Relationship between Radioulnar Incongruity of Elbow Joints and the Type of Fragmented Processus Coronoideus Medialis

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Received April 3, 2009
Accepted October 21, 2009

Abstract

The aim of the study was to find the difference between actual and anticipated frequencies of individual types of FCP (fragmented coronoid process) in relation to the extent of radioulnar incongruity.

We evaluated the radiographs of elbow joints (n = 135) of dogs (n = 77) with arthroscopically (n = 109) or arthrotomically (n = 26) proven fragmented coronoideus medialis ulnae. Radioulnar incongruity was classified as a congruent joint (0-0.5 mm), moderate incongruity (0.6-2 mm) and marked incongruity (> 2.1 mm). In elbow joints without radiologically identifiable radioulnar incongruity (0-0.5 mm) significantly higher occurrence of fissured PCM (processus coronoideus medialis) was found ($p < 0.01$). In elbow joints with pronounced radioulnar incongruity (> 2.1 mm) we found significantly higher occurrence of FCP with a dislocated fragment ($p < 0.001$).

The results of this study suggest the possibility of using the assessment of radioulnar incongruity from radiographs of elbow joints in mediolateral projection for specifying the X-ray diagnosis of FCP with regard to the type of FCP lesion.

Fragmented coronoid process, elbow, dog, radioulnar incongruence, X- ray diagnostics

Fragmented processus coronoideus medialis (FCP) of the elbow joint is the most frequently occurring developmental disease of the elbow joint in dogs (Wind and Packard 1986; Boulay 1998; La Fond et al. 2002; Meyer-Lindenberg et al. 2002; Gemmill et al 2006). As a possible cause of the FCP, temporary or permanent incongruity of articular surfaces of the elbow joint is considered (Guthrie et al. 1992; Fitzpatrick and O'Riordan 2004). Radiography is the basic and most commonly used technique in FCP diagnostics and in the assessment of radioulnar incongruity (Samoy et al. 2006). Radiography is considered as an insufficiently sensitive method for diagnosing moderate radioulnar incongruity (Murphy et al. 1998; Mason et al. 2002). It is, however, relatively suitable for the detection of medium and marked radioulnar incongruity (Blond et al. 2005). Mediolateral projection (ML) of the elbow joint in the standing angle and craniocaudal projection (CrCd) of the elbow are suitable projections for the assessment of its articular surface congruity. Mediolateral projection with a 90° flexion in the elbow joint appears as the most appropriate projection for the assessment of radioulnar incongruity (Murphy et al. 1998). Larger flexion in the elbow joint accentuates radioulnar incongruity (Murphy et al. 1998). Evaluation of elbow joint congruity is subjective and may be affected by incorrect positioning (Morgan et al. 2000). Radioulnar incongruity of the elbow joint is assessed from radiographs based on the mutual position of the subchondral bone of the radial head and the subchondral bone of the distal border of the trochlear notch of ulna (Murphy et al. 1998). The articular surface of the radial head and the craniocaudal border of incissura trochlearis ulnae under physiological conditions form a continuous arch. In serious cases radioulnar incongruity reaches 5-6 mm (Morgan et al. 2000).

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According to the appearance of PCM during arthroscopic examination the FCP is classified into seven variants (Bardet 1997; Griffon 2006). To our knowledge, it is so far unknown whether the occurrence of individual variants of FCP is affected by the extent of radioulnar incongruity. The aim of the study was to find whether there is a relationship between the occurrence of individual types of FCP and the extent of radiologically detectable radioulnar incongruity. Null hypothesis assumed that there is no relationship between the occurrence of individual types of FCP and the extent of radiologically identifiable radioulnar incongruity. Alternative hypothesis assumed that there is a relationship between the occurrence of individual types of FCP and the extent of radiologically detectable radioulnar incongruity.

Materials and Methods

Inclusion criteria

A total of 135 elbow joints of dogs with FCP and with the necessary complete records of the type of FCP during arthroscopic or arthrotomic treatment were chosen from the medical records of the Department of Surgery and Orthopaedics of the Small Animal Clinic, Faculty of Veterinary Medicine, University of Veterinary and Pharmaceutical Sciences Brno in the period of 2001-2008. The study did not include elbows with concurrent FCP and OCD (osteochondritis dissecans) of the medial humeral condyle, elbows with concurrent FCP and UAP (ununited anconeal process), and elbows in which radiographs were not done on X-ray cassettes of the 18 × 24 cm format.

Radiography

In all elbow joints included in the study, mediolateral (ML) radiographs in the standing angle and oblique craniocaudal projection (Cr15°L-CdMO) were made. All radiographs were done with patients under deep intravenous sedation induced by combination of medetomidine (10-20 μg/kg i.v. Domitor, Pfizer) and butorphanol (0.2 mg/kg i.v. Butomidor, Richter Pharma AG), or in general intravenous anaesthesia (medetomidine 10-20 μg/kg i.v., butorphanol 0.2 mg/kg i.v., propophol 1 ml/kg i.v. Propofol, Abbott). Radiographs were done on the X-ray machine Proteus XR/a without the use of a grid, with the cassette placed immediately under the elbow joint. Patients were positioned by employees of the Department of Diagnostic Imaging acquainted with the technique of correct positioning of the elbow joint. Radiographs of 105 elbows were made on X-ray films using intensifying screen with the screen speed 100, or on mammographic cassettes and films. Radiographs of 30 elbows were made in digital form in the DICOM format at a resolution of 1170 × 2370 px (CR, Capsula XL, Fuji). X-ray films were converted to digital form in the DICOM format at a resolution of 1170 × 2370 pixels using the X-ray film scanner (Diagnostic pro plus, Vidar System Corporation).

Radioulnar incongruence measurement

Radioulnar incongruence was assessed from mediolateral radiographs of elbow joints with FCP in the standing angle using the method according to Brunnberg et al. (1999). A line was traced using the DICOM viewer (JiveX, Visus-Transfer Technology GmbH) on the digital mediolateral radiograph of the elbow joint, connecting the cranioproximal and caudoproximal border of the articular surface of the radial head, demarcating the radial plateau. A parallel line was traced to this line, intersecting the apex of the processus coronoideus lateralis ulnae. The distance between these two lines was recorded in mm (of one digit) as radioulnar incongruity (Plate XIX, Fig.1). For the purpose of this study the elbow joints with FCP were divided according to radioulnar incongruity into the following groups: radioulnar incongruity of 0-0.5 mm (congruent joint), radioulnar incongruity of 0.6-2 mm (moderate incongruity), and radioulnar incongruity of > 2.1 mm (marked incongruity). For the measurements, radiological magnification of the object with regard to the direct contact of the elbow joint with the X-ray cassette was not taken into account.

FCP classification

In each elbow, the FCP variant was recorded from the operational protocol. We used the FCP classification that is used at the Department of Surgery and Orthopaedics of the Small Animal Clinic, University of Veterinary and Pharmaceutical Sciences Brno based on a modification of the arthroscopic classification of FCP variants (Bardet 1997; Griffon 2006). We divided FCP by its appearance during the arthroscopic or arthrotomic treatment into seven types – fragmented medial margin of PCM, eroded lateral rim of PCM, fissured PCM, non-dislocated fragment of PCM, dislocated fragment of PCM, chondromalacia of PCM, and osteophytes on PCM. All surgical procedures were performed and evaluated by experienced orthopaedic surgeons (arthroscopy AN, arthrotomy MD).

Statistical analysis

We found the absolute and relative frequencies of individual variants of FCP in individual degrees of radioulnar incongruity. Furthermore, we evaluated the actual and anticipated frequencies of individual FCP variants in individual intervals of radioulnar incongruity. For statistical analysis of the data Fisher's exact test was used. Categories with null frequency were not statistically evaluated.

Results

The retrospective study evaluated a total of 135 elbow joints of 77 dogs with surgically treated fragmentation of the processus coronoideus medialis. One-hundred and nine elbow joints were treated arthroscopically and 26 elbow joints were treated arthrotomically. The group comprised of 63 males and 14 females. In elbow joints without radiologically detectable radioulnar incongruity (0-0.5 mm) we found significantly higher occurrence of fissured PCM ($p < 0.01$). In elbow joints with marked radioulnar incongruity (> 2.1 mm) we found significantly higher occurrence of FCP with dislocated fragment ($p < 0.001$). In other types of FCP and individual degrees of radioulnar incongruity no significant differences were found between the actual and anticipated frequencies. The absolute and relative frequencies of individual types of FCP in relation to radioulnar incongruity are presented in Table 1.

Table 1. Absolute and relative frequencies of individual types of lesions of FCP in relation to the degree of radioulnar incongruity

Radioulnar incongruity in mm	0-0.5 mm Absolute frequency (%)	0.6-2 mm Absolute frequency (%)	>2.1 mm Absolute frequency (%)	Total Absolute frequency (%)
Fragmented medial margin of PCM	1 (0.74)	2 (1.48)	0 (0.00)	3 (2.22)
Eroded lateral rim of PCM	3 (2.22)	1 (0.74)	0 (0.00)	4 (2.96)
Fissured PCM	6* (4.44*)	1 (0.74)	0 (0.00)	7 (5.18)
Non-dislocated fragment of PCM	10 (7.41)	22 (16.30)	3 (2.22)	35 (25.93)
Dislocated fragment of PCM	8 (5.93)	23 (17.04)	13** (9.63)**	44 (32.60)
Chondromalacia of PCM	16 (11.85)	21 (15.56)	0 (0.00)	37 (27.41)
Osteophytes on PCM	3 (2.22)	2 (1.48)	0 (0.00)	5 (3.70)
Total	47 (34.81)	72 (53.34)	16 (11.85)	135 (100.00)

*$p < 0.01$
**$p < 0.001$

Discussion

In the study we evaluated the frequency of individual types of FCP in relation to radioulnar incongruity. In elbow joints without radiologically detectable radioulnar incongruity we found significantly higher occurrence of fissured PCM ($p < 0.01$). In elbow joints with radiologically diagnosed marked radioulnar incongruity (> 2.1 mm) we found significantly higher occurrence of dislocated fragment of FCP ($p < 0.001$).

Some authors consider radioulnar incongruity in the elbow joint as the primary cause of FCP (Danielson et al. 2006). Ubbink et al. (1999) found in Bernese mountain dogs radioulnar incongruity in all cases of FCP and in 80% of dogs with osteoarthrosis of the elbow joint. The cause of radioulnar incongruity is probably temporary asynchronous growth of the ulna and radius, PCM overload and subsequent fragmentation. Elbow joints with FCP and marked radioulnar incongruity are more often diagnosed in young dogs; less frequently they are described in older dogs (Morgan et al. 2000). The degree of radioulnar incongruity probably affects the severity of clinical symptoms. According to some authors, (Wind and Packard 1986; Samoy et al. 2006) the degree of incongruity corresponds to

the severity of clinical symptoms. Moderate incongruity need not be the cause of PCM fragmentation and lameness associated with it, whereas in the case of marked incongruity, fragmented PCM and lameness are very common. The results of our study show that the degree of radioulnar incongruity may affect the type of FCP. Whether the cause of rather pronounced clinical symptoms is marked radioulnar incongruity in itself or a free fragment, is presently the subject of further research. Assuming that the main cause of lameness in elbow joints with marked radioulnar incongruity is the free fragment, a marked clinical amelioration may be expected after removal of the free fragment of FCP.

The cause of more frequent occurrence of fissured PCM in elbow joints without radiologically diagnosed radioulnar incongruity is unknown. One of the possible explanations is radioulnar incongruity only on the level of PCM which is practically impossible to diagnose radiologically. Two studies observed radioulnar incongruity on the PCM level using CT (Gemmill et al. 2005; Kramer et al. 2006). However, their authors came to completely opposed results. Meanwhile Gemmill et al. (2005) came to the conclusion that radioulnar incongruity exists on the level of cranial apex of PCM but not at the base of PCM, Kramer et al. (2006) published contrasting results (incongruity at the base of PCM). The higher frequency of fissured PCM in elbow joints without radiologically detectable radioulnar incongruity in our study supports rather the theory of incongruity on the level of the cranial apex of PCM. A method for objective assessment of radioulnar incongruity has not so far been described (Samoy et al. 2006). Another possible explanation of the more frequent occurrence of fissured PCM in elbow joints with congruent formation of articular surfaces rests in insufficient sensitivity of radiography in the detection of moderate radioulnar incongruity. Wind and Packard (1986) described on a small number of dogs the reliability of radiologically detectable radioulnar incongruity as starting approximately from 2 mm. Other studies consider the evaluation of radioulnar incongruity under 2.5 mm unreliable (Murphy et al. 1998; Mason et al. 2002). Wind and Packard (1986) mention that the assessment of radioulnar incongruity of the elbow joint is not affected by elbow joint positioning. Slight supination and pronation of the extremity and centring the X-ray beam on the centre of antebrachia does not lead to incorrect evaluation of both radioulnar and humeroulnar incongruity. Likewise, slightly oblique imaging of humeral condyles does not lead to misinterpretation of the assessment of elbow joint congruity. In contrast, other studies (Murphy et al. 1998; Mason et al. 2002) mention radiography to be an unreliable method for evaluating moderate radioulnar incongruity, especially due to incorrect positioning of the elbow, superposition of the bone structures and assessment of a three-dimensional bone structure from a two-dimensional image. False positive radioulnar incongruity ensues from supination as well as pronation of the extremity (Murphy et al. 1998). Contrary to that, in an *in vitro* study, Blond et al. (2005) point out high sensitivity of radiography in detecting radioulnar incongruity and as the most sensitive they mention the ML projection of the elbow joint with a 90° flexion with a 100% sensitivity; and then the ML projection in the standing angle (135°) with a 80% sensitivity in assessing radioulnar incongruity larger than 2 mm. With incongruity smaller than 2 mm, sensitivity was 60% during radiological examination in the ML flexion projection and 80% during radiological examination in the ML neutral projection.

Assessment of the degree of radioulnar incongruity of the elbow joint in this study is accompanied with a certain inaccuracy in terms of utilisation of the imaging method, as conventional radiology does not allow direct imaging of articular cartilage. Native radiographs do not allow differentiating whether there is an actual step between the articular surface of the radius and ulna or whether the radioulnar step is compensated for by a thicker articular cartilage of the head of radius (Holsworth et al. 2005). Likewise, X-ray examination of an extremity in unweighted position does not allow accurate assessing of the elbow joint congruity. A number of forces act upon a weighted elbow that may

affect mutual positions of the radius, ulna and humerus in the elbow joint. So far it has not even been studied how elbow joint congruity is affected by the lowered muscle tone during radiological examination under general anaesthesia. For this purpose, it would be necessary to assess elbow joint incongruity in a fully weighted extremity, e.g. from a radiograph taken by horizontal ray. The elbow is a complex joint consisting of several articular surfaces on many levels. It is practically impossible to image radiologically both radiohumeral and humeroulnar joints in such a way that the X-rays fall tangentially on both articular surfaces simultaneously. That further complicates a completely objective evaluation of a three-dimensional joint from a two-dimensional image. Another possible inaccuracy in the interpretation of radioulnar incongruity may arise during comparison of the position of the proximal articular surface of processus coronoideus medialis and the articular surface of the radial head. The articular surface of processus coronoideus medialis has an oblique form and its medial margin lies below the level of the articular surface of the radial head. It is therefore practically impossible to determine from a two-dimensional image the position of the articular surface of PCM in relation to the articular surface of the head of radius.

It follows from the results of the study that the extent of step between the radius and ulna is connected with the occurrence of certain types of FCP. In elbows with marked radioulnar incongruity, complete fragmentation of PCM may be expected. In elbows without radiologically detectable radioulnar incongruity, more frequent occurrence of fissured PCM may be expected. The results of our study suggest the possibility of using the assessment of radioulnar incongruity from radiographs of elbows in mediolateral projection to specify the radiological diagnosis of FCP, and their possible use for establishing the severity of the clinical finding, especially with regard to prediction of the development of secondary degenerative changes in the joint as a results of the mentioned pathological processes.

Souvislost radioulnární inkongruity loketních kloubů s typem fragmentovaného processus coronoideus medialis

Cílem studie bylo zjistit rozdíl ve skutečných a očekávaných četnostech jednotlivých typů FCP ve vztahu k velikosti radioulnární inkongruity.

Hodnoceny byly rentgenogramy loketních kloubů (n = 135) psů (n = 77), u nichž byl artroskopicky (n = 109) nebo artrotomicky (n = 26) prokázán fragmentovaný *processus coronoideus medialis ulnae*. Radioulnární inkongruita byla klasifikována jako kongruentní kloub (0-0.5 mm), mírná inkongruita (0.6-2 mm) a výrazná inkongruita (> 2.1 mm). U loketních kloubů bez rentgenologicky identifikovatelné radioulnární inkongruity (0-0.5 mm) jsme zaznamenali statisticky významně vyšší výskyt fisury PCM ($p < 0.01$). U loketních kloubů s výraznou radio-ulnární inkongruitou (> 2.1 mm) jsme zaznamenali statisticky významně vyšší výskyt FCP s dislokovaným fragmentem ($p < 0.001$).

Výsledky naší studie naznačují možnosti využití hodnocení radioulnární inkongruity z rentgenogramů loketních kloubů v mediolaterální projekci při zpřesnění rtg diagnostiky FCP s ohledem na typ léze FCP.

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Fig. 1. Radiographic measurement of radioulnar incongruity (method according to Brunnberg). Marked incongruity of the elbow joint. Arrow points to a free dislocated fragment.