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 (B0) 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 (B0) 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 T1, relaxation time of 50–90% and decreases in T2, 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 (T1 and T2) in human knee joint at 7.0T whole body scanner.

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 16 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 (TR/TE=30/1.6 ms; acquisition matrix=512x512; FOV=150x150 mm). 2D-TSE sequence with different inversion times were utilized for T1 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 T2 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).

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 T1 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 T1 values observed at 3.0T. Two images acquired with different inversion times are displayed in Fig. 2. T2 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 T2-weighted 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.

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 T1 when compared to 3.0T but no significant changes in T2 are observed. The T2 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.

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