SPGR and GRE Cartilage Imaging of the Knee at 3T with Water Excitation and 2D Autocalibrating Parallel Imaging

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Introduction: Fat-suppression is commonly used for morphologic cartilage imaging to reduce chemical shift artifact and to optimize the overall dynamic contrast range of the image [1]. Water excitation [2] has been shown to provide improved SNR and CNR efficiency for cartilage imaging when compared to frequency selective fat-saturation methods [3,4]. Water excitation is compatible with parallel imaging and can be combined with multiple MR pulse sequences to produce high quality images of the knee with either dark or bright synovial fluid. The purpose of this study was to document the feasibility of performing dark fluid SPGR and bright fluid GRE cartilage imaging at 3T using water excitation and an autocalibrating 2D-accelerated parallel imaging technique called ARC [5].

Methods: Water excitation (SSI) was performed by means of a minimum phase water-selective spatial-spectral pulse (5 sub RF pulses with .56 ms duration, spectral bandwidth=.3 kHz, spatial bandwidth=17.7 kHz, total duration of 5.04 ms). ARC parallel imaging, accelerated 2 times in both phase encode directions with a smart fully-sampled region in the center of ky-kz space, yielded 3.7 times net acceleration. Elliptical k-space coverage enabled the corners of k-space to be cut for an additional reduction in scan time. SSI-SPGR (TR/TE=12.7/6.5, 14^o flip angle, .4 mm x .7 mm x 1.0 mm voxel size) and SSI-GRE (TR/TE=12.7/6.5, 50^o flip angle, .4 mm x .7 mm x 1.0 mm voxel size) sequences with and without ARC parallel imaging were performed twice on the knees of 8 asymptomatic volunteers using a 3T scanner (Signa Excite HDx, GE Healthcare, Waukesha, WI) and an 8-channel phased-array extremity coil. ARC parallel imaging reduced the scan time of the SSI-SPGR and SSI-GRE sequences from 5 minutes to 1:46 minutes. SNR efficiency and CNR efficiency measurements were performed using a double acquisition addition/subtraction method previously described for parallel imaging techniques [6]. T-tests were used to compare differences in SNR and CNR efficiency between sequences. In one volunteers, a high resolution SSI-GRE sequence (TR/TE=12.7/6.5, 50^o flip angle, .3 mm x .3 mm x 1.0 mm voxel size, 5 minute scan time) was also performed using ARC parallel imaging.

Results: Figure 1 shows SSI-SPGR and SSI-GRE images of the knee with and without ARC parallel imaging. Although noise was visibly increased on the SSI-SPGR and SSI-GRE images with ARC parallel imaging, SNR remained quite adequate with scan time reduced by a factor of 3. Figure 2 compares the SNR efficiency of cartilage, synovial fluid, and subchondral bone for the SSI-SPGR and SSI-GRE sequences performed with and without ARC parallel imaging. Figure 3 compares the CNR efficiency between cartilage and synovial fluid and between cartilage and subchondral bone for the SSI-SPGR and SSI-GRE sequences with and without ARC parallel imaging. There was no statistically significant differences (p-values=.29-.95) in SNR and CNR efficiency values, indicating that the parallel imaging technique did not cause an SNR penalty other than would be expected from the reduced scan time. Figure 4 demonstrates that ARC parallel imaging can be used to produce identical resolution SSI-GRE images of the knee in a shorter scan time or higher resolution images with an identical scan time.

Conclusion: Dark fluid SPGR and bright fluid GRE cartilage imaging can be performed at 3T using water excitation and ARC parallel imaging. ARC parallel imaging accelerates SPGR and GRE cartilage imaging without causing a reduction in SNR and CNR efficiency.

References: [1] Gold GE, et al. Radiographics 2003; 23:1227. [2] Meyer CH, et al. Magn Reson Med 1990; 15:287. [3] Mohr A, et al. Eur Radiol 2003; 13:686. [4] Yoshioka H, et al. J Magn Reson Imaging 2003; 18:66. [5] Beatty PJ, et al. ISMRM 2007, p. 1749. [6] Reeder SB, et al. Magn Reson Med 2005; 54:748.

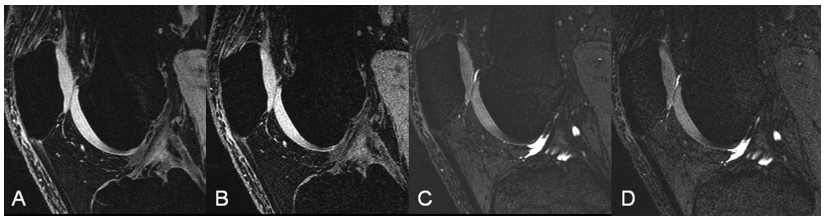

Figure 1: Sagittal (A) SSI-SPGR image without ARC (5 minute scan time), (B) SSI-SPGR image with ARC (1:45 minute scan time), (C) SSI-GRE image without ARC (5 minute scan time), and (D) SSI-GRE image with ARC (1:45 minute scan time) of the knee in an asymptomatic volunteer. All images have .4 mm x .7 mm x 1.0 mm voxel size.

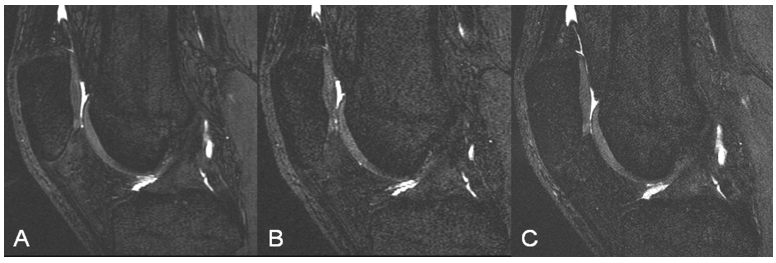

Figure 4: Sagittal (A) SSI-GRE image without ARC (.4 mm x .7 mm x 1.0 mm voxel size, 5 minute scan time), (B) SSI-GRE image with ARC (.4 mm x .7 mm x 1.0 mm voxel size, 1:45 minute scan time), and (C) SSI-GRE image with ARC (.3 mm x .3mm x 1mm voxel size, 5 minute scan time) of the knee in an asymptomatic volunteer.

Figure 2: Signal-to-Noise Efficiency

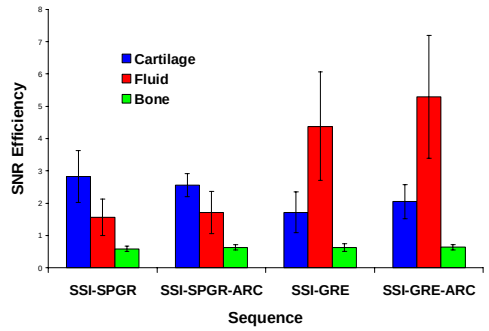

Figure 3: Contrast-to-Noise Efficiency