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Review

Magnetic resonance imaging of selected limb joints in dogs

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Abstract

The presented paper presents updated information concerning magnetic resonance imaging (MRI) of shoulder joint, elbow joint and knee joint in dogs. It describes indications, planes, standard sequences, slice thickness to perform MRI examination of above mentioned joints. Besides general information about basic physics use in magnetic resonance imaging, and practical information about magnetic resonance and its usage in orthopedic examination are given.

Key words: magnetic resonance imaging, shoulder, elbow, stifle, dog

Introduction

The range of methods deployed in imaging the shoulder, elbow and stifle joints in dogs is as varied as in human medicine. Standard methods for imaging canine, elbow and stifle joints include radiology (RTG), ultrasonography (USG), arthroscopy, computed tomography (CT) and, increasingly often, magnetic resonance (MRI). The first reports documenting the use of magnetic resonance in the treatment of dogs date back to the 1980s. In 1973, Paul Lauterbur became the first scientist who used the magnetic field gradient in diagnostic imaging (Gavin and Bagley 2009, Marino and Luoghin 2010).

MRI methods rely on the magnetic properties of the nuclei of atoms that form bodily tissue, in particular the nuclei of hydrogen which accounts for around 11% of soft tissue in the body. The distribution of light and dark images produced by magnetic resonance follows directly from the impulse excitation technique and the processing of induced signals. Two magnetic resonance scans of the same anatomical

section produced with the use of different excitation impulse sequences vary significantly e.g. one scan may be a negative image of the other. The above implies a correlation between magnetic resonance parameters, and it directly contributes to the variability in the images of the investigated anatomical region and its sections. This variability results from the spatial distribution of proton density, differences in relaxation time values and body fluid flow rates.

Magnetic resonance methods for imaging shoulder, elbow and stifle joints in dogs rely on the following standard sequences: high-resolution T1-weighted, T2-weighted, STIR and fat-suppressed proton density. Other sequences applied to diagnose the above joints include GE (Gradient Echo) and 3D HYCE (Snaps et al. 1998)

An appropriate combination of parameters, including TE (Time to Echo) or TR (Repetition Time), is required for a magnetic resonance image to be diagnostically useful.

Slice thickness is another important consideration. In an MRI examination of the elbow joint using the

T1-weighted or the T2-weighted sequence, the required slice thickness is minimum 2 mm. In large dog breeds, the suggested thickness of an axial slice is 4 mm, a sagittal and a dorsal slice – 3 mm. Slice thickness of 0.7 mm is required in 3D sequences. In the MRI technique, shoulder, elbow and stifle joints are imaged in the sagittal, axial and dorsal plane (Reichle and Snaps 1999, Cook and Cook 2009).

Shoulder joint

The examined region of the shoulder joint should be adequately positioned to enable a correct diagnosis (Agnello et al. 2008). Sagittal and longitudinal planes support the imaging of the biceps brachii tendon, infraspinatus and supraspinatus tendon and the teres minor muscle (Schaefer and Forrest 2006, Pilar-Lafuente et al. 2009). The dorsal plane and axial plane are used in examinations of the subscapularis, articular capsules and intraarticular structures. Arthrographic techniques involving the injection of contrast material into a straightened joint provide valuable information for MRI exams of intraarticular structures (Schaefer et al. 2010).

A high number of sequences supports the selection of the most diagnostically useful images. Standard sequences are the important point for every examination. In MRI exams of the shoulder joint, GE is a useful sequence for imaging ligament structures and tendons. Fat-suppressed proton density sequences facilitate imaging of fluid buildup in the articular cavity and the tendon sheath. According to Stadie et al. (2004), the selection of adequate sequences in MRI examinations of the shoulder joints supports the diagnosis of OCD in 100%, shoulder neoplasms – in 100%, mineralization of the supraspinatus tendon – in 50%, inflammations of the biceps brachii tendon sheath – in 100%. MRI is also a highly useful technique for diagnosing pathological changes in the soft tissue of the shoulder joint area and the brachial plexus (Stadie et al. 2004, Murphy et al. 2008).

Elbow joint

For a long time, dysplasia of the elbow, the most popular disease of the elbow joint, had been effectively diagnosed with the application of RTG, CT and arthroscopic methods, which is why MRI had few practical applications in this anatomical region. Technological advancement and clinical observations contributed to a rise in MRI's popularity. Magnetic resonance provides additional information in the diag-

nosis of elbow joint dysplasia, and it supports imaging of pathological changes in the muscles and tendons of the elbow region (Cook and Cook 2009). Gabriel et al. (2009) used the MRI technique to diagnose incomplete ossification of the humeral condyle in a German shepherd. Radiographic examinations had failed to indicate the cause of permanent lameness affecting the thoracic limb. Baeumlin et al. (2010) were the first to deliver a detailed report on an MRI examination of a healthy elbow joint. The above authors described in detail the recommended parameters, planes and slice thickness values for low-field MRI systems used in imaging healthy structures of the canine elbow joint. Above mentioned authors gave details for the optimal shoulder positions and flexion angles, and remarks for proper images of the lateral collateral ligament, parts of the medial collateral ligament, the triceps muscle, the pronator teres muscle, antebrachial flexors and erectors. Canine elbow joints have been the object of model studies investigating stiffness changes in immobilized muscles with the use of magnetic resonance elastography (Muraki et al. 2010).

The standard sequences in MRI examinations of the elbow joint are T1, T2 and GE. Signal intensity in the subchondral layer of the bone has been found to be weaker in T1 and T2 than in GE. Sagittal and dorsal planes support accurate imaging of the articular surface of the medial coronoid process. The sagittal plane also facilitates diagnosis of the medial condyle, the trochlear notch and the anconeal process. In all three sequences, healthy articular cartilage shows iso-signal intensity, while healthy ligaments and articular capsules are characterized by low-signal intensity.

3D sequences are particularly useful in MRI diagnostics (Figs. 1, 2). They produce high tissue contrast, and they deliver highly accurate and sensitive data for examinations of bone tissue, cartilage tissue and articular fluid, in particular in large and medium-sized dog breeds (Probst et al. 2008). The MRI techniques supports precise imaging of muscle tissue, and it is used to diagnose muscular dystrophy in golden retrievers as a model breed for investigating Duchenne muscular dystrophy in humans (Thibaud et al. 2007).

Knee joint

In human medicine, magnetic resonance is a standard technique for stifle joint imaging, next to radiography, ultrasonography, computed tomography and arthroscopy (Adamiak 2002, Marino and Luoghin 2010). The standard sequences used in examinations of the canine stifle joint are SE, FSE and STIR. Slice thickness is determined by the size of the dog breed,

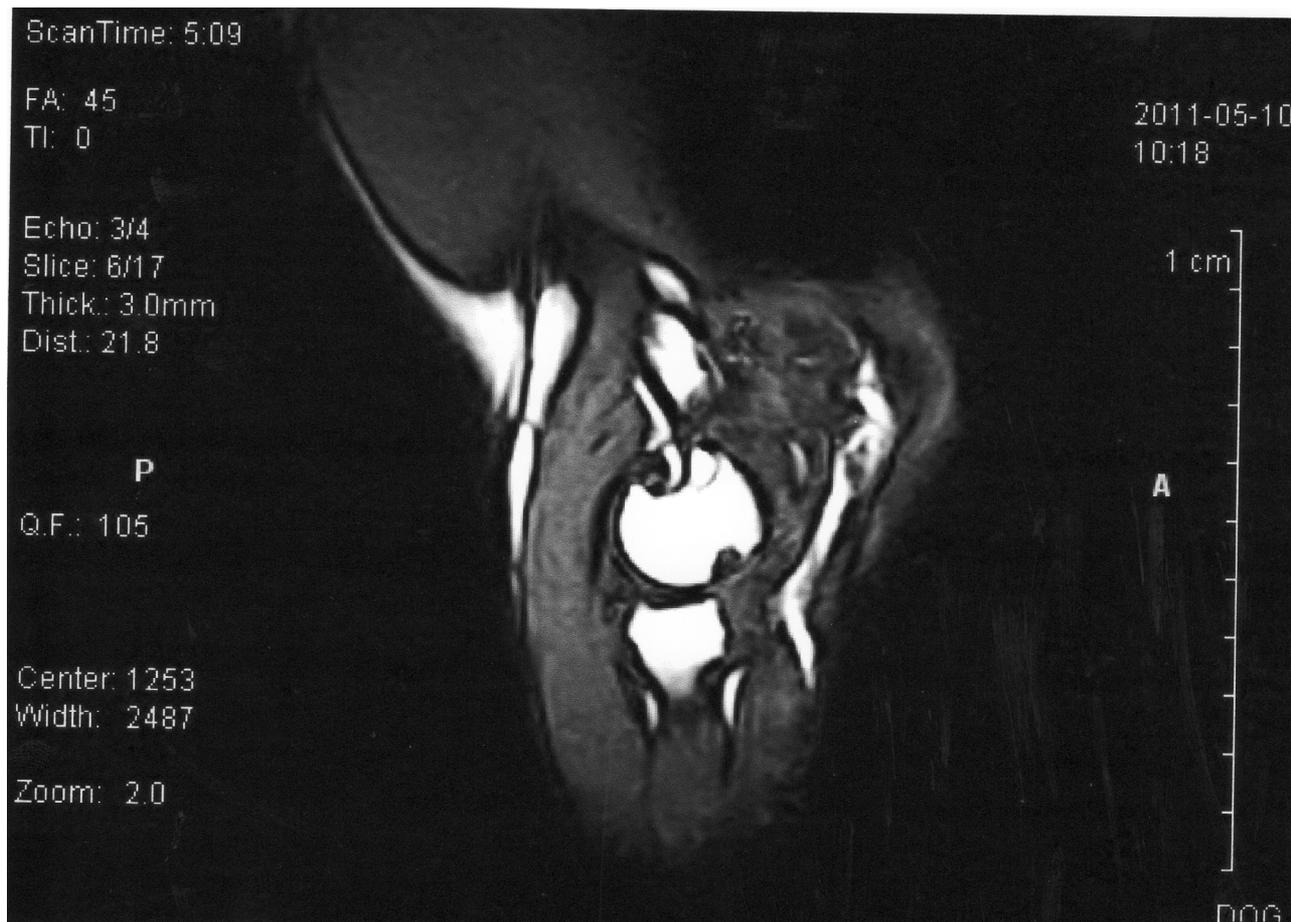


Fig. 1. Magnetic resonance image of the elbow with bone cyst.

and it ranges from 3 to 4 mm. Although MRI techniques for imaging canine limb joints are becoming increasingly available, radiological and arthroscopic examinations are still the predominant methods used in the diagnosis of pathological changes affecting the canine stifle joint (Barret et al. 2009).

MRI supports effective imaging of cranial and caudal cruciate ligaments, menisci, lateral ligaments, intraarticular fluid volume, infrapatellar fat pads and the chondral surface of articular bones. Magnetic resonance facilitates the diagnosis of cruciate ligament damage, meniscus cartilage tear, joint inflammations, degenerative articular changes, subchondral cysts and muscle injuries. Banfield and Morrison (2000) has shown, that in order to increase accuracy of stifle imaging in MRI arthrography can be done. Blond et al. (2008) informed that sensitivity of MRI for meniscal tears diagnosis was 100%. Similar observation reported Bottcher et al. (2010) and their results for meniscal tears were 95%. Stahl et al., (2010) described effectiveness of MR imaging for gastrocnemius musculotendinopathy in dogs. MRI is also an effective technique for imaging neoplastic tumors in the area of the stifle joint and the articular capsule.

Magnetic resonance imaging is still a more popular and a more acclaimed diagnostic technique for imaging limb joints in humans than in veterinary medicine. Nevertheless, the number of practical MRI applications in the treatment of horses, dogs and cats increases every year. In veterinary medicine, MRI methods are becoming part of mainstream practice in the diagnosis of canine joint disorders. Magnetic resonance techniques support imaging of all canine limb joints. The selection of the three joints discussed in this paper was dictated by the fact that these regions are most frequently investigated with the involvement of MRI.

In small animal practice, low-field MRI systems (up to 0.5 Tesla) are used in diagnoses of the joints and the skeletal system. Low-field scanners are much less expensive than high-field systems, and the relevant maintenance and service charges are also much lower in comparison with high-field scanners. Technical progress and the introduction of new sequences to low-field MRI systems will contribute to the popularity of MRI in veterinary diagnostics.

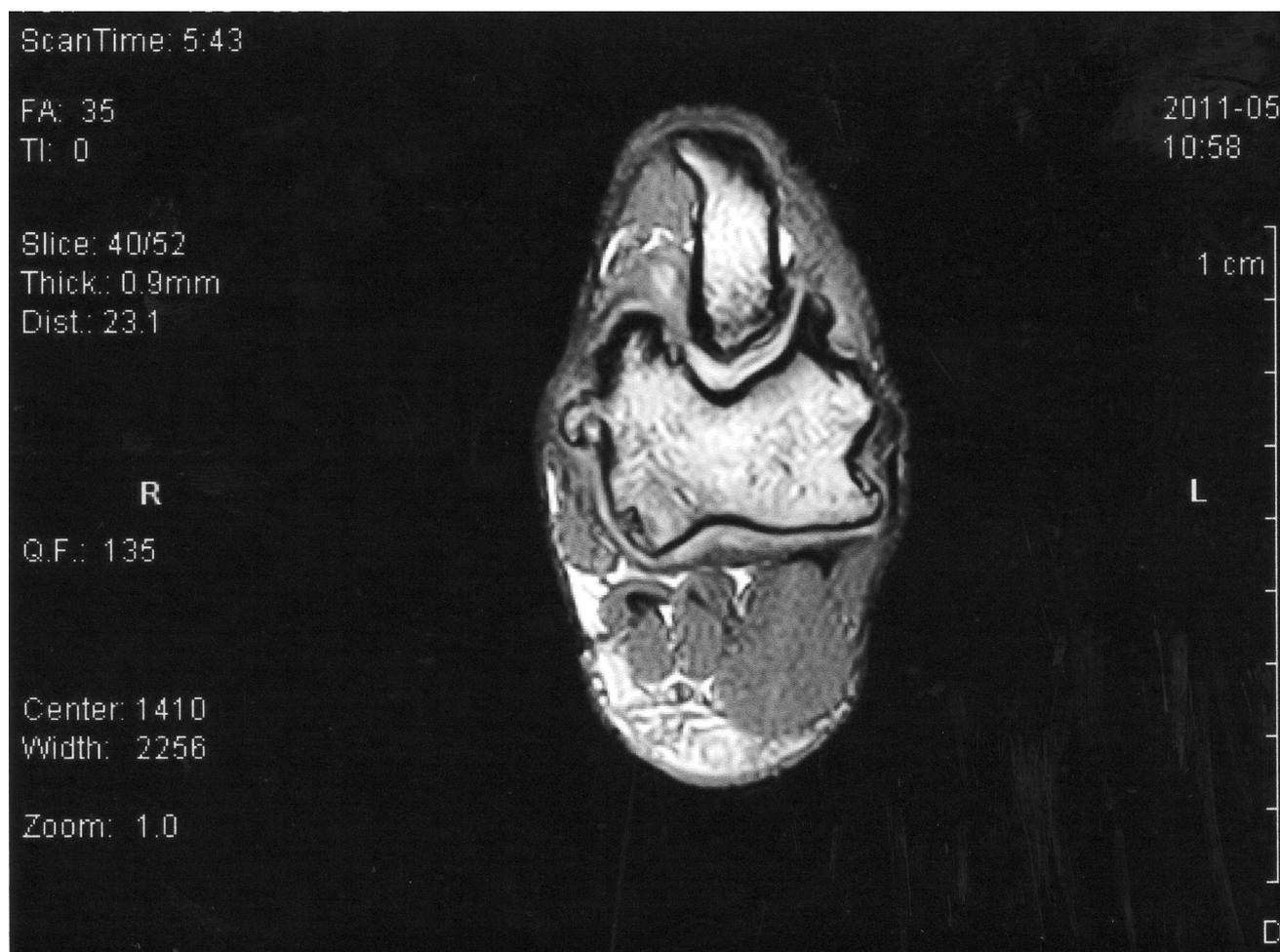


Fig. 2. Magnetic resonance image of the elbow with arthritic changes.

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