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Original article

Comparison of High Resolution Gradient Echo, XBONE T1, XBONE T2, Spin Echo T1 and 3D SST1 magnetic resonance imaging sequences for *imagining* the canine elbow

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Abstract

Twenty canine elbows were examined by low-field MRI. The objective of this study was to compare five magnetic resonance sequences: High Resolution Gradient Echo in the sagittal plane, XBONE T2 in the sagittal plane, Spin Echo T1 in the sagittal plane, Spin Echo T1 in the dorsal plane and 3D SST1 and XBONE T1 in the transverse plane, and to determine which sequences have the highest diagnostic value in imagining the canine elbow. High Resolution Gradient Echo, XBONE T2 and Spin Echo T1 sequences in the sagittal plane proved to be very useful in evaluations of osseous structures such as the medial coronoid process, the anconeal process of the ulna and joint surfaces. The above sequences facilitate evaluations of radial extensor muscle of the wrist, biceps brachii muscle, triceps brachii muscle and the flexor carpi ulnaris muscle. 3D SST1 and XBONE T1 sequences in the transverse plane produce high-quality images of the medial humeral condyle and surfaces of the elbow joint. Those sequences are also useful for evaluating the surrounding muscles: extensor digitorum communis muscle, extensor carpi radialis muscle, deltoid muscle, biceps brachii muscle, pronator teres muscle and flexor carpi ulnaris muscle. The Spin Echo T1 sequence in the dorsal plane facilitates assessments of joint surfaces, medial humeral condyle, superficial digital flexor muscle, deep digital flexor muscle, triceps brachii muscle and extensor digitorum lateralis muscle. The Spin Echo T1 sequence in the sagittal plane has a short scan time, but it produces images of lower quality than High Resolution Gradient Echo and XBONE T2 sequences in the sagittal plane.

Key words: magnetic resonance imaging (MRI), canine elbow

Introduction

The canine elbow is a hinge joint with an articular capsule that constitutes the articular cavity. In human medicine, MRI is the method of choice for diagnosing diseases of the elbow joint and other joints with cavities (Dalinka et al. 1989, De Smet et al. 1990, Hayes and Conway 1992, Hodler et al. 1992, Heron and Calvert 1992, Recht and Resnick 1994, Hill et al. 2000, Sahin and Demirtas 2006, Adamiak et al. 2011,

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de Bakker et al. 2014). In humans, MRI supports evaluations of loose cartilage bodies in joints and collateral ligaments of joints (Hill et al. 2000).

MRI is rarely used to examine elbow joints in veterinary medicine, and therefore there is a general scarcity of publications describing the application of MRI in the above diagnostic procedure (Van Bree and Gielen 2008, Cook and Cook 2009, Baeumlin et al. 2009, Klumpp et al. 2010, Adamiak et al. 2011).

The diagnostic capacity of older imaging methods, radiological techniques and CAT scans, is limited to osseous structures of the elbow joint. MRI supports detailed analyses of the soft tissues of the elbow joint, including ligaments, the articular capsule and synovial fluid, as well as muscles (Herzog 1993).

The objective of this study was to compare five low-field MRI sequences, and to determine which sequences have the highest diagnostic value in imaging the canine elbow joint.

Materials and Methods

The experiment was performed on 20 elbow joints of 10 dogs of both sexes, aged 12 months to 5 years, with body weight of 10 to 30 kg. The patients' medical history and the results of clinical, orthopedic and radiological examinations did not reveal pathological changes in the region of the elbow joint. Low-field MRI scans of the elbow joint were performed in the Esaote Vet-MR Grande 0.25T veterinary MRI system with a permanent magnet in Department of Surgery and Radiology. The patient was positioned on the right side during examinations of the left elbow joint, and on the left side during examinations of the right elbow joint. The DPA foot/ankle coil was used during the MRI examination.

All patients were prepared for general anesthesia before the MRI examination. They were premedicated with atropine at 0.04 mg/kg BW. Fifteen minutes later, the patients were administered medetomidine at 10 μg/kg BW IM and butorphanol at 0.1 mg/kg BW IM. General anesthesia was induced by intravenous administration of ketamine at 3-5 mg/kg BW and diazepam at 2.2 mg/kg BW. Anesthetized animals were placed in Faraday's cage and positioned inside the MRI coil. The dogs were supervised by the anesthesiologist throughout the procedure. The diagnostic procedure was completed in 35 to 40 minutes.

Every examination began with the Scout sequence that lasted around 12 minutes. The following sequences were then applied: High Resolution Gradient Echo in the sagittal plane, XBONE T2 in the sagittal plane, Spin Echo T1 in the sagittal plane, Spin Echo T1 in the dorsal plane, 3D SST1 and XBONE T1 in the transverse plane. Slice thickness was 2 mm and the slice gap was 0 mm in all sequences. All images were processed with the use of Esaote software.

Results

The study demonstrated that Coil 4, which is used for foot and ankle scans in human medicine, supports examinations of the elbow joint in three planes: transverse, sagittal and dorsal.

High Resolution Gradient Echo, XBONE T2 and Spin Echo T1 sequences in the sagittal plane proved to be highly useful in evaluations of osseous structures such as the medial coronoid process, anconeal process of the ulna and joint surfaces. The above sequences facilitate examinations of radial extensor muscle of the wrist, biceps brachii muscle, triceps brachii muscle and the flexor carpi ulnaris muscle (Fig. 1). 3D SST1 and XBONE T1 sequences in the transverse plane produce high-quality images of the medial humeral condyle and surfaces of the elbow joint. Those sequences are also useful for evaluating the surrounding muscles: extensor digitorum communis muscle, extensor carpi radialis muscle, deltoid muscle, biceps brachii muscle, pronator teres muscle and flexor carpi ulnaris muscle (Fig. 2). The Spin Echo T1 sequence in the dorsal plane facilitates assessments of joint surfaces, medial humeral condyle, superficial digital flexor muscle, deep digital flexor muscle, triceps brachii muscle and extensor digitorum lateralis muscle (Fig. 3). The Spin Echo T1 sequence in the sagittal plane has a short scan time, but it produces images of lower quality than High Resolution Gradient Echo and XBONE T2 sequences in the sagittal plane.

The XBONE T2 sequence in the sagittal plane revealed hyperintense synovial fluid, which facilitated the evaluation of joint surfaces and the hypointense olecranon. A comparison of XBONE T1 and 3D SST1 sequences in the transverse plane indicated that XBONE T1 was a more useful sequence in the transverse plane because 3D SST1 produced a high number of false-positive diagnoses of degeneration of the medial humeral condyle.

Discussion

MRI is a highly sensitive and non-invasive diagnostic method for evaluating soft tissues, joint surfaces and articular cavities (Konig et al. 1987, Solomon et al. 1989, Tervoven et al. 1993, Snaps et al. 1997, Miller 1999, Recht et al. 2005, Janach et al. 2006, Schaefer and Forrest 2006, Agnello et al. 2008, Probst et al. 2008, Gold et al. 2009, de Bakker et al. 2014).

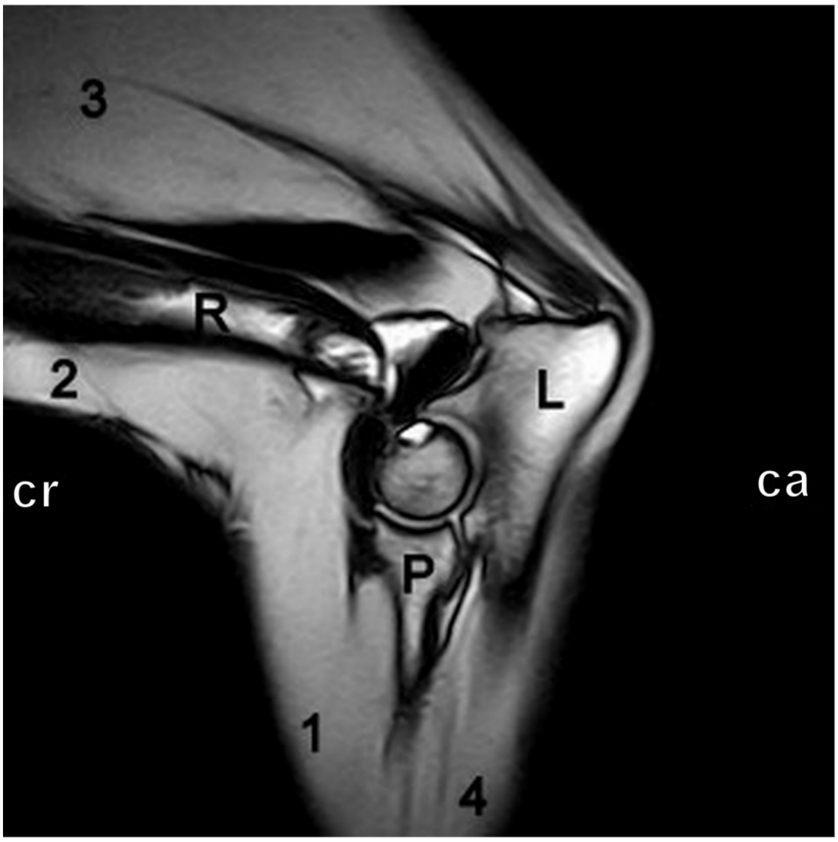

Fig. 1. High Resolution Gradient Echo sequence in the sagittal plane. R – humerus; L – ulna; P – radius; 1 – extensor carpi radialis muscle; 2 – biceps brachii muscle; 3 – triceps brachii muscle; 4 – flexor carpi ulnaris muscle.

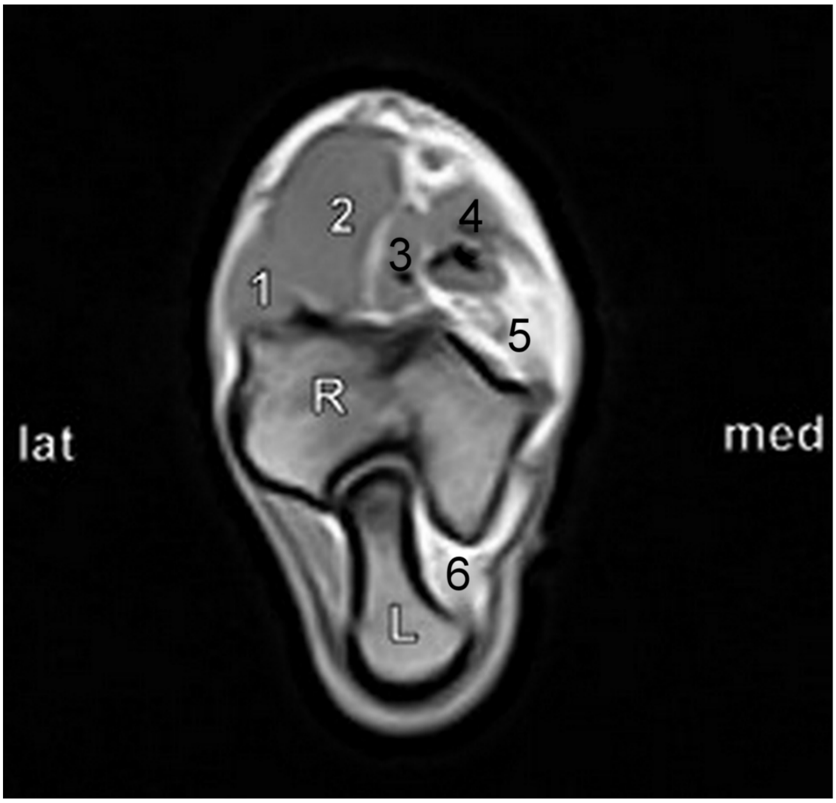

Fig. 2. XBONE T1 sequence in the transverse plane; R – humerus; L – ulna; 1 – extensor digitorum communis muscle; 2 – extensor carpi radialis muscle; 3 – deltoid muscle; 4 – biceps brachii muscle; 5 – pronator teres muscle; 6 – flexor carpi ulnaris muscle.

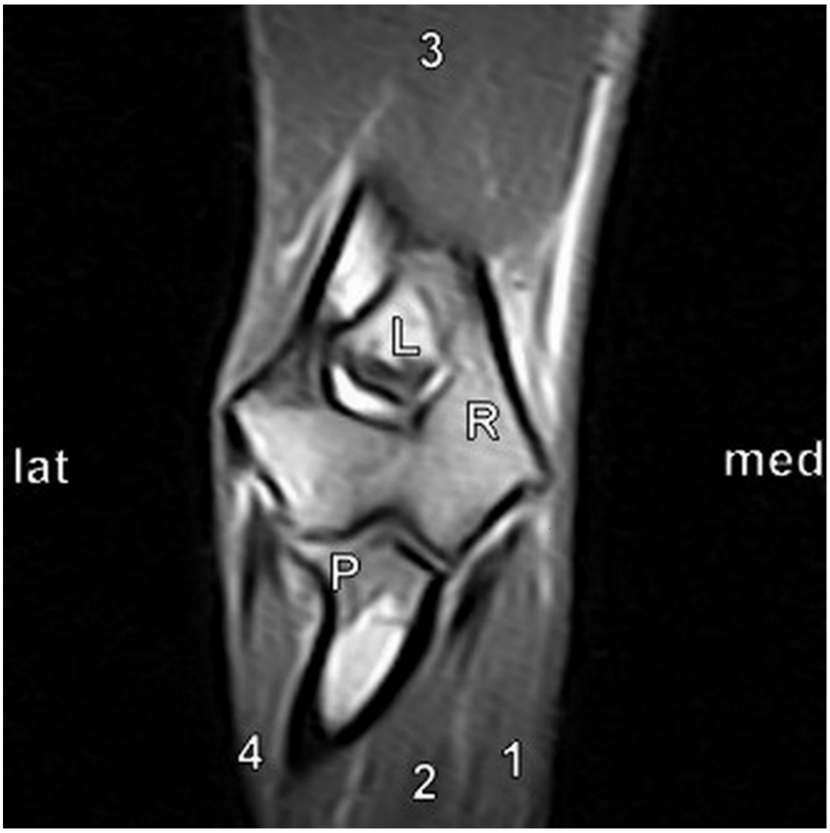

Fig. 3. Spin Echo T1 sequence in the dorsal plane. R – humerus; L – ulna; P – radius; 1 – superficial digital flexor muscle; 2 – deep digital flexor muscle; 3 – triceps brachii muscle; 4 – extensor digitorum lateralis muscle.

In MRI exams, the joint can be examined in multiple imaging planes without the need to manipulate the patient, which is one of the greatest advantages of this diagnostic technique. The patient is positioned at the beginning of the test and remains immobilized until the end of the exam. Incorrect positioning results in images with no diagnostic value.

In the experiment, slice thickness was 2 mm and the slice gap was 0 mm. According to Reichle and Snaps (1999) and Adamiak et al. (2011), slices thinner than 2 mm in Spin Echo T1 and T2 sequences produce signals of lower quality. Slice gaps of 0 mm eliminate the risk that pathological changes in the joint will be disregarded.

Images of the elbow joint produced by the Spin Echo T1 sequence in the sagittal plane were characterized by low diagnostic value. The above sequence has a short scan time. According to Baeumlin et al. (2009), T1-weighted sequences produce high-quality images of anatomical structures in the elbow. T2-weigthed sequences deliver less detailed images, but support diagnoses of cartilage defects. XBONE T1 and 3D SST1 sequences in the transverse plane facilitate detailed evaluations of the articular cavity and surfaces of the elbow joint.

During the experiment, the flexor carpi ulnaris muscle, biceps brachii muscle, triceps brachii muscle and extensor carpi radialis muscle were well visualized by sequences in the sagittal plane, but tendons of the extensor carpi radialis muscle and flexor carpi ulnaris muscle were weakly visible. According to Baeumlin et al. (2009), biceps brachii and triceps brachii muscles and their tendons are best visualized by sequences in the sagittal plane, whereas tendons of extensor muscles of the wrist and the lateral collateral ligament – by sequences in sagittal and dorsal planes.

Various imaging techniques are used to diagnose the canine elbow joint (Cook and Cook 2009). MRI examinations of the canine elbow joint have not yet entered the mainstream in veterinary practice. One of the greatest advantages of this non-invasive technique is that it can be used to evaluate the elbow joint in multiple imaging planes. MRI also supports a comprehensive assessment of soft tissues surrounding the elbow joint (Soler et al. 2007, de Bakker et al. 2014).

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