High-resolution in vivo MR imaging of mouse knee on a whole-body 3-Tesla system

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Introduction

Recently there has been advancement in new therapies for arthritis [1]. However, the repair response from these therapies cannot be rigorously evaluated in humans. Although small animal studies have been shown to be useful for testing repair response, there is a lack of longitudinal studies following therapeutic treatment. In this study, we developed a high-resolution MR imaging technique for imaging mouse knee that enables longitudinal studies in mice. In vivo monitoring of the same animal over time should decrease data variability from different animals, and reduce the number of animals necessary for each study. We conducted our study on a clinical 3-Tesla system that 1) gives higher SNR compared to conventional 1.5T clinical systems, and 2) provides larger bore access than animal magnet systems allowing potential parallel imaging of multiple mice. We designed and built a dedicated RF coil for imaging mouse knee, and developed high resolution pulse sequences to support the high image spatial resolution needed. Normal wild-type mice and transgenic mice with inflammatory arthritis were studied and their results compared.

Methods

The study was conducted on a Siemens TRIO whole body 3.0T MRI scanner after approval from the Institutional Animal Care and Use Committee of our institution. A dedicated RF coil was designed and constructed for imaging adult mouse knee (Fig. 1). The coil is made up of a 1.5cm diameter circular loop consisted of two parallel gauge-14 copper wires. The mouse knee is inserted through the coil. This simple design was found to give the optimal SNR while providing sufficient volume coverage of the joint. Three-dimensional FLASH (spoiled GRASS) sequence was used to obtain T1-weighted images. Due to the spatial resolution limitation in the manufacturer's sequence, the 3D-FLASH sequence was modified for higher resolution by utilizing the maximum gradient strength of 40mT/m in each orthogonal direction in non-oblique prescription. Imaging parameters are TR 45ms, TE 9.03ms, flip angle 25^0, FOV 20mm x 20mm, 192x192 pixels, slice thickness 0.16mm, receiver bandwidth 130Hz/pixel, signal averaging 1, and scan time 8:28 minutes. The spatial resolution is 104x104x160 microns. Nine month old wild-type mice and transgenic mice with inflammatory arthritis were imaged. Contrast enhanced scans were performed in which GdDTPA:PBS diluted to 1:10 ratio was injected via the tail vein at 0.1ml per 20g weight of the mice.

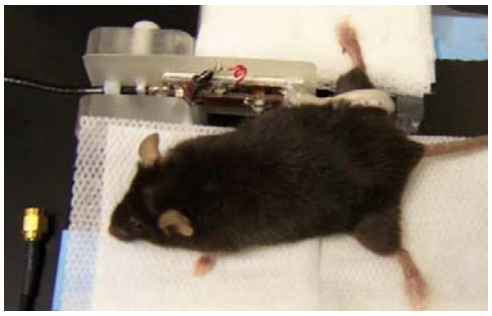
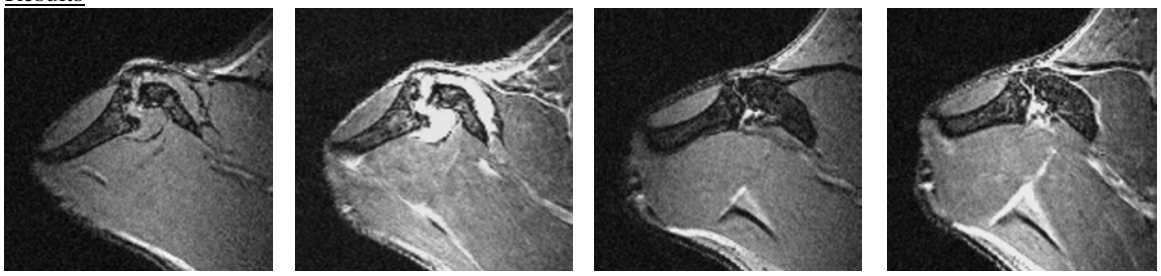


Figure 1. Photo of the RF coil setup with an anesthetized mouse.

Results



1a 1b 2a 2b

Figure 2. Knee images of transgenic (1) and wild-type (2) mice without (a) and with (b) contrast enhancement. Large pannus and serious bone erosions are observed in the transgenic mouse.

Discussion & Conclusion

This study demonstrates that arthritis changes in mouse knee joint can be clearly visualized on a clinical 3T scanner with the use of a dedicated RF coil and high resolution 3-D FLASH pulse sequence. In theory, imaging small objects at 3T increases SNR by more than a factor of two over 1.5T, and provides higher spatial resolution and image quality. On the other hand, 3-D acquisition enables tissue segmentation for volume measurement, and allows data to be reformatted for 3-D volume rendering. The use of whole-body scanner supports potential parallel imaging of multiple mice for faster scanning. The technique developed in this study should be useful for longitudinal studies of repair response following therapeutic treatment.

Reference

1. Feldmann M, Maini RN. Annu Rev Immunol 2001;19:163-196.