

Unspoiled Gradient Recalled-Echo Acquired in the Steady-State (GRASS) with IDEAL Fat-Suppression for High Resolution Cartilage Imaging at 3T

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Objective: Iterative Decomposition of water and fat with Echo Asymmetry and Least-squares estimation (IDEAL) is a three-point fat-water separation method that uses asymmetric echoes and least squares fitting in order to achieve the maximum possible signal-to-noise ratio (SNR) performance. (1) The IDEAL method has been previously combined with spoiled gradient recalled-echo (SPGR) and steady-state free-precession (SSFP) techniques to create high quality fat-suppressed images of articular cartilage. (2, 3) This study was performed to demonstrate the feasibility of combining IDEAL fat-water separation with unspoiled gradient recalled-echo acquired in the steady-state (GRASS) technique and to optimize the IDEAL-GRASS pulse sequence for cartilage imaging.

Methods: Bloch equation simulations were performed to determine the influence of flip angle of the IDEAL-GRASS sequence on the SNR of articular cartilage and synovial fluid and the contrast-to-noise ratio (CNR) between articular cartilage and synovial fluid. Previously published relaxation parameters for articular cartilage (T1= 1240 msec and T2= 37 msec) and synovial fluid (T1= 3620 msec and T2= 767 msec) at 3T were used in the simulations. (4) The simulations were then tested in a clinical pilot study involving 10 knees in 5 asymptomatic volunteers. All volunteers underwent magnetic resonance (MR) examinations on the same General Electric 3T scanner using a single-channel extremity coil. The IDEAL-GRASS sequence was performed during all MR examinations using the following imaging parameters: 20°, 30°, 40°, 50°, and 60° flip angles, 10 msec TR, 4.6 msec TE, 2.5 mm slice thickness, 420 x 256 matrix, 16 cm field of view, and +/- 41.47 kHz bandwidth. For each MR examination, the SNR of articular cartilage, synovial fluid, subchondral bone, and muscle and the CNR between articular cartilage and synovial fluid, subchondral bone, and muscle were calculated for all flip angles.

Results: At all flip angles, the IDEAL-GRASS sequence provided excellent visualization of the articular cartilage of the knee joint (Figure 1). According to the Bloch equation simulations, the SNR of articular cartilage was highest at a flip angle of approximately 10° and the SNR of synovial fluid was highest

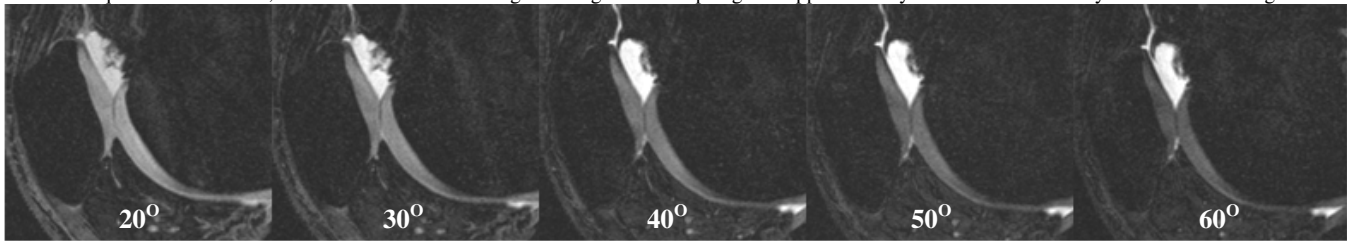


Figure 1: IDEAL-GRASS images of the articular cartilage of the knee joint of an asymptomatic volunteer at various flip angles.

at a flip angle of approximately 40° (Figure 2). According to the clinical pilot study, the SNR of articular cartilage was highest at a flip angle of 20° and the SNR of synovial fluid was highest at a flip angle of 50° (Figure 3). According to both the Bloch equation simulations and the clinical pilot study, the CNR between articular cartilage and synovial fluid was highest at a flip angle of 50° (Figures 2 and 4).

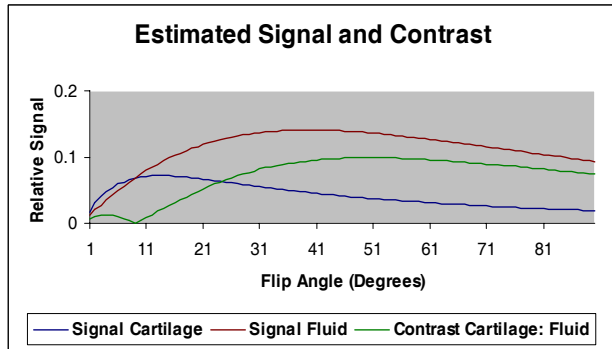


Figure 2: SNR of articular cartilage and synovial fluid and CNR between articular cartilage and synovial fluid according to Bloch equation simulations.

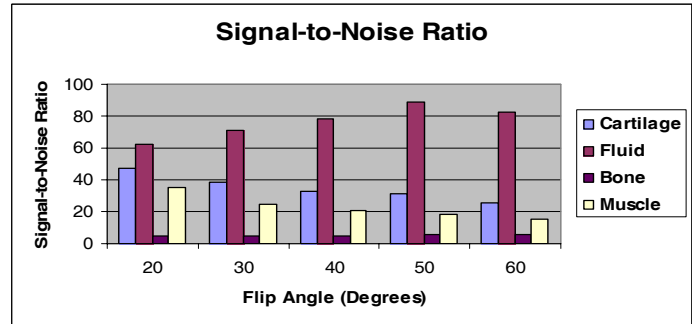


Figure 3: Average SNR (n= 10 knees) of articular cartilage, synovial fluid, subchondral bone, and muscle according to clinical pilot study.

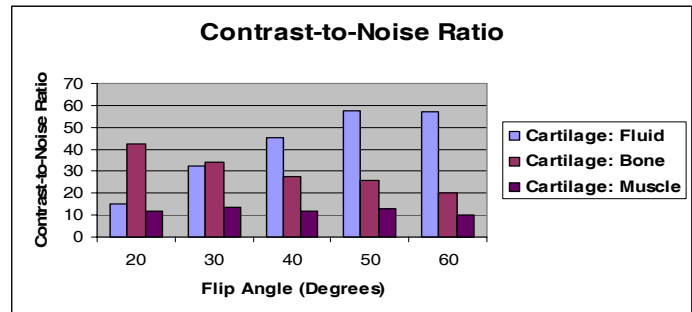


Figure 4: Average CNR (n= 10 knees) between articular cartilage and synovial fluid, subchondral bone, and muscle according to clinical pilot study.

Conclusion: According to both Bloch equation simulations and a clinical pilot study, 50° is the optimal flip angle for IDEAL-GRASS cartilage imaging. This flip angle provides the greatest contrast between articular cartilage and synovial fluid while maintaining high cartilage SNR and adequate contrast between articular cartilage, subchondral bone, and muscle.

References: 1) Reeder, et al. *Mag Reson Med* 54:586-93, 2005. 2) Kornaat, et al. *Osteoarthritis Cartilage* 13:338-44, 2005. 3) Gold, et al. *Radiology* 41:147-53, 2006. 4) Gold, et al. *Am J Roentgenol* 183:343-51, 2004.