. The beam is centered on the medial epicondyle. This view optimizes the following:

- osteophytes on the anconeal process
- ununited anconeal process
- flexor enthesopathy

Extended supinated mediolateral

For an extended supinated mediolateral (Cd75°MCrLO) view the patient is positioned in lateral recumbency lying on the affected limb. The upper limb is retracted. The joint is maximally extended and the limb supinated about 15 degrees. The beam is centered on the medial epicondyle. This view optimizes the cranial border of the medial coronoid process and increases the possibilities of detecting a FMCP, as the primary beam is more likely to be in line with the fragment edge

Craniolateral-caudomedial oblique (pronated view)

For a craniolateral-caudomedial oblique (Cr15°LCdMO) view the patient is positioned in sternal recumbency ensuring the humerus, radius and ulna are in a straight line and the limb is pronated 15 degrees (15–50 degrees is the range in the literature). The beam is centred on the joint. This view optimizes the following:

- medial humeral condyle osteochondral defects
- elbow incongruity but extended ML view is more reliable
- the MCP as it is isolated from other structures, improving visibility of fragments.

Craniomedial-caudolateral oblique (supinated view)

For a craniomedial-caudolateral oblique (Cr45°MCdLO) view the patient is positioned in sternal recumbency ensuring the humerus, radius and ulna are in a straight line and the limb is supinated 45–50 degrees. The beam is centred on the joint. This is not a standard elbow dysplasia view but is useful to optimize the following:

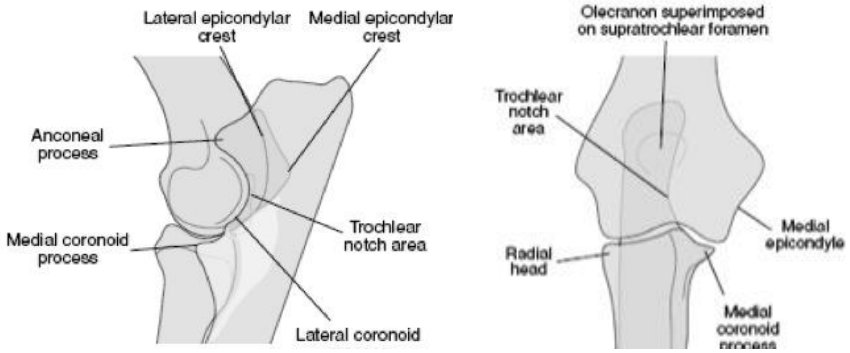
- visibility of the lateral humeral condyle
- visibility of the supinator longus tendon sesamoid which could be confused with a medial coronoid fragment on ML views
- incomplete ossification of the humeral condyle; best seen on 15 degree supination.

Distomedial-proximolateral oblique

Distomedial-proximolateral oblique (Di35°MPrLO) view is also known as the medlap view. The patient is positioned in lateral recumbency lying on the affected limb. The upper limb is retracted. The joint is flexed to 90 degrees, the antebrachium elevated 35 degrees and the extremity supinated 40 degrees. A foam wedge may be used for this. The beam is centered on the medial epicondyle. This view optimizes the medial coronoid process, which is now seen proximal to or superimposed on the humero-radial joint.

Normal Anatomy

The elbow is a composite joint consisting of three bones, resulting in a structurally complex joint with superimposition of several clinically significant structures. Several views may be needed to identify the various components.



Incidental Findings

In up to 15% of large breed dogs a sesamoid may be seen in the origin of the supinator muscle on CrCd or Cr45°MCdLO views. The sesamoid is located laterally or craniolaterally to the radial head and may have a distinct articulation with the radius. It should not be confused with joint mice, chip fractures or a medial coronoid process fragment which lies medially. It is rarely seen on ML views and if seen lies slightly more proximal than a fragmented medial coronoid process with which it can be confused on this view. It may also be seen in the cat where it often is located more cranially than laterally.

Pathology

Developmental elbow abnormalities included in the term elbow dysplasia are:

- FMCP or medial coronoid disease
- osteochondritis dissecans of the medial humeral condyle
- ununited anconeal process
- elbow incongruity

In affected dogs a skeletal survey should be considered to rule out concomitant hip dysplasia and other potential OCD lesions. Osteoarthrosis, the end result of elbow dysplasia is a common finding and is seen as osteophyte formation at the following locations:

ML views

- on the dorsal border of the anconeal process
- on the cranioproximal edge of the radius and craniodistal aspect of the humeral condyle
- on the cranial edge of the medial coronoid process
- on the proximal edge of the lateral epicondylar crest
- subtrochlear sclerosis at the base of the medial coronoid process

CrCd and Cr15°LCdMO views

- distal aspect of medial humeral condyle
- medial aspect of medial coronoid process

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Dog Positioning for CT Scanning of the Elbow Joints.

Dr. S.F. Lau, DVM, PhD and Prof. em. Dr. G. Voorhout, DVM, PhD, Dipl. ECVDI.

In comparison to diagnostic modalities such as conventional radiography, ultrasonography, and magnetic resonance imaging, computed tomography (CT) is a more accurate tool for diagnosing elbow joint disease, particularly for medial coronoid disease (MCD). Its ability of interpreting the images in different reconstructive views and planes allows CT to be superior to conventional radiography because there is no distraction of superimposed images. Lesions involved in elbow joint diseases such as displaced mineralized fragments of the medial coronoid process, signs of radioulnar incongruence (RUI), and the presence of subtrochlear notch sclerosis are easy to detect using CT (Cook and Cook, 2009).
In a previous study (Lau *et al*., 2013), we followed the development of MCD by using both radiography and CT. CT had the higher sensitivity (30.8%) in comparison with radiography (0%) in detecting incipient MCD. In that particular study, the dogs were anesthetized and positioned in dorsal recumbency on the CT scanning table with the elbow joints extended approximately 135°. The antebrachia were positioned parallel to each other and as symmetrically as possible at the same level using a custom-made positioning device. Transverse views, perpendicular to the antebrachia, were made with a third- generation single-slice helical CT scanner (Philips Secura, Philips) using 120 kV and 120 mA with an exposure time of 1000 ms. One millimeter thick slices of the elbow joints were made with the joints in neutral position. The earliest signs of MCD were detected by using CT at 14 weeks with a mineralized bone fragment detected at the base of the MCP subchondral bone, which did not extend to the apex of the MCP.
By using CT, other entities of elbow dysplasia, namely, ununited anconeal process (UAP) and osteochondrosis lesions are best seen on sagittal and dorsal plane reformatted images as either a partial or complete hypoattenuating line and as lucency or flattening of the medial aspect of the humeral condyle with surrounding subchondral bone sclerosis (Reichle and Snaps, 1999). Different positioning with the elbow either in in supination or pronation, extension and standing angle (135°) are more critical in evaluating RUI (Murphy *et al*., 1998; Wagner *et al*., 2007). Maximal supination and pronation of the antebrachium leads to a significant variation in measurements of the radioulnar joint space; hence, a neutral position of the antebrachium during scanning is critical to detect RUI. On joint extension (160°), there would be a cranial translation of the ulna, increasing the space between the radius and ulna at the ulnar incisures (Wagner *et al*., 2007). Reconstructed images from dorsal and sagittal planes are useful for accurately determining incongruity of the radius and ulna (Reichle *et al.,* 2000). The most reliable reconstruction plane is the mid-coronoid oblique plane, because it allows the most accurate measurement of radioulnar congruence (Holsworth *et al.,* 2005).

Despite of its great advantages, CT does have certain limitations. It cannot be used to assess cartilage integrity and the animals are not in weight bearing position during the examination. These disadvantages mean that it is not possible

to detect or assess pathological changes in cartilage and make it more difficult to determine the congruity of the elbow joints. The physiological incongruity of the elbow joints during movement also could not be detected.

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Radiograph for FCP, OCD, UAP and Elbow Incongruity, Additional Value of Extra Views or Other Imaging Modalities.

Dr. H.G. Heng, DVM, MVS, MS, DACVR, DECVDI.

Elbow dysplasia is a common developmental disorder of the elbow joint of dogs. The common causes that will lead to this are fragmented medial coronoid process (FMCP), ununited anconeal process (UAP), osteochondrosis (OC), and incongruity of the elbow joint. Concurrent presence of 2 of more causes in a single joint is not uncommon. Clinically, we are not able to differentiate the cause based on clinical signs. Regardless of the primary cause of the elbow dysplasia, it will eventually lead to secondary degenerative joint disease.

Diagnostic imaging plays a very important role in evaluation of the elbow dysplasia. There are two important aspects of diagnostic imaging: 1) diagnose the disorder by identifying the cause, and 2) screen and identify dogs with and without this disorder. Radiography evaluation of the elbow joints is acceptable as the initial step for diagnosing and screening purposes as radiography is readily available and not too technical to perform.

As a rule of thumb, a minimum of 2 orthogonal views (mediolateral and craniocaudal) are needed to diagnose elbow disorders with manifestation of clinical signs. Additional craniolateral-15°-caudomedial oblique may be needed (1). As for the purpose of screening, the international elbow working group recommended at least a flexed lateral view of dogs with a minimum age of one year. The objective of performing only one flexed lateral view is to evaluate the secondary arthrosis. However many countries require additional views such as mediolateral, craniocaudal, and sometimes a craniolateral-15°-caudomedial oblique view to identify the primary cause in addition to the secondary arthrosis.

Anconeal process is a separate ossification center of the proximal ulna. It is normally fused at the age of 5 months. Thus, it is only possible to make a diagnosis of ununited anconeal process in dogs older than 5 months old. A mediolateral view demonstrating separation of the anconeal process from the proximal ulna with an irregularly marginated lucent gap is the hallmark of ununited anconeal process.

Osteochondrosis occurs mostly on the weight-bearing surface of the distal medial humeral condyle. The radiographic features are subchondral flattening or defect with sclerotic margins. Depending on the size and severity of the lesion, most of the time OC can be identified on all views.

The primary lesion of FMCP is not easily detected on radiography. Absence of the sharply marginated triangular-shaped MCP suggests FMCP. In severe cases, flattening, rounding, proliferation and distinct fragmentation of the MCP could be observed on multiple radiographic views. Due to the low sensitivity of radiography to visualize the primary lesions of FMCP, secondary osteoarthrosis seen without other primary causes such as UAP, OC or elbow incongruity is considered as having FMCP.

Sensitivity of radiographic detection of elbow incongruity depends on the severity of the incongruity. The sensitivity is higher for detection of an incongruity > 2mm

(2). A flexed mediolateral view at 90° with the radiographic beam centered at the medial epicondyle is recommended. The radiographic signs of incongruity are a step defect between the radial head and the ulnar lateral coronoid process and an increase in the humero-ulnar joint width.
The purpose of screening is to identify dogs with radiographic elbow dysplasia but without any clinical signs. Thus, identifyingthe primary cause is not important since a treatment plan is usually not needed. Only a flexed mediolateral radiograph is needed to assess the secondary arthrosis (presence of osteophytes dorsal to the anconeal process) of the elbow neglecting the primary cause. However, if secondary arthrosis is present some owner/veterinarians perform additional radiographs to identify the primary cause. This is to prevent repetition of the elbow radiographs in case the dog develops clinical sign in the future.
Computed tomography (CT) evaluation of elbow dysplasia is particularly targeted to the evaluation of MCP as OC and UAP are readily identified with radiography. This is performed mainly after radiographic examination and diagnosis of the primary cause of the elbow disorder could not be made or the radiographic changes of the elbow are subtle and a definitive diagnosis is difficult to achieve. Information that could be obtained from CT includes changes of the subchondral bone (sclerosis, fissures, necrosis, cysts and fragmentation). In addition, CT can detect abnormalities of the MCP such as abnormal shape, sclerosis, presence of osteophytes, fragmentation, and changes of the bone attenuation. Computed tomography has been widely used for the evaluation of joint congruence due to the advantage of its capability of performing multiplanar reconstruction of the joint with CT study. Diagnostic certainty of joint congruency was higher with sagittal plane. Higher diagnostic certainty of MCP and subchondral abnormalities was transverse plane and dorsal plane respectively. It is suggested that CT has a higher sensitivity for diagnosing elbow dysplasia (3). A different window display is needed for the evaluation of different lesions in the elbow (4).
In conclusion, the objective of the diagnostic imaging investigation of the elbow should be established before the procedure as this may help in deciding the views needed and also the imaging modality used.

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Treatment Strategies in the Growing and Adult Dog with Elbow Disease.

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The most common elbow disease of growing dogs is elbow dysplasia. Elbow dysplasia is manifested as a collection of different diseases including ununited anconeal process (UAP), osteochondritis dissecans (OCD) and fragmented medial coronoid process (FMCP). The most common elbow diseases seen in the adult dog are degenerative joint disease and medial compartment disease. Both are usually the long-term sequels of ED. Medial compartment disease is also seen in adult dogs that had previously no elbow dysplasia. Regardless the causes they all result in complete loss of cartilage on the medial coronoid and the medial aspect of the humeral condyle.
This presentation will focus primarily on the management of medial coronoid diseases of young and adult dogs, as this is the most controversial topic.

Ideal goal of any treatment of elbow disease should be to eliminate pain, to stop the progression of the disease and to prevent degenerative joint disease.
As difficult as it is to define the exact causes of the different manifestations of elbow dysplasia, as difficult it is to choose the optimal treatment regimen. Unfortunately there is still a lack of good long-term studies comparing outcomes between surgical and conservative treatment regimens as well the different surgical treatments.
In the absence of sufficient evidence, treatment decisions remain largely empirical and subjective. Irrespective of this fact, treatment in young dogs should always be focused on prevention, while in older animals palliation will be the primary goal. Independent of surgical procedures weight management, activity modifications, medical management, as well as physiotherapy should be included in every treatment plan.

It is not surprising that there are a variety of surgical treatment options to help dogs affected with elbow disease. The most commonly performed procedures are:

Fragment removal (FR)

The arthroscopic removal of medial coronoid fragments has been the standard of care for years. Although the fragments are typically necrotic, they typically have strong joint capsule attachments or are squeezed between radius and ulna. The fragments act like a joint mouse causing synovitis, pain and osteoarthritis. Fragment removal alleviates synovial irritation and joint capsule tension during ambulation and this is thought to be the basis for treatment efficacy.

Subtotal coronoid ostectomy (SCO)

In many cases of FMCP the remaining portion of the medial coronoid is diseased as well. Histological analysis has revealed extensive microcrack formation in the subchondral bone of the medial coronoid[3]. As with stress fractures, this is a cause

of significant pain. The SCO involves ostectomy of the diseased bone, i.e. removing the majority of the medial coronoid process.

Biceps ulnar release (BURP)

The biceps brachialis complex inserts on both the radius and the ulna at the medial aspect of the elbow joint. Contraction of the muscle complex leads to compression of the radial head into the radial incisure of the ulna. Recently the release of the ulna portion of the biceps tendon has been advocated to reduce the risk of fragmentation of the medial coronoid in dogs with synovitis and elbow pain or in those with small fragmentation of the medial coronoid and significant remaining portion of the coronoid that may be at risk to fragment in the future[6].

Dynamic, proximal ulna osteotomy

An oblique osteotomy of the proximal ulna should release the pressure on the joint caused by incongruence between radius and ulna. It is ideally performed in young growing dogs with a good healing potential, as the dynamic nature of the osteotomy does not allow for stabilization of the osteotomy. As the joint is destabilized and the bone ends loose, these dogs are quite painful until the osteotomy has healed.

Distal ulna osteotomy (DUO)

In the young dog less then 6 – 8 month of age, a partial osteotomy of the distal ulna might be preferred, as this is less painful for the dog than a proximal osteotomy. At that age the interosseous ligament is not yet restricting motion between radius and ulna thus allowing shifting of the ulna in relationship to the radius. This procedure is primarily indicated if there is already obvious incongruence between radius and ulna at that age.

Proximal abducting ulnar osteotomy (PAUL)

This technique was developed on the basis of several observations and biomechanical analysis of the canine elbow joint. A consequence of medial compartment syndrome is medial collapse of the joint. Medial collapse overloads the medial compartment, exacerbating existing lameness and joint pain. A slight abduction of the ulna of about 4 to 6 degrees seem to result in a unloading of the medial compartment alleviating pain and lameness. The Paul procedure involves an osteotomy of the proximal ulna. A specially designed plate is applied to impose the desired modification of limb alignment aimed at unloading the medial compartment.

Sliding humeral osteotomy (SHO)

A midshaft humeral transverse osteotomy is performed and the bones fixed with a special step plate that keeps the distal humerus in a medially shifted position. This unloads again the medial compartment and shifts the weight-bearing axis to the lateral compartment.

Canine unicompartmental elbow system (CUE)

This hemi arthroplasty is performed in joints of older dogs with medial compartment disease. The destroyed surface is restored with a small inlay

prosthesis. This medial resurfacing procedure aims to reduce or to eliminate the pain and lameness that was caused by the bone-on-bone grinding while preserving the dog's own "good" cartilage in the lateral compartment.

Total elbow replacement (TER)

Total elbow replacement with a prosthesis has not yet really taken off. The main reason lies in the complexity of function of the elbow and the heavy loading, to which any prosthesis is exposed. The usually severe osteoarthritis with osteophytes, fibrosis of the joint capsule, makes the operation a demanding procedure and affect prognosis.
Most experience exist to date with the "TATE Elbow®". In this unique and patented system the artificial joint is inserted like a cartridge without opening the joint.
Both the system and the surgical technique are very sophisticated and well thought out. Nevertheless, the operation is very demanding and expensive.

The decision how to proceed, depends not only on the patient's age at the time of diagnosis, but also (if present) on the type and severity of incongruence of the joint, on the condition of the cartilage and the extent of osteoarthritis already present at the time of diagnosis[1,2,5,7]. Elaborated algorithms have been postulated intended to help in the decision process[4].
If osteoarthritis is already severe, treatment options are limited, expensive and with questionable success. Thus our treatment efforts must focus on early intervention in the young dog to delay progression of the disease.
Early preventive surgical measures to consider are the BURP, the dynamic proximal ulna osteotomy, and a distal ulna osteotomy or may be a PAUL procedure
Already resulting fragments should always be removed, the risk of further fragmentations be prevented by a subtotal coronoid ostectomy. The earlier we intervene, the better the chances are to optimize the joint function and the more likely the patients remain pain free.

If the cartilage is already destroyed, as this is the case with medial compartment disease, preservation of a pain-free function becomes the primary goal.
Since most surgical interventions at this stage are expensive and not necessarily crowned with success, a conservative therapeutic trial should always be tried first. These include medical therapy with non-steroidal anti-inflammatory drugs, intra-articular administration of steroids, platelet-rich plasma (PRP) or stem cells, laser therapy and physiotherapy. Many joints can be maintained quite successful at this stage. If this is not the case palliative surgery can be considered.

In spite of all our efforts and advancements in the treatment of dogs with ED, affected dogs have a poor long-term prognosis due to osteoarthritis.

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The Etiology of Medial Coronoid Disease.

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Introduction

Medial coronoid disease (MCD) is one of the most frequently diagnosed heritable orthopaedic disorders of dogs and usually affects young, large breed dogs. This disease of the medial coronoid process (MCP) was first called *"ununited medial coronoid process"* of the canine elbow joint and was described as the presence of an ossified bone loosely attached to the MCP of the ulna (Tirgari, 1974). In later years, it became known as *"fragmented medial coronoid process (FMCP)"*. The term "medial coronoid disease (MCD)" was introduced in 2008 as being a more representative term for FMCP, as it encompasses lesions of both articular cartilage and subchondral bone (Moores *et al.*, 2008; Fitzpatrick *et al.,* 2009). Despite of the extensive research, the etiology of MCD remains uncertain. Different theories regarding the etiology of MCD have been postulated.

Etiology of MCD

Although MCD has been recognized as a heritable disease for more than 30 years, its mode of inheritance is still unclear. The disease is suggested to have a multifactorial and polygenic origin (Guthrie and Pidduck, 1990). Salg *et al.* (2006) hypothesized that the disturbance of one or more collagen genes in an indirect manner (disturbance in expression or alteration in post-translational modification) may cause MCD. The causative genes have not yet been identified and more disease- and breed-specific research is recommended.

MCD was also believed to be caused by osteochondrosis (OC), which is defined as a focal disturbance of endochondral ossification of articular cartilage in growing animals (Olsson, 1981). The presence of retained cartilage is thought to serve as a weak starting point for fissures to develop in the articular cartilage layer. The occurrence of osteochondrotic lesions has been associated with chondronecrosis, caused by a failure of blood supply to growing cartilage.

In the 1990s and 2000s, results from histological studies were more supportive of MCD to be caused by abnormalities of the underlying subchondral bone. Danielson *et al.* (2006) reported the size of fatigue microcracks increased by an increase of disease severity and damage being more severe at the fragmented site than at the rest of the bone. The loss of osteocytes with more pronounced osteoporosis of the fragmented MCP has also been reported. Later studies with dual-energy x-ray absorptiometry (DEXA) showed the mean bone mineral density of the MCP to be lower in MCD-positive animals than in controls. In both groups, bone mineral density was 50% lower at the axial border of the MCP than at the abaxial border. This suggests that the abaxial border might be more resistant to compressive loading than the axial border, and that this difference might predisposes the axial border of the MCP to develop microcracks.

The opposite, i.e. an increase in bone density at the MCP and ulnar trochlear notch, was also suggested to contribute to the development of MCD (Smith *et al*., 2009). Subtrochlear notch sclerosis (STS), which is characterized by increased radiopacity adjacent to the ulnar trochlear notch and caudal to the coronoid

process, is an important indicator in diagnosing MCD radiographically. Although there is evidence that there is a relationship between STS and MCD, it is still debated whether STS is the cause of MCD or the result of secondary degenerative changes. It was postulated as a cause of MCD with the explanation that increased stiffness of subchondral bone would cause the overlying articular cartilage layer to become more vulnerable to injury.

Another postulated important cause of MCD was abnormal mechanical loading, which might be due to changes in joint alignment and spaces that result in radioulnar incongruence (RUI) because of a disparity in the length of the radius and ulna, underdevelopment of the ulnar trochlear notch, or physiological incongruity during loading. Although RUI in conjunction with MCD is typical finding in Bernese Mountain dogs (in 50% of the cases of ED; Lavrijsen *et al*., 2012), RUI has been reported in Labrador retrievers in a much lower frequency. Labrador retrievers with MCD are believed not to have significant RUI at the medial coronoid region at the time of diagnosis. Other possible causes or factors contributing to MCD development include changes in the magnitude and topographic distribution of loading, pressure or forces within the joint, such as tensile forces originating from the annular ligament, and shear stress between the contact area of the proximal radial head and the axial border of the MCP during pronation and supination. It has been suggested that biceps brachii/brachialis muscle complex in relation to the bony anatomy might lead to rotational instability, and give rise to shear planes between the radial head and the radial incisure of the MCP. This may result in micro-damage or even fragmentation of the MCP.

Several studies have investigated the role of the shape of the MCP, trochlear notch, and the articular contact areas in the development of MCD. Compared between the different breeds, there is high variability between growth in the length and width of the MCP. Large breed dogs are believed to have a less pronounced growth in length of the MCP in comparison to the width of the MCP during growth of the elbow joint, resulting in a more obtuse shape of the MCP in comparison with small breed dogs. Hence, loading and forces acting on the MCP might be larger in large breed dogs than expected. A difference in the rate of ossification between small and large breed dogs is suggested to predispose large breed dogs to MCD: ossification of the MCP is completed significantly earlier in small breed dogs than in large breed dogs, and slow maturation of the MCP is believed to be a cause of MCD in larger dogs.

In one of the studies following the development of incipient MCD (Lau *et al*., 2013) by using radiograph and computed radiography, the histological results showed that MCD in Labrador retrievers is most likely the product of delayed endochondral ossification at the lateral aspect of the MCP at the level of the base of the MCP, with focus on the delay in calcification of the calcifying zone without concurrent abnormalities in the superficial layers of the joint cartilage. The persistence of retained cartilage provides a weak point at the cartilage-bone interface, where biomechanical forces may initiate cleft formation. In the same study also, there was no evidence of STS found radiographically in the MCD positive dogs. This suggests that STS develops in an advanced stage of MCD and should be regarded as secondary changes. In addition, other environmental factors such as nutrition, exercise, and microtrauma cannot be ruled out as playing a role in MCD development and this has yet to be investigated.

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Genetic Backround of Elbow Dysplasia

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Elbow dysplasia (ED) is a skeletal disease that can present as one or several manifestations including; fragmented medial coronoid process (FCP) of the ulna, osteochondritis dissecans (OCD) of the humeral condyle, ununited anconeal process (UAP), and incongruity of the elbow joint (INC). It is a complexly inherited disorder, indicating the involvement of multiple genes as well as environmental factors. Environmental variables can include dietary load and degree of activity/mechanical stress.

PATHOGENETIC FACTORS

To understand the genetic background of elbow dysplasia, we have to consider how different genetic factors can contribute to its development. Genetic factors that have been proposed include those controlling endochondrial ossification, inherited factors affecting differential growth rates of the three bones of the elbow joint, and liability genes for osteoarthritis. Each individual dog, familial cluster, and breed may have a different mix of genes responsible for the phenotypic expression of ED.

FCP is the most common presentation of ED. Specific incongruities dictate the location of fragmentation, or presentation of UAP. These include; short radius/long ulna, long radius/short ulna, humeroulnar incongruity, and radioulnar incisure incongruity. Each of these occur due to differences in bone growth rate or growth plate closure. While the OCD lesions seen in ED have been considered and evaluated for primary cartilage disease, many researchers feel that they occur in the specific areas identified due to secondary contact damage, or “kissing lesions”.

The different lesions of FCP and UAP vary between breeds, as well as between familial clusters within breeds. Ubbink et al. (1999) found different familial influences in Bernese Mountain Dogs between FCP and INC. However the specific lesions of FCP were not identified to more accurately represent different causative genotypes. Genomic studies of genes controlling collagen and cartilage formation have not been found to correlate to the development of ED. To date, specific genes affecting differential bone growth or growth plate closure have not been found.

When the frequency of ED is examined between large and small varieties of the same breeds, it is seen with greater frequency in larger varieties than in smaller or miniature varieties. The genetic components of ED may be similarly inherited between these varieties, but without the weight/stress component the pathological lesions may not form. In some breeds, there is an increased frequency of ED in male dogs that appears to be correlated to their increased body size. Some studies show a correlation between the development of ED and hip dysplasia (HD), and some do not. However it is recognized that both ED and poorer hip conformation can occur more frequently in heavily boned individuals.

HERITABILITY & PENETRANCE

Heritability (h^2) is the phenotypic variation cause by the genotype divided by the total phenotypic variation (the sum of the variation caused by genotype plus the

variation caused by environment). It is described as the percentage of variation, ex) 17% heritable. A completely penetrant monogenetic disorder would be 100% heritable. A higher heritability translates to a greater phenotypic response to selection.
As the computed heritability is directly related to the environmental variation, heritability estimates for genetic disorders will vary between studied populations. A heritability estimate is specific only for that population. The increased the environmental variability that is present, the lower the heritability estimate. Controlling environmental variability produces a higher heritability estimate and perceived inheritance of the disorder.
Published heritability estimates for ED range from 17% to 77%, however most studies show a heritability of 18% to 21%. This makes elbow dysplasia a moderately heritable disorder, comparable to other complexly inherited traits such as canine hip dysplasia, egg production in poultry, and milk production in cattle. Proper selection against elbow dysplasia should result in a reduction of the frequency of affected dogs.
Penetrance is a measure of the percentage of phenotypic expression of a certain genotype. A monogenetic trait that is always expressed is completely penetrant. Most issues of incomplete penetrance have to do with complexly inherited traits where multiple genes must combine to either cross a threshold (qualitative genes) or trigger expression (qualitative genes). Therefore, statements of incomplete penetrance for complexly inherited disease should be more accurately described as the carrying of a genetic load of disease liability genes rather than being genetically affected with incomplete penetrance.

SELECTION BASED ON PHENOTYPE

Evaluation of phenotypically normal breeding stock based on a single elbow radiograph under represents the percentage of dog affected with ED. The IEWG recommends multiple views of the elbow for phenotypical diagnosis, and MRI of the elbow is shown to be the most superior imaging modality for ED. The older the age of the dog at imaging, the greater the expression of osteoarthritis secondary to ED.
An important issue with the phenotypical diagnosis of ED is that dogs with Grade I ED have not uniformly been selected against. These dogs rarely show clinical signs of morbidity due to the disorder, but have clearly identifiable radiographic changes. The OFA has shown that having one parent with Grade I ED bred to a normal parent produces twice as much ED (23%) than when two normal parents are used. Whenever a dog with Grade II or III ED is identified, screening of first degree relatives often finds dogs with Grade I ED. Grade I ED is evidence of an accumulation of ED liability genes. Due to this, the BVA/KC has now changed its recommendations to only breed from two parents with radiographically normal elbows.

USING FAMILIAL DATA FOR SELECTION

Complexly inherited disorders show a greater response to selection when it is based on familial data. OFA vertical pedigrees offer a graphical view of depth and breadth of elbow ratings in the pedigree. Familial data can also be computed as estimated breeding values (EBVs), based on the phenotype of the parents, siblings, siblings of parents, offspring, and other relatives. By utilizing phenotypical

depth and breadth of pedigree, EBVs utilize information that can more accurately reflect the cumulative genetic influences passed down to the individual dog.
Lewis et al. (2013) computed EBVs for elbow dysplasia on several high registration breeds in the UK Kennel Club registry. They found that the use of EBVs could increase the selection for normal elbows more than 10 fold versus selection based on a single dog's phenotype.
An issue with the accuracy of calculating EBVs involves dogs with missing phenotypes – as most breeds have less than 10% of breeding dogs or their siblings evaluated. In an applied setting, dogs with high EBVs may also become popular sires thus putting pressures on gene pools that can affect genetic diversity.
Genomic breeding values (GBVs) are computed based on the identification of liability genes or quantitative trait loci (QTLs) statistically associated with the disease phenotype. Pfahler and Distl (2012) identified several genetic markers associated with ED in Bernese Mountain Dogs that could be used as a genomic screening panel. However, their work on hip dysplasia has identified genetic liability markers in German Shepherd Dogs and Bernese Mountain Dogs that are different and not shared between the breeds. This shows that genetic marker based association is specific to the population being studied, and may not reflect genetic liability in a larger or different population.
GBVs and EBVs are continually being improved and enhanced, and will undoubtedly be important in the future control of complexly inherited disorders such as ED. In the meantime, selection based on the best available phenotypical imaging and incorporating familial breadth and depth of pedigree data should improve the elbow status of individual dogs and thus their breeds.

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Explanation of grading according to IEWG and discussion of cases.

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The diagnosis of canine elbow dysplasia (ED) in screening programs is based on the evaluation of radiographs according to the protocol of the **International Elbow Working Group (IEWG)**. The most recent update of this protocol is available on the IEWG web site (*http://www.iewg-vet.org*). A mediolateral flexed projection of each elbow joint is mandatory for interpretation and an additional craniocaudal pronated view is highly recommended. The IEWG protocol allows for both registration of **arthrosis** and the presence of the major forms of **primary lesions**: FCP, OCD, UAP, INCONGRUITY. Radiographs are evaluated in a two-tiered procedure: joints are evaluated and graded according to the presence of arthrotic changes first and assessed for signs of a primary lesion in a second step. Any other abnormal finding should be reported too.

Arthrosis scores are assigned as **normal** (Grade 0) in the absence of arthrotic lesions or according to the height of osteophytes as either **mild** (Grade 1, osteophytes less than 2 mm in height), **moderate** (Grade 2, osteophytes 2 – 5 mm) or **severe** (Grade 3, osteophytes higher than 5 mm). In the updated protocol the severity of joint incongruity has been included.
The primary lesions **FCP, OCD, UAP, INCONGRUITY** have been defined by the IEWG (for details see the table below and IEWG website).

Scoring (last updated 2010)

The elbow findings are scored according to the severity of the arthrosis (DJD) **and/or** the presence of a primary lesion

Elbow Dysplasia Scoring		**Radiographic Findings**
0	Normal elbow joint	Normal elbow joint, No evidence of incongruity, sclerosis or arthrosis
1	Mild arthrosis	Presence of osteophytes < 2 mm, sclerosis of the base of the coronoid processes - trabecular pattern still visible
2	Moderate arthrosis or suspect primary lesion	Presence of osteophytes 2 - 5 mm Obvious sclerosis (no trabecular pattern) of the base of the coronoid processes Step of 3-5 mm between radius and ulna (INCONGRUITY) Indirect signs for other primary lesion (UAP,

		FCP/Coronoid disease, OCD)
3	Severe arthrosis or evident primary lesion	Presence of osteophytes > 5 mm Step of > 5 mm between radius and ulna (obvious INCONGRUITY) Obvious presence of a primary lesion (UAP, FCP, OCD)

A Borderline (BL) score between ED 0 and ED 1 is allotted to dogs with minimal anconeal process modelling of undetermined aetiology in some countries (i. g. Germany, France, Italy).

ED scoring based on the combination of arthrotic changes and presence of primary lesions is used non-uniformly throughout Europe and overseas. In Scandinavia, UK and USA/Canada for example classification is based on the degree of arthrosis mainly, whereas the UAP is the only primary lesion recorded.

Radiographic views

The minimal requirement for elbow joint scoring is a true ML projection of each elbow.
As has been reported before two ML-projections, a flexed (30°-40°) and a neutral (100° - 120°) position provide the best information regarding the medial coronoid process, incongruity, and presence of osteophytes. With high image quality even OC lesions may be recognized on ML views with reasonable consistency. With modest image quality many OC lesions go undetetected on ML views. The by far best view to highlight medial trochlear OC lesions is the Cr Cd 15° pronated projecion. Protocols lacking this view – as conducted in many European countries - approve the flaw of missing potential OC lesions depending on image quality.

Conclusion

The IEWG scoring system is a two-tiered procedure, a) assessing the degree of arthrosis and b) registering any signs indicative of a primary lesion of ED. Bear in mind that various countries in Europe and overseas only rely on step a). Both concepts have proven to be useful in reducing ED in a population. However problems arise when dogs are to be used for breeding in countries with differing scoring system. In such a case it is advised to re-score the dog again according to the local scoring mode. It will be the aim of IEWG to harmonize the scoring systems in the future.

International Elbow Working Group

The International Elbow Working Group [IEWG] was founded in 1989 by a small group of canine elbow experts from the USA and Europe to provide for dissemination of elbow information and to develop a protocol for screening that would be acceptable to the international scientific community and breeders.
The annual meeting is organized for the purpose of exchanging information and reviewing the Protocol. All interested persons are invited to attend the meeting and to participate in its activities.
The IEWG is an affiliate of the WSAVA.

IEWG meetings were held in

Davis	1989
San Francisco	1990
Vienna	1991
Rome	1992
Berlin	1993
Philadelphia	1994
Konstanz	1995
Jeruzalem [cancelled]	1996
Birmingham	1997
Bologna	1998
Orlando	1999
Amsterdam	2000
Vancouver	2001
Granada	2002
Estoril	2003
Bangkok	2003
Rhodes	2004
Amsterdam	2005
Mexico	2005
Munich	2005
Prague	2006
Munich	2007
Dublin	2008
Sao Paulo	2009
Bologna	2010
Amsterdam	2011
Birmingham	2012
Cape Town	2014
Bangkok	2015

IEWG 2015

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