# Development of a Low Field MRI System for Small Animal Veterinary Diagnosis

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We describe the physics and engineering aspects of the development of a low cost 0.2 Tesla MRI suitable for small animal veterinary diagnosis. The areas covered include B0 field stabilization to counteract thermal drift; RF coils design, including distributed capacitance solenoids and surface coils; patient table design; a new design of PC-based MR console; imaging methods for dog and cat brain and spine. Following the current development and testing phase, the system will be permanently installed in a veterinary college, in early spring 2002. The low field technology developed also has applications in areas such as hyperpolarized gas imaging; interventional MRI and multi-modal studies.

## Introduction

The primary purpose of this work was to develop a low cost MRI suitable for small companion animal veterinary diagnosis, for siting in an animal teaching hospital. A secondary aim is to develop low field MR techniques for other applications, such as interventional surgery and hyperpolarized gas MRI.

## Methods

***Magnet System:*** The system is based around an existing four-poster (vertical field) 0.2 T permanent magnet, with a 27cm diameter imaging volume and a 45cm gap available for rf coils, patient and patient bed. Magnet covers, patient bed, and positioning devices are being custom designed in house.

***Field Stabilization:*** The field strength of a permanent magnet is sensitive to environmental and gradient-induced heating, so a system employing a B0 correction coil was designed. An automated field stabilization algorithm based on the monitoring of temperature at multiple points on the magnet structure was used to predict field drift and hence the required correction current. This system can operate during long imaging acquisitions without need for NMR measurement of the resonant frequency.

***RF Coils for "All Creatures Great and Small"*** The great challenge of veterinary MRI is the diversity of patient size, shape and anatomy; consequently a wide range of RF coil designs has been investigated. The most successful coil developed is the distributed capacitance solenoidal coil, of which a number in a range of sizes have been constructed for brain, body and spine imaging. Variable size coils have also been developed.

***Control Electronics and Software:*** The design of the console has been described elsewhere (1). The system is PC-based, with conventional analogue rf electronics, operating at a fixed frequency of 8.6 MHz for protons at 0.2 Tesla. This is a simplified version of a system being designed for research use.

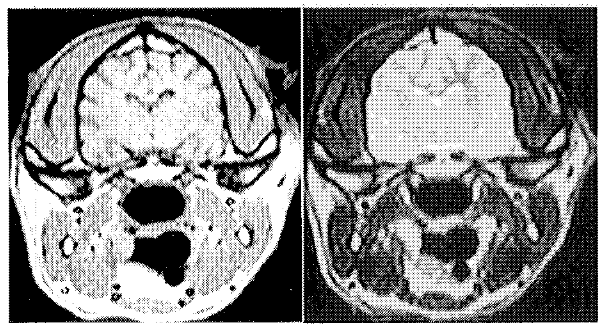
***Imaging Methods:*** Gradient-echo, spin-echo and fast-spin-echo sequences have been implemented. Gadolinium enhancement is used when a suspicious lesion is seen on T1 or T2 scans. All animals are ventilated and anaesthetized using gas inhalation. Synchronization of ventilator rate with the sequence TR allows artifact-free abdominal images to be obtained.

## Results

To date 22 animals have been imaged, primarily dog brain, but also cat brain and dog spine. The animals were referred from local veterinary practices, the most common symptoms being seizures of unknown origin.

## Discussion

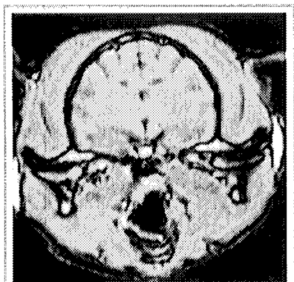
Both dog and cat T1 and FSE T2 brain images are of high and diagnostic quality. We continue to work on achieving narrow slice thicknesses for spine imaging to allow three sagittal slices through the cord for the smallest patients. The 0.2T permanent magnet system is proving to be very feasible for straightforward veterinary diagnostic applications.



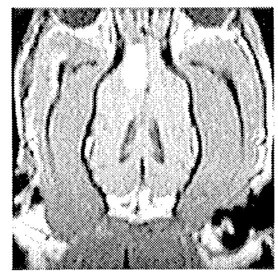
**T1-weighted spin-echo:** TR= 500ms, TE=19ms, Aves=10 imaging time 10.6 min.

**T2-weighted FSE**: TR=4200 ms, Eff. TE=90ms, ETL= 8, Aves=12, imaging time=13 min

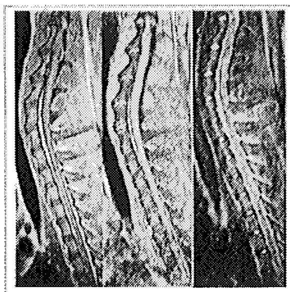
Other: 1.5 years dog, 12kg male Sheltie. 0.2 Tesla, FOV= 130mm, 128x128, slice= 3.5mm, Resolution=1.01 mm, BW= 10kHz. 16 slices



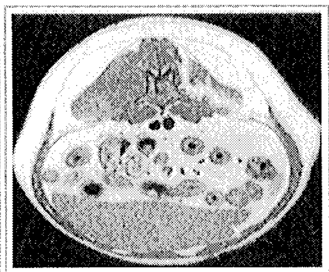
**Cat Head:** 3D T1-weighted GE (128 x 128 x 32) 0.86 x 0.86 x 2mm TE/TR=16/60ms, FA=60deg Aves=2, BW= 5 kHz Total imaging time 8.2 min



**Brain Tumour in 12 years old dog, 80lb:** 0.2T T1-w SE after contrast agent injection. TE/TR=19/460ms, FOV= 160mm, 9.8min, 128x128, sl= 3.5mm, BW = 10kHz, 10 Aves



**(a)** SE 19/467ms; 270mm; 3mm; 256x256, 16 min.
**(b)** GE 12/467ms; 270mm; 3mm; 256x256; 12min.
**(c)** FSE 90/3750ms, ETL=8, 300mm 256; 3mm, 16 min.
**12kg Sheltie**



**Abdomen of 6 years old male Cocker- Spaniel**
1 mm x 1mm x 3.5 mm 256x256
T1w spin-echo BW=20kHz
TE/TR=19/430 ms Aves=6
Total imaging time 11 min.

**Acknowledgements**: MRV Systems, Allan Turner
**References**: J.C.Sharp et al. p.1046, ISMRM 2001