Magnetic Resonance Imaging : Optimal Cartilage Visualization of Equine Distal Interphalangeal Joint Cartilage

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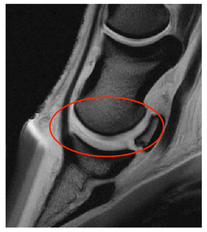
A specific equine cartilage MRI protocol is necessary

Osteoarthritis of the distal interphalangeal joint (DIPJ) is a common problem affecting horses' soundness and well being, but techniques to diagnose early cartilage injury are limited. Magnetic resonance imaging (MRI) is used to diagnose cartilage injury in people and is promising for horses. Differences of cartilage properties between people and horses suggest the need for equine-specific protocols to improve diagnosis of cartilage injuries in horses. We will test MRI hardware (RF coil) and software (pulse sequence) combinations for optimal equine cartilage visualization.



Phantoms were constructed to test MRI protocols

- Constructed six synthetic gel phantoms with equine DIPJ MRI properties
  - 3% carrageenan, 1.6% agarose, 35 μM GdCl3
- Tested twelve MRI protocols with following software/hardware combinations:

MRI hardware: **Radiofrequency (RF) Coil**

Knee coil | 3" Surface coil | 5" Surface coil

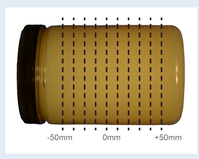
MRI software: **Pulse Sequence**

FastSpin Echo	Gradient Echo
FSE TR4400 TE15	FSPGR TR190 TE12 FA20
FSE TR4400 TE15 FatSat	FSPGR TR620 TE3 FA90

Other factors affecting image quality

Location in image

Image slice location



- Obtained phantom MR images with protocols above.
- Evaluated image quality using MATLAB software

Evaluation Criteria

Signal-to-noise ratio (SNR)

$$SNR = \frac{Signal}{\sqrt{2/\pi} \cdot noise}$$

Image Nonuniformity

$$Nonuniformity = \frac{\sigma}{\mu}$$

Final Image Quality Index (IQ)

$$IQ = \frac{SNR}{Max(SNR)} - \frac{Nonuniformity}{Max(Nonuniformity)}$$

Hypotheses

- 3" Surface coil will generate best SNR but worse image uniformity
- Knee coil will provide best image uniformity but worst SNR
- One pulse sequence will have better SNR and image uniformity than others.

All factors significantly affect image quality

- Coil, pulse sequence, location within image, and slice location all have significant impact on SNR, image uniformity, and image quality index.

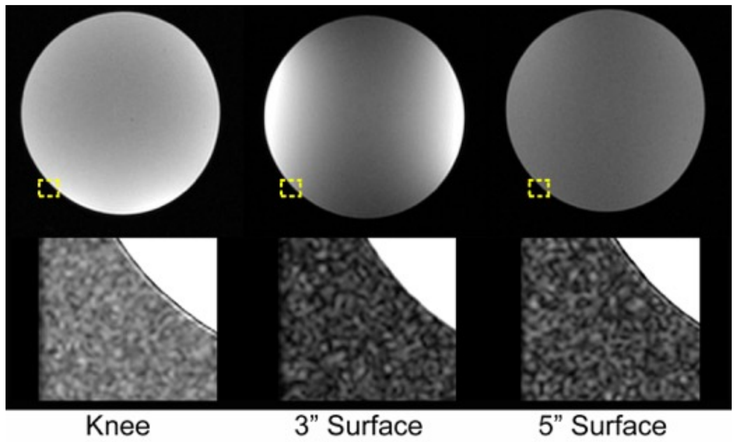


Figure 1. Radiofrequency coils and their effects on MR images. The upper row are images taken with the same pulse sequence, slice location, and phantom. 3" Surface coil (center image) has the least uniform signal across the image with varying image quality between regions. The lower row images are magnified and adjusted to depict background noise. The 3" Surface coil has the least noise, while Knee coil generates the most noise.

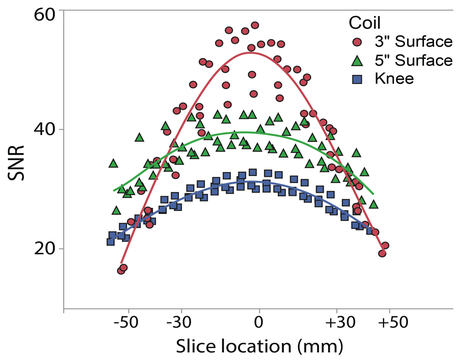


Figure 2. SNR as a function of coil and slice location. Slice location is the distance between each image and the center of the study object. 3" Surface coil has the best SNR in the central 60 mm of the phantom, and the 5" Surface coil has better SNR at the margins of the phantom

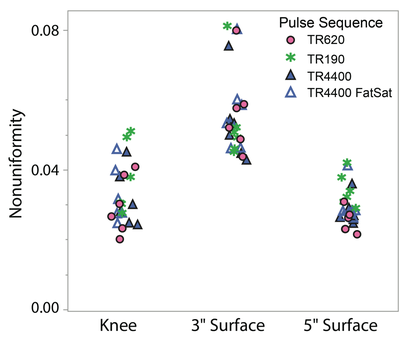


Figure 3. Image nonuniformity as a function of coil and pulse sequence. 3" Surface coil has the highest image nonuniformity, which significantly deteriorates image quality. There is no significant effect of pulse sequence on nonuniformity.

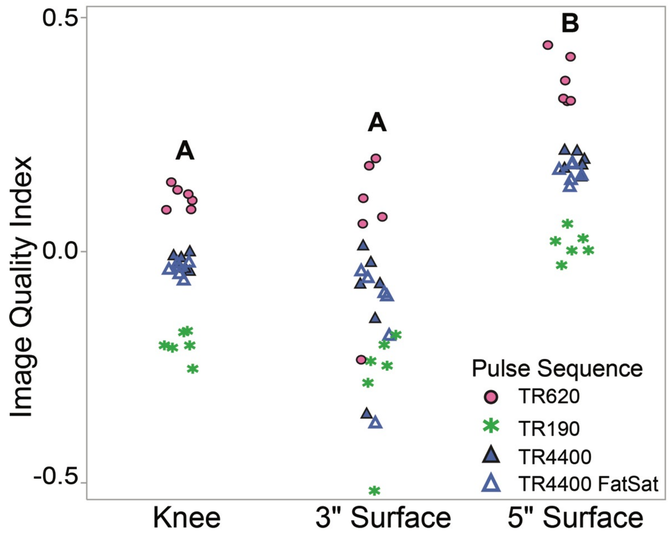


Figure 4. Image Quality Index (IQ) for coils and pulse sequences. The 5" Surface coil and pulse sequence FSPGR TR620 TE3 FA90 have the highest IQ.

5" Surface coil and TR620 have superior image quality

- Pulse sequence FSPGR echo TR620 TE3 FA90 is superior to others. It gave excellent SNR and good image uniformity.
- 5" Surface coil provided the best overall image with great SNR and excellent image uniformity.
- We recommend the 5" Surface coil and FSPGR TR620 TE3 FA90 pulse sequence as the MRI protocol for the next experiment phase.

Future Research

The results of this study will be carried on to the next phase of the project to test the best protocol for visualization of cartilage in equine cadaver limbs as judged by board-certified veterinary radiologists.

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