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Use of Ultrasonography in Diagnosis of Medial Compartment Disease of the Elbow in Dogs

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Abstract

Objective The objective of this prospective study was to evaluate the use of ultrasonography in the diagnosis of medial coronoid process disease in unclear cases.

Study Design Fifteen elbows (on thirteen dogs) for which radiography and computed tomography did not lead to a clear diagnosis of medial coronoid process disease were included. On each elbow, ultrasonography was performed with a high frequency linear transducer (12–18Hz). Then, arthroscopic examination of the joint was performed by a surgeon who was unaware of ultrasonographic findings to confirm medial coronoid process disease.

Results At least one ultrasonographic lesion was detected in 13 out of 15 elbows. The main reported ultrasonographic lesions were joint effusion (10/15 elbows) and an abnormal shape of the medial coronoid process (irregular, ill-defined or fragmented) (9/15).

Conclusion Ultrasonography can be a helpful additional diagnostic tool to confirm medial coronoid process disease of the elbow joint before performing arthroscopy in unclear cases. Further studies will be needed to evaluate the use of higher frequency transducers and determine if it could improve the diagnostic value of ultrasonography.

Keywords
- arthroscopy
- dog
- ultrasonography
- elbow dysplasia
- coronoid process

Introduction

Ultrasonography is a non-invasive diagnostic technique relatively uncommon in cats and dogs to diagnose osteoarticular diseases. However, it is more commonly used in humans and horses to investigate joint disorders.[1–4] In dogs, even if it can have indications in the stifle joint and the shoulder, very few studies were reported in elbows.[5–8]

Medial coronoid process disease of the elbow is frequent in large and giant-breed dogs and is represented by different stages of lesions on the medial coronoid process including chondromalacia, fissures, fragments and cartilage erosion. Diagnosis may be difficult because of limited clinical or radiographic signs or a combination of both.[9] Thus, diagnosis based on radiography and computed tomography (CT) can be challenging when the medial coronoid process is not displaced or only fissured, and when few osteoarthritic lesions are present.[5,10,11] Radiography and CT scan have a reported sensitivity of 56.7 and 86.7% to detect a medial coronoid process disease respectively.[12,13] Moreover, neither radiography nor CT scan can directly identify cartilage erosion.[14] Arthroscopy allows the direct observation of primary elbow dysplasia lesions as well as evaluation of articular surfaces. Arthroscopic evaluation of the joint is therefore still considered the gold standard for clinical evaluation of cartilage lesions and more generally for the diagnosis of medial

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coronoid process disease that can be purely cartilaginous in early stages.[8,14]

The first description of ultrasonographic anatomy of the elbow was only made in 2005 in dogs and precise correlation between anatomic sections and ultrasonographic images has been reported.[15,16] In 2009, Seyrek-Intas and colleagues made the unique study assessing the accuracy of ultrasonography in detecting fragmentation of the medial coronoid process in dogs.[5] This study revealed that only 55% of free fragments and 9% of nondisplaced fragments were detected using ultrasonography. These authors concluded that ultrasonography was of limited diagnostic value in detecting fragmentation or fissuring of medial coronoid process in dogs.[5] However, this study mainly reported the identification of fragments which are not always present. Thus, we believe that availability of higher frequency transducer may improve the diagnostic value and usefulness of ultrasonography in medial compartment disease especially in dogs with few radiographic and CT abnormalities.

The purpose of this prospective clinical study was to determine if ultrasonography could complement radiographic and CT imaging techniques to confirm medial coronoid process disease in dogs with a challenging diagnosis.

Materials and Methods

Inclusion Criteria

This clinical study was performed prospectively, between November 2016 and January 2021 (Vetagro Sup, Marcy l'Etoile, France). All owners gave full consent for inclusion in the study. Each dog was presented for the complaint of unilateral or bilateral thoracic limb lameness. History was recorded and full clinical and orthopaedic examinations were performed by the same surgeon (TC, board-certified surgeon). For each elbow, lameness duration, lameness score at a walk and at a trot (from 0 (no lameness) to 5 (continuous non-weight-bearing lameness)), elbow palpation (joint effusion, pain upon palpation, pain during hyperflexion and/or hyperextension, decreased range of motion, crepitus) and Campbell test (internal and external carpal rotation) were appreciated. An exhaustive grid was completed for each elbow and all data were recorded in a computer database (4D Clovis, ►**Supplementary Table S1**, available in the online version). Each elbow included in this study was suspected of having a medial coronoid process disease based on these data. For each dog, three radiographic views, a CT scan and a complete ultrasonographic examination of both elbows were obtained. Elbows were systematically examined with ultrasonography, and all of the anatomic structures were appreciated. Then, elbows were explored through arthroscopy to confirm the medial coronoid process disease and to provide surgical treatment. To meet the inclusion criteria, no lesion or only minor lesions that did not allow for definitive diagnosis of medial coronoid process disease (ulnar subtrochlear sclerosis or medial coronoid process lucency) must have been detected on radiography and CT scan. Definitive inclusion was made when arthroscopy confirmed a medial coronoid process disease. Elbows with clear lesions of the medial compartment using radiography, CT scan or a combination of both modalities were excluded.

Radiography and Computed Tomography

Under sedation, three radiographic views (craniolateral-caudomedial oblique, 45 degrees flexed mediolateral and extended 15 degrees supinated mediolateral) were made for each elbow with clinical suspicion of medial coronoid process disease, as recommended by the International Elbow Working Group for the screening protocol to detect elbow dysplasia.[17,18] Lesions of osteochondritis dissecans, medial compartment disease, elbow incongruency (humeroradial, humeroulnar), ununited anconeal process, joint effusion, periarticular tumefaction, osteophytes and their description, ulnar subtrochlear sclerosis and measurement of its percentage and eventual kissing lesions (medial humeral sclerosis, subchondral bone flattening or irregularity) were investigated. The subtrochlear sclerosis percentage was measured in the mediolateral view in flexion, as described in the literature.[19,20] Every visible lesion was noted in an exhaustive grid for each elbow (►**Supplementary Table S2**, available in the online version).

A CT examination was performed after the radiographs under general anaesthesia, using a General Electric Brightspeed Elite 16-slice helical CT scanner, with 120 kV and 150 mA parameters. Entire thoracic limbs including the shoulder and carpal joints were systematically examined to eliminate other pathology that could explain the lameness. Transverse images with 0.625 mm and 1.25 mm slice thickness were obtained of the elbow and shoulder. Medial coronoid process fragmentation, fissure, sclerosis or lucency, subchondral sclerosis of the ulnar trochlear notch, irregularity of the radial incisures of the ulna, subchondral defect of the medial part of the humeral condyle, subchondral sclerosis of the humeral condyle and humero-radio-ulnar incongruity were investigated. Exhaustive grids were completed for each elbow (►**Supplementary Table S3**, available in the online version).

Two experienced observers judged the radiographic and CT images (MH, imaging specialist and VL, surgeon specialist respectively). When radiography and CT scan showed only minor modifications (subtrochlear sclerosis and/or medial coronoid process lucency) or did not reveal any abnormality, ultrasonography of the elbow was performed.

Elbow Ultrasonography

A high frequency 12 to 18 MHz linear matrix transducer (Aplio 500; Toshiba) was used. After a slight sedation and local clipping, dogs were first positioned in right lateral recumbency to evaluate the lateral part of the left elbow. Gel was applied and no stand-off pad was necessary. Triceps muscle tendon, anconeal process, lateral humeral epicondyle and lateral collateral ligament were evaluated. Then, the medial part of the right elbow was assessed, with evaluation of medial coronoid process (►**Fig. 1**), medial collateral ligament, medial humeral epicondyle, tendons of the flexor muscles and of the brachial biceps. The medial coronoid process was considered abnormal when it appeared irregular, ill-defined or fragmented. The dog was finally positioned

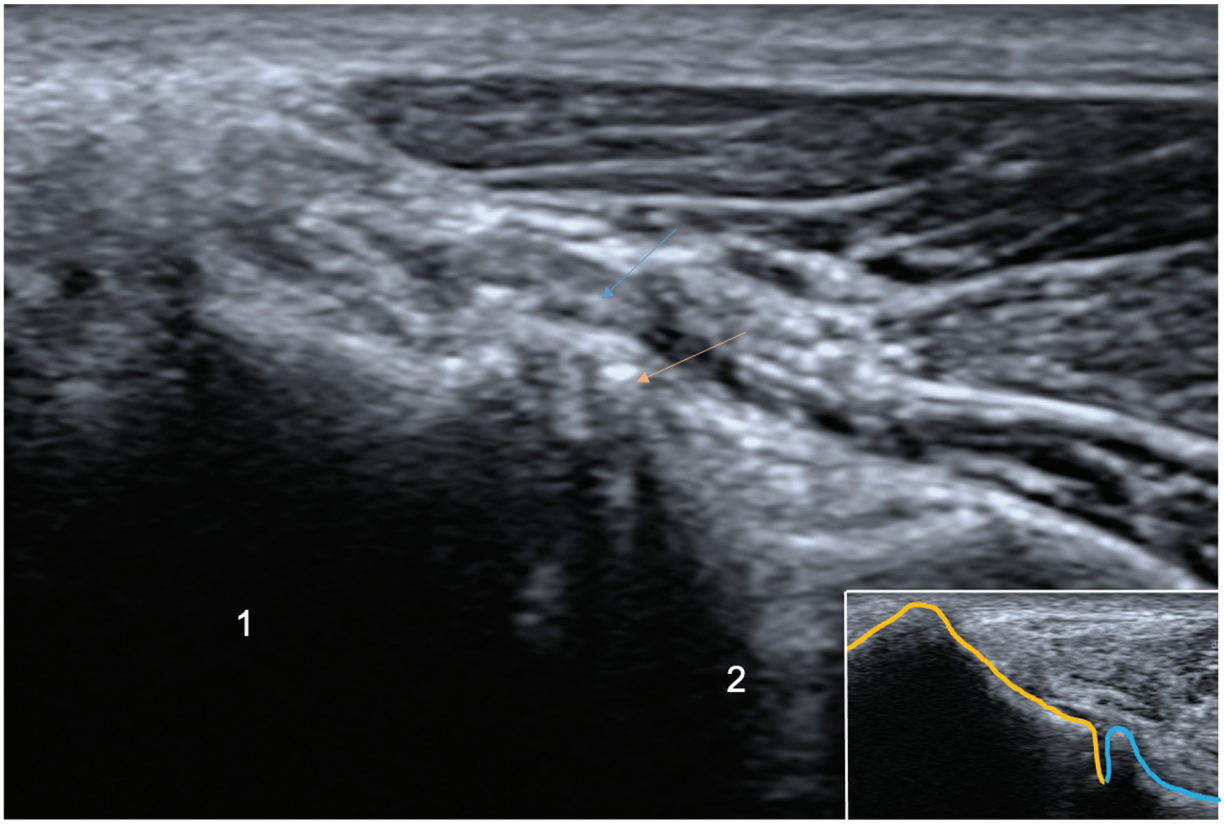

Fig. 1 Ultrasonographic observation of a normal medial coronoid process and medial collateral ligament in longitudinal section. Blue arrow: medial collateral ligament. Orange arrow: medial coronoid process. 1 = Medial humeral epicondyle; 2 = Ulna.

in left recumbency and the same protocol was applied to evaluate the lateral part of the right elbow and medial part of the left elbow.

The same experienced radiologist performed ultrasonography (JS), and was unaware of orthopaedic examinations, radiographic and CT scan results. The systematic protocol defined for the study was followed step by step.[15,16,21] For each elbow, an exhaustive evaluation grid was completed (►**Supplementary Table S4**, available in the online version).

Arthroscopic Evaluation and Treatment of the Elbow Joints

Arthroscopy was used as the gold standard to detect the medial coronoid process disease. All elbows included in this study were treated by arthroscopy within 2 days of the imaging exams, as described by Beale.[22] A 1.9 or 2.4mm short 30-degree oblique arthroscope was used, depending on the size of the dog. The surgeon was unaware of the results of ultrasonographic examinations. An exhaustive grid was also completed by the surgeon, and cartilage evaluation was made based on Outerbridge Classification, with scores ranging from 0 (no cartilaginous lesion) to 5 (eburnation with visibility of subchondral bone)[17] (►**Supplementary Table S5**, available in the online version).

Results

Fifteen elbows met the criteria for inclusion in this study (13 dogs). Eleven out of thirteen dogs were male, the median age was 14 months and the median body weight was 24.6 kg (from 17.6 to 50kg).

There were two Australian Shepherds, two English Bulldogs, two Crossbreeds, one Bernese Mountain dog, one Rottweiler, one Golden Retriever, one Malinois, one Staffordshire Bull Terrier, one Anatolian Shepherd and one Boxer. The median lameness duration was 3 months (range: from 1 to 8 months). Three dogs out of thirteen had bilateral lameness (3/13).

Orthopaedic Examination

Positive Campbell test was the most frequent clinical finding (14/15) (14 out of 15 on external carpal rotation, 12 out of 15 on internal carpal rotation). Pain was noted in elbow hyperextension in 8/15 elbows, and in hyperflexion in 3/15 elbows. Forelimb lameness was noted at a walk, trot or both, in 14/15 thoracic limbs.

Radiography

Subtrochlear sclerosis in the mediolateral view in flexion was visible in 7/15 elbow joints, and was the only abnormality that could be found on radiography. The median subtrochlear sclerosis percentage was 42.1% (28–53.3%).[19,20]

Computed Tomography

The only lesions were subtrochlear sclerosis in 6/15 elbows, and medial coronoid process lucency in 7/15 elbows. Six out of fifteen elbows did not reveal any abnormality.

Ultrasonography

Ultrasonographic examination of both elbows took between 15 and 20 minutes.

Abnormal medial coronoid process was noted in 9/15 elbows (irregular (7/9), ill-defined (1/9), fragmented (1/9)) and joint effusion between the medial coronoid process and the medial humeral epicondyle in 10/15 elbows. Irregularity of the medial humeral epicondyle was noted in 2/15 elbows, and a focal hypoechoic lesion on flexor muscles tendons in 1/15 elbow. Based on these results, two main lesions were frequently noticed, a structural abnormality of the medial coronoid process and joint effusion around it. In 13/15 elbows, at least one of these two lesions was present.

When only a minor joint effusion was present in the medial compartment, it was noticed that it usually creates a slight hypo- or anechoic area between the medial coronoid process and the medial humeral epicondyle (►**Fig. 2**). When abnormality of the medial coronoid process was associated with more severe joint effusion, joint effusion was surrounding the medial coronoid process (►**Fig. 3**).

Arthroscopy

According to Outerbridge Classification on the fifteen studied medial coronoid process cartilage, the Outerbridge scores were one (8/15), two (4/15) and three (3/15).[16] Regarding the humeral condyle, only one elbow presented a score different to 0, with moderate chondromalacia (score = 1). Regarding the humeral trochlea, all elbows had a score equal to 0. On the radial head, only one dog had a score different to 0, bilaterally, with scores equal to 2 and 3 on the right and left elbows respectively. Thirteen out of fifteen elbows had a medial coronoid process fissuring, and not a real fragmentation with a free fragment. In eight elbows, surgical treatment consisted in curettage of the abnormal cartilage until the exposure of normal subchondral bone, and eventual fragment removal. In the remaining elbows (7/15), a subtotal coronoid ostectomy was performed.

Discussion

Results of the present study revealed that joint effusion was more frequently found by ultrasonography (10/15), than subtrochlear sclerosis in radiography (7/15) or CT (6/15). Abnormal medial coronoid process was also more frequently seen by ultrasonography (9/15), than by radiography (0/14) or CT (7/15). In all elbows, at least one lesion (subtrochlear sclerosis, joint effusion, or medial coronoid process abnormality) was noticed with at least one imaging technique (radiography, CT scan or ultrasonography) (15/15). In eleven elbows (11/15), at least two lesions were noticed in the medial compartment, and at least three lesions were seen in five elbows (5/15). On the fifteen diseased elbows included in this study, seven and six had not any lesion on radiography and CT scan respectively. Using ultrasonography, joint

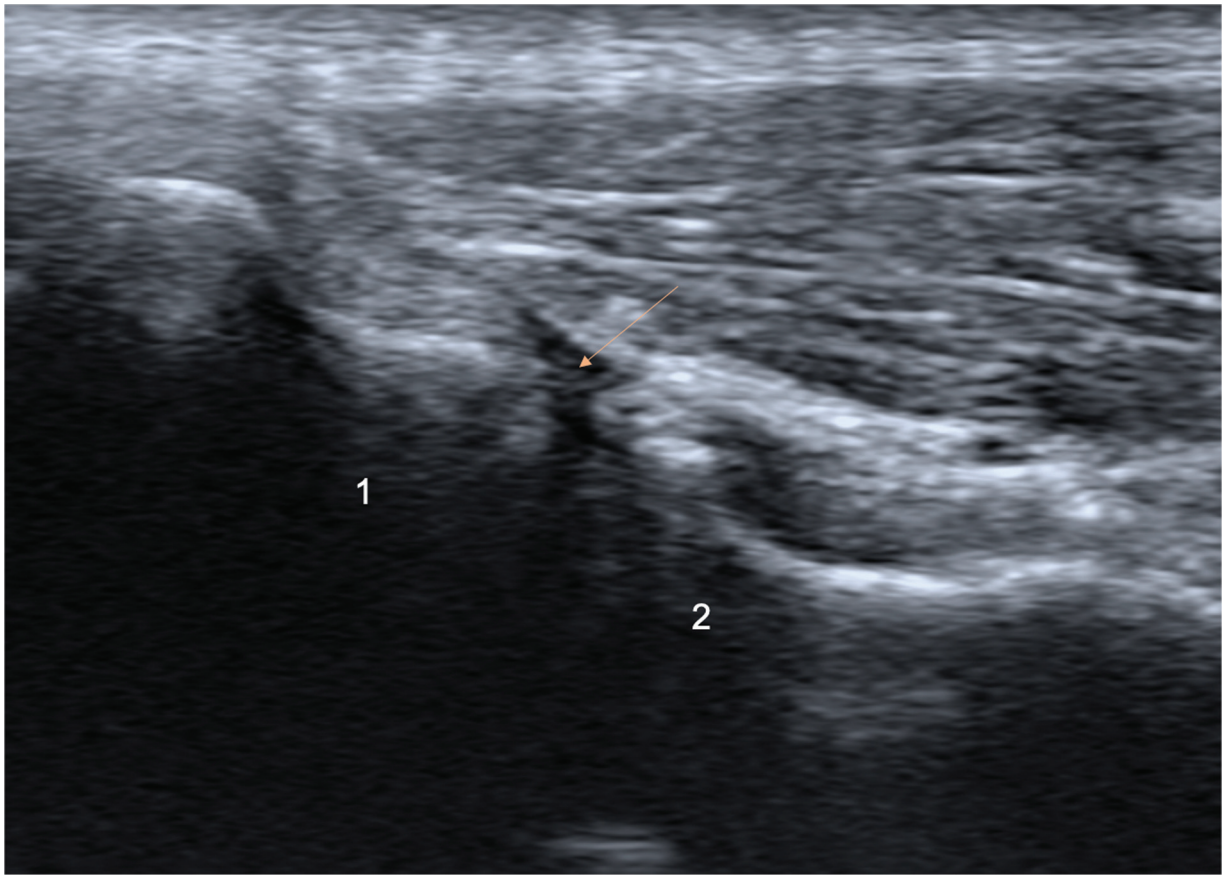

Fig. 2 Slight joint effusion in a dog with an early stage of medial compartment disease. Orange arrow: joint effusion. 1 = Medial humeral epicondyle; 2 = Ulna.

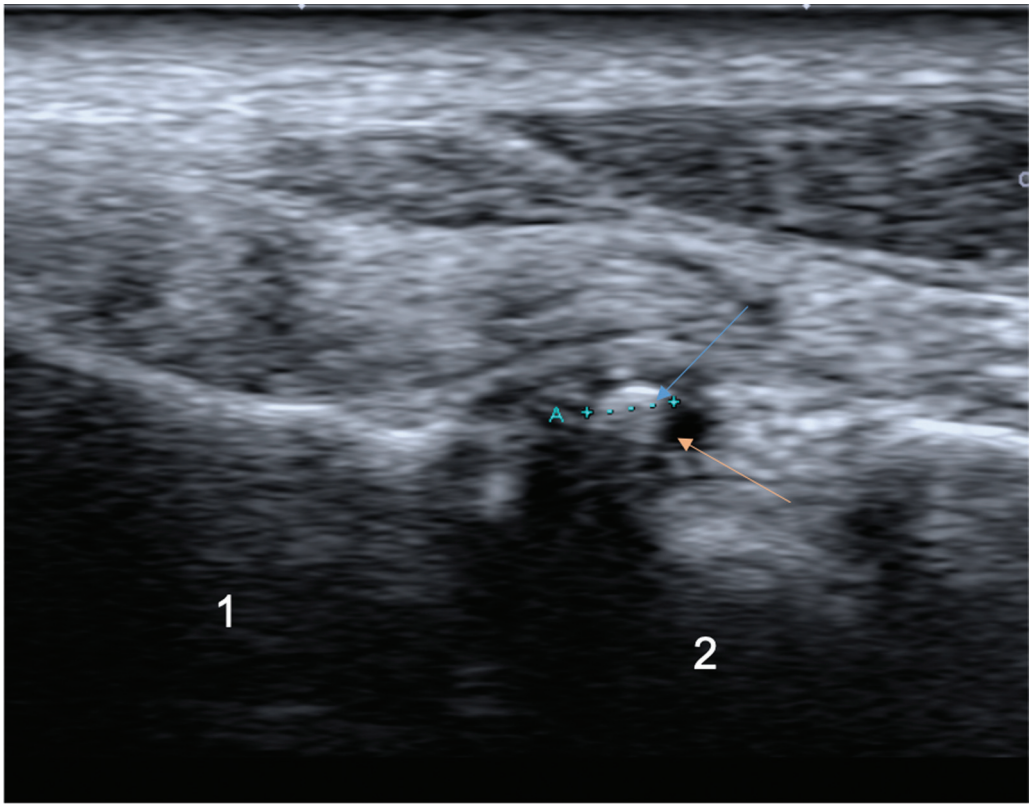

Fig. 3 Severe joint effusion in a dog with irregular medial coronoid process. Note that in this case, X-rays and computed tomography scanning were normal, while arthroscopy revealed a medial coronoid process fissuring. Blue arrow: Tip of the medial coronoid process. Orange arrow: Joint effusion surrounding the tip of the medial coronoid process. 1 = Medial humeral epicondyle; 2 = Ulna.

effusion surrounding the medial coronoid process and shape abnormality of the medial coronoid process were the two most frequently observed lesions. In thirteen of the studied elbows (13/15), at least one of these two lesions were noticed. Included diseased elbows usually had a medial coronoid process fissuring, and not a real fragmentation (13/15). Based on those results, ultrasonography may have value in early diagnosis on elbows with medial coronoid process fissuring, on which radiography and CT scan are less sensitive, especially when fissuring is purely cartilaginous.[14]

Medial coronoid process disease is a degenerative disease, and diagnosis is usually made between 6 and 18 months in dogs.[17] The challenge is to establish an early diagnosis to prevent inevitable osteoarthritis.[11,23,24] As cartilaginous lesions are not visible using radiographic and CT imaging, these modalities sometimes do not allow identification of medial coronoid process fissuring. In those cases, only late secondary changes such as subtrochlear sclerosis and osteophytosis are noticeable.[14,23] Medial coronoid process fragmentation can appear with high variability using CT scan, depending on imaging planes and imaging windows used, and diagnostic certainty for medial coronoid process fissuring is considered low.[25] Its accessibility may also be limited in general practice, and in a recent study, inter-observer agreement to detect changes consistent with medial coronoid process disease was estimated fair to moderate, and poor for sclerosis grading.[26] As shown in this study, Campbell test has a good sensitivity. Thereby, the clinician usually has a strong clinical suspicion of medial coronoid process disease, but the disease can be in an early stage with only minor lesion on classic imaging techniques. Hypothetically, ultrasonography might detect lesions like joint effusion with more precocity.

In humans, ultrasound can detect the early stages of inflammation within the soft tissues.[27] Superficial cartilage and osseous lesions may be seen before they are apparent on radiographs.[28] It is commonly used to detect soft tissues abnormalities on the elbow, superficial osteoarticular lesions and joint effusion.[2–4,29] In dogs, ultrasonography has already been proposed for the detection of subtle changes in soft structures in joints.[30] Ramírez-Flores and colleagues revealed that in the stifle joint, ultrasonography was the most beneficial non-invasive diagnostic technique in evaluating the joint's integral health and providing evidence of osteoarthritis-related injuries. Ultrasonography was then proposed as a complement to radiograph examination in the stifle joint to help demonstrate the changes that occur in soft tissues before osteoarthritis is too advanced and the disease more complicated to manage. They suggested conducting similar studies on different joints to determine if ultrasonography can routinely be used as an early osteoarthritis evaluator and diagnostic tool.[30]

Ultrasonography has several limitations. It is known to have a poor sensitivity to detect cartilaginous lesions, which is in accordance with our results (no visible cartilaginous lesion on ultrasonography).[5,31] It only allows visibility of the

cortical surface of the bone and not the subchondral bone. Yet, latest publications revealed that accumulation of fatigue microdamage in the medial coronoid process with microcracks on subchondral trabecular bone has an importance on medial compartment disease development.[11] Only Seyrek-Intas and colleagues evaluated the accuracy of ultrasonography in detecting fragmentation of the medial coronoid process.[5] They revealed that its accuracy was 77%, sensitivity was 80%, specificity was 17%, positive predictive value was 94% and negative predictive value was 5%.[5] In their study, no statistical agreement was found between ultrasonographic and intraoperative findings. They concluded that ultrasonography was of limited value in detecting medial coronoid process fragmentation in dogs.[5] However, they detected secondary lesions in 86% (96/112) of elbows, with joint effusion in 45% of elbows, while we found joint effusion in 67% of elbows (10/15).[5] The difference can be explained by the transducer we used, which has a higher frequency (12–18 MHz compared with a 8–12 MHz transducer in their study).[5] They also positioned the probe in a transverse section to evaluate the medial coronoid process, as we preferred a longitudinal section, as described in the literature.[21,32] As only unclear elbows were selected in our study, this percentage could intuitively have been even higher.

Our study has several limitations. Only one clinician performed ultrasonographic examinations. As joint effusion is potentially a subjective parameter, an interobserver study would have been interesting. As few elbows were included, additional research is required to refine the value of ultrasonography and to precisely establish its sensitivity, specificity, positive predictive value and negative predictive value. In this study, ultrasonography was performed with a 12 to 18 MHz transducer. The use of a higher frequency transducer or a Hockey Stick linear transducer might have increased the sensibility of ultrasonographic diagnosis. Indeed, quality of ultrasonography is constantly and quickly improving with development of very high frequency transducers (40 MHz) to improve cartilage evaluation, which is encouraging for the investigation of the value of ultrasonography in the diagnosis of medial compartment disease in the future.[33]

Finally, structural abnormality of the medial coronoid process and focal joint effusion were the two main lesions to investigate by ultrasonography when a medial coronoid process disease was suspected. Results confirmed that ultrasonography can add complementary information in cases with doubtful results on radiography and CT. These findings support the assumption that a presumptive diagnosis of medial coronoid process disease can be made when evidence of abnormality of the medial coronoid process and/or joint effusion is seen on ultrasonography. Results suggested that ultrasonography could bring complementary information when radiographic and/or CT examinations do not reveal clear lesion of the joint, to strengthen a clinical suspicion of medial coronoid process disease before eventual arthroscopic exploration. A standardized ultrasonographic protocol using a 12 to 18 MHz linear transducer provides a reliable means of assessing adjacent soft tissues of the elbow and medial compartment, but not the articular cartilage.

Authors' Contribustions
All authors contributed to conception of the study, study design and/or acquisition of data. M.J. primarily drafted, revised and approved the submitted manuscript. All authors revised and approved the submitted manuscript.

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Conflict of Interest
None declared.

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