High Field MRI of Musculoskeletal System at 7.0T: SNR, Contrast and Relaxation Times

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Introduction

MRI of the musculoskeletal system is performed at variable field strengths. In academic settings, 1.5T was the gold standard for the last decade. For the last five years, 3.0T scanners have been increasingly utilized. The initial purported reason for increasing static field strength (B_0) was to allow improved functional imaging, predominantly in the subspecialty of neuro-radiology. Later, the improvements in signal-to-noise ratio (SNR) due to field strength (B_0) have led to the rapid utilization of 3.0T for clinical studies in the musculoskeletal system. The field strength of clinical MR systems are likely to increase the further in the near future. Previous measurements of relaxation times at 3.0T & 4.0T showed increases in T_1 relaxation time of 50–90% and decreases in T_2 relaxation time of 5–15% compared with relaxation times at 1.5T [1]. Relaxation times up to 4.0T are currently reported in the literature. However, to our knowledge, no *in vivo* measurements of musculoskeletal system at 7.0T have been reported. Therefore, the purpose of this study is to measure SNR, contrast and relaxation times (T_1 and T_2) in human knee joint at 7.0T whole body scanner.

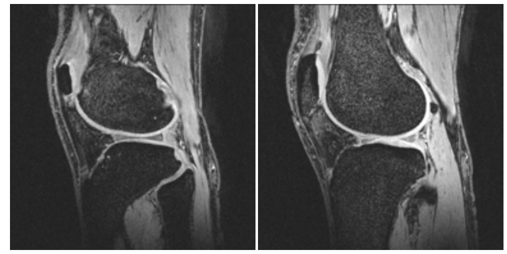

Fig. 1: Two slices from 3D high res. knee scan

Methods

5 asymptomatic volunteers (3 male and 2 female) were recruited in this study which was approved by the Institutional Review Board of New York University Medical Center. All MRI experiments were performed on a 7.0T whole body scanner (Siemens Medical Solutions, Erlangen, Germany) with 1mm slice thickness. We employed a transmit/receive 18 cm diameter birdcage knee coil (*In vivo Corp.,* FL) in this study. High resolution 3D sagittal images of the knee joint were acquired using a 3D-FLASH sequence (slices=64; TR/TE=20/3.7 ms; acquisition matrix=512x512; FOV=150x150 mm). 2D-TSE sequence with different inversion times utilized for T_1 mapping of the knee joint (single slice, TR/TE=8000/15 ms; acquisition matrix=256x128; FOV=150x150 mm). A 2D-SE sequence with multi-contrast was used to obtain T_2 mapping of the knee joint (number of slices=5; TR/TE=6000/20.3, 40.6, 60.9, 81.2, 101.5 ms; acquisition matrix=256x128; FOV=150x150 mm).

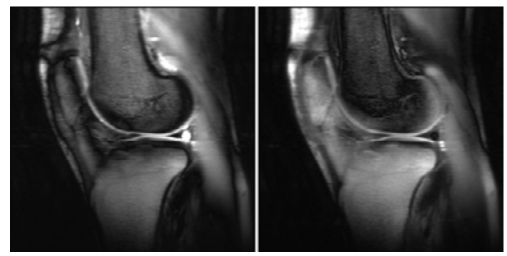

Fig. 2: Two T_1-weighted images acquired with different inversion times.

Results and Discussion

High resolution images of the knee at 7T provided excellent contrast between cartilage and menisci. Two representative slices can be seen in Fig. 1 from the 3D data set of 64 slices. The contrast at the boundaries of the menisci is especially apparent. The average T_1 of patellar, femoral, and tibial cartilages were computed as 1.66, 1.69, and 1.90 sec, respectively. These values correspond to an increase of ~35-45% compared to T_1 values observed at 3.0T. Two images acquired with different inversion times are displayed in Fig. 2. T_2 values of patellar cartilage and lateral gastrocnemius muscle were 36.57 and 33.94 ms, respectively. These values are not significantly different than the values previously reported at 3.0T [2]. Two axial T_2-weighted axial images are displayed in Fig. 3. The SNR of patellar cartilage, patella, synovial fluid, meniscus, and subcutaneous fat as a function of TE can be seen in Fig. 4A. The signal difference-to-noise ratios (SDNR) among the patellar cartilage and patella, synovial fluid, meniscus, subcutaneous fat as function of TE are also displayed in Fig.4B.

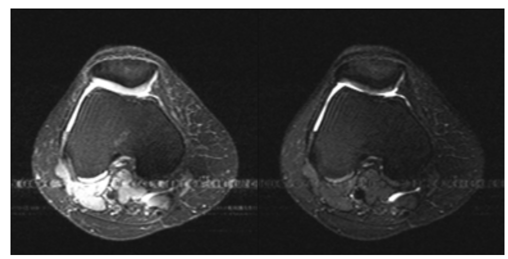

Fig. 3: Two T_2-weighted images acquired with different TE.

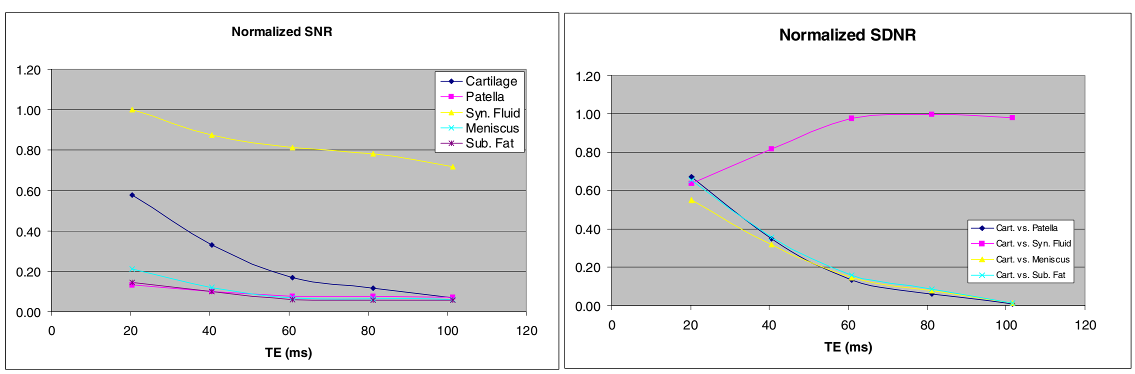

Fig. 4: (A) Normalized SNR values of the various tissues at the knee joint. (B) Normalized SDNR values among the patellar cartilage and other tissues at the knee joint.

Conclusion

SNR, contrast and relaxation times of the knee joint were measured at 7.0T using a whole body scanner. High resolution 3D-FLASH provides excellent contrast among various musculoskeletal tissues *in vivo*. This study demonstrated that there is ~35-45% increase in T_1 when compared to 3.0T but no significant changes in T_2 are observed. The T_2 advantage can be exploited for improving spatial and temporal resolution especially for musculoskeletal system at 7T. We are currently in the process of improving the resolution by acquiring isotropic voxels of 200μm size.

References:

1) Gold GE *et al.* AJR 2004;183:343-351. 2) Stanisz GJ *et al*. MRM 2005; 54:507-512.