Use of the distomedial-proximolateral oblique radiographic view of the elbow joint for examination of the medial coronoid process in dogs

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Objective—To describe and evaluate a new radiographic view of the elbow joint in dogs that would potentially enhance observation of the medial coronoid process (MCP).

Sample Population—Twenty cadaver limbs from 10 dogs and clinical examination of 100 elbow joints of 53 dogs.

Procedure—Twenty elbow joints from 10 cadavers were imaged by use of mediolateral, flexed mediolateral, cranio-caudal, cranio-caudal-caudomedial oblique (Cr15L-CdMO), and distomedial-proximolateral oblique (Di35M-PrLO) radiographic views before and after placement of 3 lead pellets placed on the cranial, medial, and craniodistal aspect of the MCP. Three examiners independently reviewed these radiographs. One hundred elbow joints of 53 dogs with forelimb lameness and signs of pain elicited on palpation of the elbow joint were examined. These joints were radiographed and treated by use of arthroscopy. Three examiners independently graded the radiographs.

Results—The MCP was identified on all Di35M-PrLO views made during the anatomic study. The Di35M-PrLO view had the largest area under the receiving operating characteristic (ROC) curve for detection of abnormalities of the MCP. Fractured and nonfractured MCP could only be significantly differentiated on Di35M-PrLO and mediolateral views. The Di35M-PrLO view had a higher agreement between examiners than other radiographic views for detection of fractures of the MCP.

Conclusion and Clinical Relevance—The Di35M-PrLO view enhances the identification of anomalies and fragmentation of the MCP in dogs, compared with other radiographic views. The Di35M-PrLO view may be of benefit for early screening of dogs potentially affected with elbow dysplasia. (Am J Vet Res 2002;63:1000–1005)

Elbow dysplasia is the most common developmental anomaly of the elbow joint in dogs and one of the most common orthopedic problems affecting large and giant breed dogs. The manifestations of elbow dysplasia may include an abnormal medial coronoid process (MCP) that may have chondromalacia, be fissured or fractured, or have an abnormal shape, osteochondritis dissecans of the trochlea, failure of the anconeal process to unite with the olecranon process, and incongruity of the joint surfaces. Fragmentation of the MCP appears to be the most common manifestation of elbow dysplasia. Early diagnosis of fragmentation of the MCP is critical to provide optimal treatment before the development of degenerative joint disease and for early selection of healthy breeding stock. The MCP is unfortunately the most difficult portion of the joint to image on radiographs. Multiple radiographic projections have been used to image the MCP: mediolateral, flexed mediolateral, extended 15°-supinated mediolateral, cranio-caudal, cranio-caudal-caudomedial oblique (Cr15L-CdMO), and mediocaudal-laterocranial oblique projections. The sensitivity of the conventional radiographic projections to image the MCP is suboptimal and has been estimated to only range from 10 to 62% at a specificity of 100%. Additional diagnostic imaging methods used in the identification of fragmentation of the MCP include linear tomography, xerography, computed tomography, and magnetic resonance imaging. Computed tomography and magnetic resonance imaging have a higher accuracy, sensitivity, and specificity than radiography. These methods, however, are more costly than radiography and have a limited availability.

The purpose of the study presented here was to describe and evaluate a new radiographic view that would potentially enhance observation of the MCP in dogs. We hypothesized that the distomedial-proximolateral oblique (Di35M-PrLO) radiographic view enhances detection of fragmentation of the MCP in dogs. To test this hypothesis, we conducted an anatomic study on 20 cadaver limbs and a blinded, prospective clinical study on 100 elbow joints of 53 dogs with a history of forelimb lameness and pain elicited on palpation of the elbow joint.

Materials and Methods

Anatomic study—Twenty cadaver limbs from 10 dogs euthanatized for reasons independent from our study were included in an anatomic study. The criteria for inclusion were prior owner approval, a body weight of >15 kg, and the absence of current orthopedic problems in or adjacent to the elbow joints. Immediately after euthanasia, both elbow joints were radiographed by use of the following 5 views: mediolateral, flexed mediolateral, cranio-caudal, Cr15L-CdMO, and the Di35M-PrLO (Fig 1). A medial intermuscular approach to
the elbow joint was performed between the pronator teres and the extensor carpi radialis muscles. The annular liga-ment was transected to view the cranial aspect of the MCP. When additional exposure was necessary, the medial collateral liga-ment was also transected. Two-millimeter-diameter holes were drilled at the cranial, medial, and craniodistal edges of the MCP. Two-millimeter-diameter lead pellets were placed in the holes. The transected medial collateral ligaments were repaired by use of a 3-loop pulley suture pattern with 3-0 monofilament nylon. The elbow joints were radiographed by use of the 5 views as described. The elbow joints were opened again to confirm the absence of pellet migration.

Clinical study—Dogs referred between June 1997 and July 1999 with a history of forelimb lameness were candidates for inclusion in our study. An owner's informed consent was obtained prior to inclusion in the clinical study. Physical and orthopedic examinations were performed. The examination of the elbow joint included extension and hyperflexion of the elbow with carpal pronation. The dogs with a painful response to palpation of the elbow joints were sedated with an IV injection of medetomidine hydrochloride (30 µg/kg) and ketamine hydrochloride (10 mg/kg) and radiographs of both elbow joints were made by use of the 5 views as described. An arthroscopic exploration of the elbow joint was performed. Acepromazine maleate (0.05 mg/kg) and glycopyrrolate (0.05 mg/kg) were given IM for premedication. General anesthesia was induced with thiopental sodium (10 mg/kg) and maintained with halothane inhalation. The dogs were placed in lateral recumbency with the operated limb dependent if 1 elbow was operated, and in dorsal recumbency when both limbs were operated. Arthroscopy was performed via the medial portals by use of a 2.7-mm-diameter 30° oblique scope placed in a 3.5-mm-diameter sleeve. A 250-watt cold light source and a video-camera were used. The joints were distended and irrigated with lactated Ringer's solution. The ulnar notch, lateral coronoid process, radial head, capitulum, trochlea, MCP, and medial collateral ligament were evaluated. All procedures were recorded on videotapes, and the lesions were documented with still pictures. The lesions of the MCP were recorded as chondromalacia (articular cartilage with abnormal color or consistency), fissures, or fractures with or without displacement. Lesions were then treated arthroscopically by curettage or excision. Instruments were removed, and the skin wounds were closed with skin staples. Meloxicam (0.2 mg/kg) was injected IM at the end of surgery for analgesia. The dogs were discharged on the day of the surgery. The clinical study included examination of 100 elbow joints of 53 dogs with a history of forelimb lameness and pain elicited on palpation of the elbow joint.

Radiographic positioning and interpretation—The anatomic and clinical studies included 5 radiographic views. All radiographs were made by use of a nonrigid table-top technique with a detail film-screen system. The intensity ranged from 9.6 to 15 mA and the penetrability ranged from 50 to 60 kVp. Craniocaudal and Cr15L-CdMO views were
made with the dogs in sternal recumbency and the forelimb extended and taped in a neutral position. The radiographic beam was directed vertically and centered over the elbow. The antebrachium was pronated by 15° for the Cr15L-CdMO view.6,20 Mediolateral, flexed mediolateral, and Di35M-PrLO views were made with the dogs in lateral recumbency and the radiographic beam centered over the dependent elbow. Mediolateral views were made with the elbow placed at an approximate angle of 120°.19 The flexed mediolateral view was made with the elbow placed at an approximate angle of 45°.19 The Di35M-PrLO view was made by placing the dog in lateral recumbency and placing the dependent antebrachium at a 90° angle, and supinating the extremity by 40° (in a custom foam wedge elevating it by 35°, placing the elbow at a 90° angle, and supinating the extremity by 40° (Fig 2).19 The Di35M-PrLO views were considered acceptable if the cranial aspect of the MCP was located approximately at the midpoint of the humeral condyle in a cranial to caudal direction, the medial and lateral aspects of the humeral condyle overlapped by approximately 50%, and the distance between the MCP and anconeal processes was decreased by a third compared with the mediolateral view (Fig 1).

For the anatomic study, radiographs were independently reviewed by 3 examiners (a resident in radiology, a resident in surgery, and a board-certified surgeon) to determine whether the MCP could be viewed unequivocally on plain radiographs by comparison to radiographs with pellets for specific identification of the MCP. For the clinical study, 3 examiners (a resident in radiology, a board-certified radiologist, and a board-certified surgeon) read the radiographs independently and in random order. The readers were blinded to the results of the arthroscopic examination. The MCP was considered abnormal on radiographs if it could not be viewed, had a convex or flattened shape, appeared osteopenic, or cortical irregularity was present.6,20 The readers used these criteria to grade each view as definitely abnormal, probably abnormal, possibly abnormal, probably normal, or definitely normal with regards to the MCP. When identified, fragmentation of the MCP was also recorded.

**Statistical analysis**—The statistician was blinded to the view and the examiner’s identity in the initial analyses. The likelihood of identifying a MCP on various radiographic views was determined and compared with the likelihood of identifying an abnormal MCP on arthroscopy by use of repeated F-tests. The radiographic findings were compared with the findings of arthroscopy by use of receiver operating characteristic (ROC) curve analysis.21 Areas under the ROC curves were determined for all radiographic views for detection of an abnormal MCP and a fractured MCP. Areas under the curves were compared by use of a computer program22 with a nonparametric method.23 The Fisher exact test was used to compare the association between the radiographic and arthroscopic detection of fracture of the MCP. To compare the agreement between examiners, κ statistics were used.21

**Results**

For the anatomic study, identification rate of the MCP varied widely depending on readers and views (Table 1). The Di35M-PrLO view allowed positive identification of the MCP in all joints and was more sensitive than the craniocaudal and Cr15L-CdMO views.

Fifty-three dogs were included in the clinical study. Six dogs had unilateral arthroscopy and 47 dogs had bilateral arthroscopies for a total of 100 arthroscopies. Thirty-four (64%) dogs were male and 19 (36%) were female. Dogs from 12 breeds and 1 mixed-breed dog were included in our study. Of the 53 dogs, 23 (43%) were Labrador Retrievers. The median age was 9 months (range, 3 months to 11 years old). The median weight was 31 kg (range, 16 to 49 kg). Of 47 elbows joints with pathologic changes of the trochlea, 23 (43%) were fractured (19 fractures were displaced), 35 were fissured, and 2 had chondromalacia. Forty-seven elbow joints had pathologic changes of the trochlea with 11 dogs having osteochondritis dissecans. Forty-six of 47 dogs with pathologic changes of the trochlea had an abnormal MCP.

At a specificity of 90%, median sensitivities to detect anomalies of the MCP were 0.35 for the craniocaudal view, 0.39 for the Cr15L-CdMO view, 0.43 for the mediolateral view, 0.54 for the flexed mediolateral view, and 0.56 for the mediolateral view. At a specificity of 90%, the sensitivities to detect a MCP were 0.35 for the craniocaudal view, 0.39 for the Cr15L-CdMO view, 0.43 for the mediolateral view, and 0.54 for the flexed mediolateral view. At a specificity of 90%, the sensitivities to detect a MCP were 0.35 for the craniocaudal view, 0.39 for the Cr15L-CdMO view, 0.43 for the mediolateral view, and 0.54 for the flexed mediolateral view.
view, and 0.80 for the Di35M-PrLO view. At a specificity of 90%, median sensitivities to detect fractured MCP were 0.29 for the craniocaudal view, 0.34 for the Cr15L-CdMO view, 0.30 for the mediolateral view, 0.41 for the flexed mediolateral view, and 0.55 for the Di35M-PrLO view. The ROC curves representing the detection of an abnormal (Fig 3) and fractured (Fig 4 and Table 2) MCP by use of the median value of the examiners for each view were drawn. For detection of abnormal MCP, the area under the curve for the Di35M-PrLO view was significantly higher than the area under the curves for the mediolateral (P = 0.008) and craniolateral-caudomedial oblique view (P = 0.042), but was not significantly higher than the area under the curves for the flexed mediolateral view (P = 0.094). Analysis could not be performed to compare the craniocaudal and Di35M-PrLO views as a result of degenerate data (full ranges of scores not available for these data) and a high Pearson correlation (r = 0.9). Analyses could not be performed to compare ROC curves of dogs with fracture of the MCP as a result of high correlations of the curve shapes (Pearson correlation = 0.9 in most instances). The percentage of accurate detection of fractured MCP (defined as the sum of true positives and true negatives divided by the total number of cases) and the percentage of accurate positive detection of fractured MCP (defined as the number of true positives divided by the total number of cases) were determined for all radiographic views (Table 3). Results of the Fisher exact test demonstrated that only the Di35M-PrLO and mediolateral views could significantly differentiate fractured from nonfractured MCP. The κ agreement between the radiographic and arthroscopic detection of fracture of the MCP was 0.17 for the mediolateral, 0.16 for the flexed mediolateral, 0.02 for the craniocaudal, 0.16 for the Cr15L-CdMO, and 0.32 for the Di35M-PrLO view.

Discussion

The aim of our study was to determine the diagnostic value of the Di35M-PrLO view to assess the MCP in dogs. We chose to compare the Di35M-PrLO view to the following 4 conventional radiographic views: the craniocaudal and mediolateral views, the flexed mediolateral view, an oblique view, and the Cr15L-CdMO. The range of obliquity of the cranio-
The identification of the MCP on all radiographic views is inherently difficult and subjective. The wide variation present between the findings of 3 examiners evaluating normal MCP in our anatomic study illustrates the subjectivity of this interpretation (Table 1). Variation was also present between the radiographic findings of the 3 examiners in the clinical study, but to a lesser extent (Table 3). When examining both normal (anatomic study) and potentially abnormal (clinical study) MCP, variation in findings may have resulted from subtlety of morphologic changes in MCP and from individuality and amount of experience among examiners. A nonconservative examiner tends to be more sensitive but less specific in radiographic interpretation than a conservative examiner. In the clinical study, we dampened the effects of the interobserver variation in radiographic findings by use of the median sensitivity and specificity values for the 3 examiners and by use of ROC curve analysis. The evaluation of the sensitivity of a test at a fixed specificity is a method considered highly reader-dependent. The ROC curve analysis, however, is considered to be reader-independent. The ROC curve analysis was performed by correlating the radiographic and arthroscopic findings. Although arthroscopy has not been validated as the standard to assess the status of the MCP in our study or in other studies, it allows clear observation of the MCP and of other regions of the elbow joint, and therefore appeared to be the best comparison method to be used in a clinical study. Arthroscopy seemed particularly relevant because we intended to compare the diagnostic values of various radiographic views to determine whether the MCP was abnormal (ie, fissured or chondromalacic) but not necessarily fractured. Fissures or chondromalacia of the MCP were present in 37 of 82 (45%) abnormal elbow joints in our clinical study. This high proportion of abnormal but not fractured MCP was comparable to the areas under the ROC curves had fair grading for all views except the Di35M-PrLO view that had a good to excellent grading by use of a scoring system proposed by Tape. The Di35M-PrLO view improved observation of abnormal MCP compared with the craniolateral and Cr15L-CdMO views (Table 2). The Cr15L-CdMO view was determined to be the most sensitive for the identification of fragmentation of the MCP in 19 dogs. The Cr15L-CdMO and, to a lesser extent, the cranioproximal views allowed a good observation of the medial aspect of the MCP but not of its cranial aspect. The medial aspect of the MCP appears to be the site of secondary osteophytic changes, but primary fragmentation generally occurs on the craniolateral aspect of the bone. The cranial and oblique cranial views may therefore be more sensitive for detection of degenerative changes secondary to elbow dysplasia than for primary lesions of the MCP. The cranioproximal aspect of the MCP appeared to be more radiopaque and more clearly identified on Di35M-PrLO views than on mediolateral and flexed mediolateral views (Fig 1). The radiopacity and contrast of the MCP on the Di35M-PrLO and other radiographic views were not directly compared in our study but could potentially be compared in the future by use of standardized exposure methods and image analysis software. The agreement between examiners was fair for the Di35M-PrLO view (κ agreement of 0.32; range for fair agreement, 0.2 to 0.4), compared with a slight κ agreement between examiners for other views (κ agreement of 0.02 to 0.17; range for slight agreement, 0.0 to 0.2). Ranges of κ agreement reported in our study are similar to ranges reported from a previous study involving 31 elbow joints (κ agreement of 0.04 to 0.23 for the craniolateral, mediolateral, mediocaudal-laterocranial 75° oblique, and flexed mediolateral views), with the exception of the Cr15L-CdMO oblique view that had a κ agreement of 0.35.

The findings of our study indicate that the Di35M-PrLO radiographic view allows better observation of the MCP than several previously described views used to detect pathologic changes and fragmentation of the MCP. The Di35M-PrLO view seems to be particularly advantageous for detection of an abnormal MCP, even in the absence of a separate MCP fragment. This may make the Di35M-PrLO view particularly suited as a screening radiographic view when elbow dysplasia is suspected in young dogs.

References

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