Computed tomography of the elbow joint in clinically normal dogs

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Objective—To use computed tomography (CT) to provide a detailed description of elbow joint structures in clinically normal dogs.

Animals—Six clinically normal adult mixed-breed dogs weighing 24 to 37 kg and one 12-month-old Labrador Retriever weighing 27 kg.

Procedure—To perform CT of both elbow regions, dogs were anesthetized and placed in lateral recumbency. One- and 2-mm contiguous slices were obtained by use of a third generation computed tomographic scanner. Good resolution and anatomic detail were acquired from the computed tomographic images by use of a bone (window width, 3,500 Hounsfield units; window level, 500 Hounsfield units) and soft-tissue setting (window width, 400 Hounsfield units; window level, 66 Hounsfield units). After euthanasia, the forelimbs from the Labrador Retriever were removed and frozen in water at -18°C. Elbow joints were sectioned into approximately 1-mm-thick slab sections by use of an electric planer. Anatomic sections were photographed and compared with the corresponding computed tomographic images. Computed tomographic reconstructions of the elbow joint were created in sagittal and dorsal planes.

Results—Structures on the computed tomographic images were matched with structures in the corresponding anatomic sections. The entire humeroradial joint surface could be evaluated on the reconstructed images in the sagittal and dorsal plane.

Conclusions and Clinical Relevance—Computed tomographic images provide full anatomic detail of the bony structures of the elbow joint in dogs. Muscles, large blood vessels, and nerves can also be evaluated. These results could be used as a basis for evaluation of computed tomographic images of the forelimbs of dogs with elbow joint injuries. (Am J Vet Res 2002;63:1400–1407)

The elbow joint in dogs is a complex and compound joint with the following multiple articulations: the humeroradial joint, the humeroulnar joint, and the radioulnar joint. Although its radiographic anatomy and gross necropsy appearance have been investigated in detail,1-3 the information acquired has limitations, primarily as a result of superimposition of the radial head over the medial coronoid process and the tight fit between the humerus and the trochlear notch of the ulna. Therefore, the radiographic diagnosis of elbow lesions, including medial coronoid process fragmentation and joint incongruity, can be challenging, and an exploratory arthrotomy has been advocated as a reasonable diagnostic option by some authors.4-5 Computed tomography (CT) has a high accuracy for the diagnosis of a fragmented coronoid process (FCP) and associated changes and may be useful when findings on survey radiographs are negative.6-12 The advantages of CT over conventional radiography include the following: depiction of detailed cross-sectional anatomy without distraction from superimposed structures, thereby decreasing the complexity of the image, variation in gray scale formats, and enhanced contrast resolution and computer reconstruction of multiplanar images.13-16

In human medicine, CT is an established diagnostic tool. In humans with osteochondrosis dissecans, intra-articular fragments, complex intra-articular fractures, and subchondral bone sclerosis, CT is useful and expedient for precise diagnosis, and it helps to identify subtle subchondral lucencies and the presence of loose bodies.13-16 The knowledge of the anatomy of the elbow joint on computed tomographic images is necessary to provide accurate interpretation and to describe abnormalities that may be present. The purpose of the study presented here was to provide a detailed description of the elbow joint in clinically normal dogs, as revealed by CT.

Materials and Methods

Animals—Six healthy mature mixed-breed dogs weighing 24 to 37 kg and one 12-month-old Labrador Retriever weighing 27 kg were used for our study. Prior to use in our study, the dogs had their elbow joints physically and radiographically examined. Three radiographic views were obtained as follows: the neutral and flexed mediolateral view of a lateral survey view was made by a third generation computed tomographic scanner in the gantry. Wedge sponges were placed between both joints parallel and extended cranially. The heads of the dogs were positioned on the computed tomographic scanning table with the elbow joints, parallel and extended cranially. The heads of the dogs were pulled back to the lateral side to scan both elbow joints in the gantry. Wedge sponges were placed between both elbow joints to avoid rotation. This position allows a perfect symmetry and comparison of both elbows at the same level. A lateral survey view was made by a third generation computed tomographic scanner to confirm correct positioning. On a craniocaudal survey view, computed tomographic scans were performed from the proximal aspect of the olecranon to 3 cm distal to the elbow joint and parallel to the humeroradial joint space.
Two-millimeter-thick contiguous views were obtained from the most proximal part of the ulna to 3 cm distal to the radial head. However, in the region of the radioulnar joint, 1-mm-thick contiguous views were obtained. Individual images were reviewed by use of a bone setting (window width = 3500 Hounsfield units; window level = 500 Hounsfield units) and a soft-tissue setting (window width = 400 Hounsfield units; window level = 66 Hounsfield units). Settings for the computed tomographic image technique were as follows: 120 kV and 130 mA. Image acquisition time was approximately 10 minutes for each study. Images from all 7 dogs were formatted on x-ray film and evaluated.

Comparison of computed tomographic and anatomic images—All 6 dogs recovered from anesthesia. The Labrador Retriever was euthanatized for reasons not associated to orthopedic conditions. The forelimbs of the Labrador Retriever was euthanatized for reasons not associated to orthopedic conditions. The forelimbs of the Labrador Retriever were removed and frozen at –18°C with the elbow joint capsule also identified (rows E and F). On the soft-tissue setting, computed tomographic images of all these structures and 1 supplementary muscle, namely the cleidobrachialis muscle, were visible. All previously mentioned bony structures could be identified on computed tomographic images at the bone setting (rows A through F).

Bony structures that were visible on the more distal anatomic sections (Fig 2; rows G through J) included the proximal portions of the radius and ulna with the lateral and medial coronoid processes, the radial notch, and the ulnar tuberosity. Compared with the more proximal located anatomic sections, the tendon of the triceps brachii muscle was absent, the brachialis muscle and biceps brachii muscle were disappearing, and 5 additional muscles could be identified. The distal anatomic sections of the elbow joint (rows H through J) revealed the median vein, formed by the anastomosis of the brachial vein and the median cubital vein, and the median artery, which is the continuation of the brachial artery. In addition, the anular ligament of the radius (row H) and the antebrachial intersosseous membrane (row J) were visible. On computed tomographic images at the soft-tissue setting, the same osseous and soft-tissue structures could also be identified, except for the ulnar and median nerve, the anular ligament of the radius, and the antebrachial intersosseous membrane. All bony structures that were seen on the anatomic sections were visible on computed tomographic images at the bone setting.

Sagittal and dorsal reconstructions were made of the right elbow region of a large-breed dog that had been euthanatized for reasons unrelated to forelimb lameness. The identified anatomic sections by comparing all features with a dissected right elbow region of a large-breed dog that had been euthanatized for reasons unrelated to forelimb lameness. The identified structures were subsequently located on the corresponding computed tomographic images (both bone and soft-tissue settings), and afterwards the list of identified structures was evaluated on the computed tomographic images of the 6 other dogs. The nomenclature used for designating all structures was in accordance with official anatomic terms. Computed tomography-based reconstructions of the elbow joint in a sagittal and dorsal plane were made to determine whether an evaluation of the entire joint surface could be performed without superimposition of any bony structures.

**Results**

Ten selected levels of the right elbow joint of the Labrador Retriever were determined on a craniocaudal computed tomographic-image survey view (Fig 1). A comparison was made between the computed tomographic images (bone and soft-tissue settings) and the cut-surface of the corresponding anatomic sections of the right elbow joint (Fig 2).

On the proximal anatomic sections (Fig 2; rows A through F), several osseous, muscular, tendinous, vascular, and nervous tissue structures could be identified. Bony structures included the distal portion of the humerus with the lateral and medial parts of the humeral condyle, the lateral and medial epicondyle, the radial, olecranon and supratrochlear fossa, and the proximal part of the ulna with the olecranon and olecranon tuber, the anconeal process, and the trochlear notch. A number of soft-tissue structures, including 9 muscles, were visible on the proximal anatomic sections. Four major blood vessels (3 veins and 1 artery) and 3 nerves could be identified on all sections. The lateral and medial collateral ligaments and the elbow joint capsule were also identified (rows E and F). On the soft-tissue setting, computed tomographic images of all these structures and 1 supplementary muscle, namely the cleidobrachialis muscle, were visible. All previously mentioned bony structures could be identified on computed tomographic images at the bone setting (rows A through F). A number of soft-tissue structures, including 9 muscles, were visible on the proximal anatomic sections. Four major blood vessels (3 veins and 1 artery) and 3 nerves could be identified on all sections. The lateral and medial collateral ligaments and the elbow joint capsule were also identified (rows E and F). On the soft-tissue setting, computed tomographic images of all these structures and 1 supplementary muscle, namely the cleidobrachialis muscle, were visible. All previously mentioned bony structures could be identified on computed tomographic images at the bone setting (rows A through F).

**Figure 1**—Craniocaudal survey view of the elbow joint of a clinically normal dog indicating the levels (A through J) at which computed tomographic images were obtained.
Figure 2 continued—See legend on page 1405
Figure 2 continued—See legend on page 1405
the right elbow joint of the Labrador Retriever (Fig 3). The sagittal images were reconstructed in the lateral compartment of the joint and through the central ridge of the trochlear notch. All images allowed a thorough evaluation of the shape of the trochlear notch and the congruity of the 3 joint spaces.

For the other 6 dogs, all osseous structures mentioned for the Labrador Retriever could be seen on computed tomographic images at the bone setting. Similarly, all bony, muscular, nervous tissue, and vascular structures that could be identified on computed tomographic images at the soft-tissue setting for the Labrador Retriever were also noticed on the computed tomographic images at the soft-tissue setting for the 6 mixed-breed dogs. In 2 dogs, however, the median artery could not be identified.

Discussion

Lameness referable to the elbow joint is a common finding among young, rapidly growing large- to giant-breed dogs. It can be caused by several developmental conditions including FCP, osteochondritis dissecans.
(OCD) of the medial part of the humeral condyle, ununited anconeal process, articular anomaly, or joint incongruity.3,10,12 Of these developmental conditions, FCP is most common.5,13,14,20,21,22,23,24,25 Crowding, however, is minimal and secondary degenerative joint disease (DJD), loss of range of motion, and possible lameness as the animal ages.26,27,28,29,30,31,32

It has been stressed that early diagnosis is essential for the successful treatment of FCP and OCD.30,31,32,33,34,35 Besides the clinical signs, the diagnosis is usually made on the basis of the radiographic examination of the patients. Unfortunately, the radiographic findings may not be conclusive, and in most instances, the lesions can only be indirectly diagnosed by the appearance of secondary osteophytes. These osteophytes are signs of a secondary DJD, and they do not appear until the dog is about 7 to 8 months old.33,36,37 The ideal situation, however, would be that FCP, OCD, or both within the elbow joint could be directly diagnosed before the radiographic appearance of DJD changes, which are signs of joint damage. Moreover, in some dogs with radiographic changes suggestive of FCP, grossly normal appearing joints can be found at surgery, and in those dogs unnecessary arthrotoomies are performed.4,32,33

For these reasons, imaging techniques that provide a direct observation of the medial coronoid process and other joint structures would greatly improve the accuracy of preoperative diagnosis of FCP and would contribute to the early diagnosis of this condition. Magnetic resonance imaging has been described as being useful in the detection of FCP, especially in instances of nonmineralized cartilaginous fragments that cannot be seen on computed tomographic images.38 Although arthroscopic techniques to evaluate elbow structures of clinically normal dogs are described39 and the possible arthroscopic changes are reported,40 this technique is more invasive than CT and can only evaluate the surface of the lesions.

Although some information on computed tomographic images of the elbow joint in dogs exists41 and a number of reports have been published on the clinical application of CT in elbow disorders,42,43,44,45,46 a detailed description of the computed tomographic anatomy of that region in clinically normal dogs is lacking. With the increasing availability of CT for the veterinary profession,47,48 its application in elbow disease will undoubtedly increase and such a description is useful to detect and evaluate pathologic changes.

In the published reports on CT of the elbow joint in dogs,8,9,11,14,16,35,50 no definite protocol has been described on the positioning of the dog. We had excellent results with the positioning in lateral recumbency with the elbow joints parallel and extended cranially. The head of the dog was pulled back to the lateral side with the elbow joints parallel and extended cranially. This positioning allowed us to scan both elbows in perfect symmetry at the same time and made comparison of both joints at the same level possible. Avoiding supplementary tissue within the gantry increases the quality of the images because beam-hardening can be avoided.39

The results of our study indicate that by the use of CT, not only can bony structures be evaluated but that with the correct window settings a detailed observation of muscular, tendinous, vascular, and even some nervous tissue structures is possible. By studying the axial computed tomographic images, the complexity of the radiographic images can be reduced, although some familiarization with this type of imaging is necessary. Use of CT offers the advantage of evaluating the medial coronoid process and the medial part of the humeral condyle in detail and without superimposition of bony structures. From reports on the arthroscopic findings in FCP,49 it is obvious that besides fragmentation of the medial coronoid process, there are other pathologic entities in that area including chondromalacia. Fragmentation of the coronoid process is easy to recognize on computed tomographic images, but the computed tomographic appearance of other conditions is yet unknown. The exact and objective evaluation of the area of the medial coronoid process requires the study of grossly normal structures to compare with pathologic conditions.

From studying the sagittal and dorsal reconstructions, the entire humero-radiloulnar joint surface could be studied, as well as the intimate relation of the bony structures (ie, humerus, ulna, and radius) composing the complex elbow joint. In the evaluation of incongruity, the information gained by CT could be more objective than findings obtained by radiography of which the evaluation is always somewhat subjective as a result of superimposition. Major incongruity is easy to evaluate radiographically, but minor incongruity can be hard to recognize. The situation becomes even more complicated as some degree of incongruity has been proven to be typical in clinically normal humans50 and animals.1 For the detection of minor incongruity, comparative studies on clinically normal dogs are also prerequisite.

The major disadvantage of CT is the requirement of general anesthesia and the purchase and maintenance costs of the equipment. The overall examination time of 10 minutes, however, is acceptable especially if the computed tomographic examination can be combined with the eventual arthroscopic or surgical procedure.

References