Optimising the MRI Protocol for Imaging of the Canine Stifle Meniscus Using a Low Field System

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ABSTRACT

A study was undertaken to determine the optimal protocol for MRI of the medial meniscus in dogs. Using a 0.2T MRI scanner the factors of image quality, positioning, sequence, coil choice, time and orientation were altered and compared to enable the optimal combination to be found. Image quality and time were deemed to be the most important factors and risk benefit analysis was undertaken to conclude which combination produced the image quality in the quickest time. The optimal combination was found to be T1 turbo 3D arthrogram in sagittal and dorsal planes with the dog on lateral recumbency.

INTRODUCTION

Joint MRI in humans is recognised as the gold standard for imaging of articular cartilage, subchondral bone, meniscus and ligament tears[1-4]. MR arthrography in humans is also used for supplemental imaging of the meniscus, cartilage and loose intraarticular bodies [5-7]. In dogs high field MRI was proven to be 100% sensitive to detect meniscal tears[8,9.] Low field MRI studies of the stifle 10 in dogs with experimental cranial cruciate ligament ruptures detected subchondral bone cysts[11] and was successful in detecting meniscal pathology[12]. MR arthrography did not provide any additional information on the meniscus of normal canine joints[13].

METHODS AND MATERIALS

The study consisted of two sections, of which the first was with using cadaver specimens and the second was with dogs with naturally occurring cranial cruciate ligament rupture. The cadaver specimens were from dogs euthanazied for some unrelated reason and had no stifle pathology. Each cadaver was scanned immediately following euthanasia to reduce any artefact formation. The various factors examined were

1. Positioning of the limb in the coil were there were three options lateral, dorsal and ventral recumbency.
2. Orientation or plane of the scan being sagittal, dorsal or transverse. This altered depending on the position of the limb.
3. Choice of coil of which there were 6 choices including wrist, knee, elbow.
4. Sequence chosen which includes Spin Echo T1, T2, Proton density, Gradient echo STIR, Turbo T1 3D, and arthrography (Table 1)

Table 1 Comparison of the sequence details

Sequence	Average Time		Average number slices of meniscus		TR	TE	Nex	Matrix	FOV
	Dorsal Min	Sagittal Min	Dorsal	Sagittal					
T1 3D	4.20	4.20	10	10	47	20	1	192*184	240*230
T1	1.37	1.37	3	3	490	18	1	192*192	200*200
T2	5.33	5.33	5	5	3000	100	1	192*184	200*200
PD	8.57	8.57	4	4	2800	28	1	192*192	220*220
GE STIR	9.14	9.14	3	3	300	16	1	192*108	130*110

5. Time or length of the scan, were the aim was to have the shortest time scanning possible.
6. Image quality which was determined not just by clarity of image but also by the number of slices

As the image quality was considered the main goal of the study it was used as the aim of the studies in the cadaver specimens. Image quality was directly controlled by the positioning, orientation, coil choice and sequence. As a combination, positioning and orientation were chosen first as the foundation for further studies. Sequences were then painstakingly followed through in all planes to produce images for comparative examination. Finally time or length of the scan was added as a factor and the risk benefit analysis of image quality and time were determined to reach an optimal combination. The combination reached after the cadaver studies was then used to scan dogs with naturally occurring cranial cruciate ligament ruptures. Further adjustments were made to improve the image quality and length of the scan from the studies in the dogs.

RESULTS

The best position was found to be lateral recumbency with affected limb uppermost. The position of dorsal recumbency was also useful but at times in some dogs it was difficult to maintain good limb positioning within the coil. Orientation in the transverse plane, which is parallel to the plane of the meniscus was not found to be useful, so only the planes of sagittal and dorsal were used. The best coil was found to be the knee coil. Image quality was comparable between T2 and proton density sequences, but was not satisfactory in STIR sequences. T1 weighted images also had good image quality even though the meniscus was not as hypointense as the T2 weighted images (Fig 1). 3D sequences had 3 times as many slices as other sequences. MR arthrography produced very good images of the meniscus (Fig 2). The times of the various sequences in 2 planes show that T1 images were by far the fastest (Table 1).

DISCUSSION

High field MRI has been established as an excellent mode of imaging for the human knee. Low field MRI systems have many advantages compared to the high field MRI for veterinary practices. An increasing number of veterinary practices have a low field MRI scanner on site. The signal to noise ratio is significantly lower in low field systems compared to high field systems so images are of higher resolution in the latter. The limitations of the low field MRI scanner and in particular the coil size have led to the need to develop new approaches to scanning veterinary patients, which has led to increased quality of images. There is a need for a noninvasive method to image the medial meniscus in the dog due to high incidence of tears associated with rupture of the

Fig 1 *T1 Sagittal view of medial meniscus*

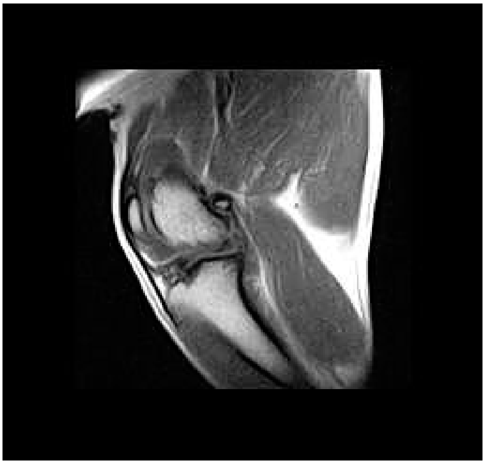
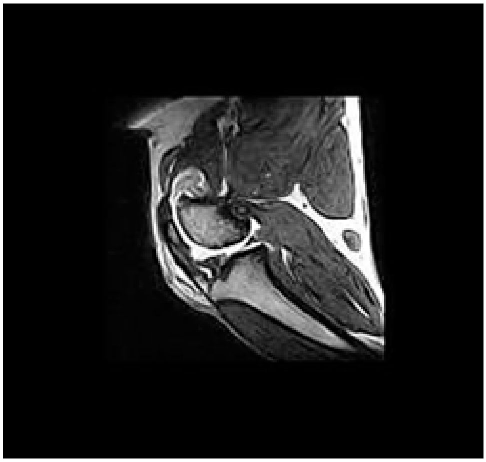


Fig 2 *T1 Turbo 3D arthrogram sagittal view of medial meniscus*



cranial cruciate ligament, and the difficulties associated with surgical access to the medial meniscus. Currently MRI is the only proven imaging modality that accurately provides an image of a canine torn meniscus between MRI, CT[14-16] and ultrasound.

The recommended scanning protocol in the human knee specifically to image the meniscus is Fast Spin Echo Proton Density fat saturated in three planes with possible additional sagittal T2* Gradient Echo and also a T1 sequence. Another option is 3D volume sequence to reduce scan time with minor loss of quality in high field scanners. For dogs the recommended sequence using a low field system is a gradient echo T2* because the TE time is short and therefore the SNR is maximised[17]. In the report by Harper and authors (2011) the slice thickness was 3mm and partial volume averaging could be a concern[17]. Other options in dogs include STIR, T2 and proton density using high field systems[18]. Volume imaging has been recommended in human MRI of joints as an alternative to slice sequence when the slices are small (2-5mm) to reduce the partial volume artefact [19,20]. By using a 3D T1 sequence the scanning time is reduced with smaller voxel size allowing for a multiplanar reconstructed image of good quality[19,20]. This recommendation is in agreement with our findings in this investigation were we found the 3D T1 sequence produced the shortest scan whilst maintaining image quality.

In this study we have found three factors which have improved the usefulness of low field MRI in medial meniscus imaging. The first is the length of the scan and we have been able to reduce this to 8 minutes 50 seconds, compared to 60[17] and 75[13] minutes in a previous study. Secondly the number of slices which we have shown can be achieved is up to 10 slices using 3D compared to 5 or less with other sequences. The final and third factor is the use of contrast which allows for better image quality whilst maintaining a short scan time.

REFERENCES

1.Grainger AJ, Elliott JM, Campbell RS. Direct MR arthrography: a review of current use. *Clin Radiol* 2000;55:163-176

2. Murphy WA, Trotty WG. Musculoskeletal magnetic resonance imaging *Magn Reson Annu* 1986, 1-35

3. Rubin DA, Paletta GA jr. Current concepts and controversies in meniscal imaging. *Magn Reson Imaging Clin N Am* 2000;8:243-270

4. Crues JV III, Mink J, Levy TL, Lotysch M, Stoller DW. Meniscal tears of the knee:accuracy of Mr imaging. *Radiology* 1987;164:445-448

5. Steinbach LS, Palmer WE, Schweitzer ME. Special focus session. MR arthrography. *Radiographics* 2002;22:1223-1246

6. Helgason JW, Chandnani VP, Yu JS. MR arthrography:a review of current technique and applications. *Am J Roentgenol* 1997;168:1473-1480

7. Osinski T, Malfair D, Steinbach L. Magnetic resonance arthrography. *Orthop Clin N Am*

2006;37:299-319

8. Blond L, Thrall DE, Roe SC . Diagnostic accuracy of magnetic resonance imaging for meniscal tears in dogs affected naturally occurring cranial cruciate ligament rupture. *Vet Radiol Ultrasound* 2008;49:425-431

9. Banfield CM, Morrison WB. Magnetic resonance arthrography of the canine stifle joint:technique and applications in eleven military dogs. *Vet Radiol Ultrasound* 2000;41:200-213

10. Baird DK, Hathcock JT, Rumph PF. Low field magnetic resonance imaging of the canine stifle joint:normal anatomy. *Vet Radiol Ultrasound* 1998;39:87-97

11. Baird DK, Hathcock JT, Kincaid SA. Low field magnetic resonance imaging of early subchondral cyst-like lesions in induced cranial cruciate ligament deficient dogs. *Vet Radiol Ultrasound* 1998;39:167-173

12. Martig S, Konar M, Schmokel HG. Low field MRI and arthroscopy of meniscal lesions in ten dogs with experimentally induced cranial cruciate ligament insufficiency. *Vet Radiol Ultrasound* 2006;47:515-522

13. Pujol E, Van Bree H, Cauzinille L, Poncet C, Gielen I, Bouvy B. Anatomic study of the canine stifle using low field magnetic resonsnce imaging (MRI) and MRI arthrography. *Vet Surg* 2011;40:395-401

14. Tivers MS, Mahoney P, Corr SA. Canine stifle positive contrast computed tomography arthrography for assessment of caudal horn meniscal injury:a cadaver study. *Vet Surg* 2008;37:269-277

15. Samni V, Dyce J, Pozzi A. Computed tomographic arthrography of the stifle for detection of cranial and caudal cruciate ligament and meniscal tears in dogs. *Vet Radiol Ultrasound* 2009;50:144-150

16. Tivers MS, Mahoney P, Baines S. Diagnostic accuracy of positive contrast computed tomography arthrography for the detection of injuries to the medial meniscus in dogs with naturally occurring cranial cruciate ligament insufficiency. *J Small Anim Pract* 2009;50:324-332

17. Harper TAM, Jones JC, Saunders GK, Daniel GB, LeRoth T, Rossmeisl E. Sensitivity of low field T2* images for detecting the presence and severity of histopathologic meniscal lesions in dogs. *Veterinary Radiology& Ultrasound* 2011;52:428-435

18. Galvin PR, Bagley RS. Orthopedic. *In Practical Small animal MRI.* Wiley-Blackwell, Iowa. 2009;233-273.

19. Boesen M, Ostergaard M, Cimmino MA, Kubassova O, Jensen KE, Bliddal H. MRI quantification of rheumatoid arthritis:Current knowledge and future perspectives. *European Journal of Radiology* 2009;71:189-196

20. Qazi AA, Dam EB, Nielson M, Karsdal MA, Peterson PC, Christiansen C. Osteoarthritic cartilage is more homogenous than healthy cartilage: identification of a superior region of interest colocalised with a major risk factor for osteoarthritis. *Acta Radiol* 2007;14:1209-20