

High Resolution 3D T2-Weighted Imaging For Evaluation of Cartilage Lesions of the Knee

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Introduction:

Magnetic resonance imaging (MRI) is an excellent modality for non-invasive evaluation of cartilage lesions in knees. T2-weighted contrast with low to intermediate cartilage signal and high fluid signal is one of the primary methods to establish contrast in cartilage. Although several types of pulse sequences have been proposed for evaluating cartilage (1,2), the optimum sequence(s) has yet to be determined. The purpose of this study is to generate diagnostic-quality T2-weighted images with high spatial resolution at 3.0 Tesla, all within 10 minutes. We propose the use of the refocused SSFP echo to generate T2-weighted images for better delineation of cartilage and fluid in muscular-skeletal joints.

Methods:

A GE 3.0 Tesla scanner with a 4-channel phased array knee coil was used to generate fat-suppressed, 3D, T2-weighted images of the knee using a fast SSFP-S(-) echo (3) sequence (S-minus). The scan parameters for T2 images are: sagittal, 3D, TR = 11.5 msec, TE = 17.1 msec, FA = 45°, 1.2 mm thick, matrix = 256x256 zipped to 512, FOV = 14x14 cm, 90 slices, 1 NEX, RBW = 15.625 kHz, scan time ≈ 6 min. Contrast-to-noise ratios (CNR) between cartilage, bone marrow, joint fluid, meniscus, and muscle were measured for quantitative assessment. In clinical studies, 20 patients with osteoarthritis were scanned with S-minus sequence. In addition, sagittal 2D proton density-weighted (PDWI) images with and without fat suppression were obtained. Cartilage-joint effusion CNR and cartilage-bone marrow CNR were calculated.

Results:

3.0 Tesla scanners provide higher SNR and better fat suppression than at 1.5 Tesla, which are essential for high spatial resolution and high contrast isotropic images, but produce T1-weighted images with apparent T2-weighted characteristics, with signal intensity in fluids being higher than that of cartilage. This is due to the increase in T1 relaxation times at 3.0 Tesla and the increase in the effective TR time (interval between excitation rf pulses) caused by the presence of the fat suppression rf pulse (Figure 1). CNRs between cartilage and bone marrow, fluid, muscle, or muscle were 7.75, -12.26, 85.0, and 4.93, respectively. This result means S-minus could provide clear contrast between fluid and cartilage, and between cartilage and bone marrow. In clinical studies, the mean (SD) fluid-cartilage CNR and cartilage-bone marrow CNR with S-minus were 20.1 (7.22) and 3.38 (2.50), respectively. Quantitatively, S-minus images often appreciated small degeneration as high intensity area in the cartilage substance, while this lesion was rarely demonstrated on regular PDWI with and without fat suppression, because S-minus was obtained with high cartilage-water contrast and this section.

Figure-1: T1 weighted image (left) and fat suppressed S-minus at 3T. A small amount of joint fluid is indicated as high signal intensity on T1 and T2 contrast images at 3T. The T2 contrast image with S-minus sequence clearly delineates the cartilage surface, even in the posterior region of the femoral condyle, with high SNR and contrast.

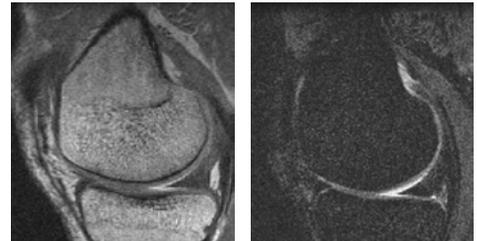
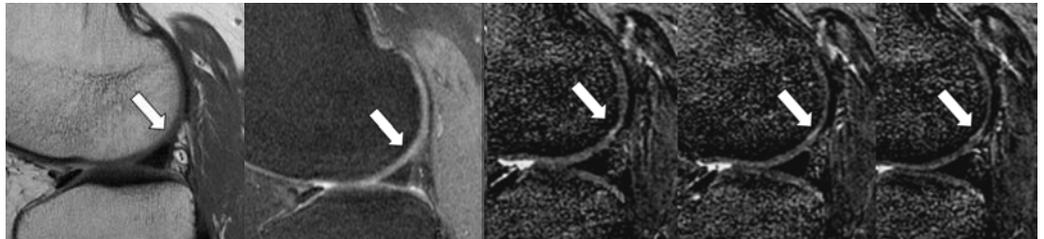


Figure-2: Comparison between a proton density weighted (PDWI) without fat suppress, PDWI with fat suppression, and three fat suppressed S-minus images at 3T. The S-minus images allowed picking up subtle degenerative changes



Conclusion:

S-minus with fat suppression demonstrated high fluid-cartilage contrast and better delineation of small degenerative change in the cartilage at 3T. Therefore, this sequence would be a promising sequence for osteoarthritis. Additional work is planned to develop a protocol for 3D isotropic images of the knee using an 8-channel knee coil.

References:

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