Osteoarthritis of the Knee Joint: Cartilage Imaging with Water-Excitation 3D Spoiled Gradient-Echo Sequences and Fat-Suppressed Three-Dimensional Spoiled Gradient-Echo MR Imaging

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Abstract

The purpose of this study was to compare water-excitation 3D fast SPGR imaging with fat-suppressed 3D SPGR sequences in MR imaging of articular cartilage of the knee joint in six patients with osteoarthritis. Water-excitation 3D fast SPGR images demonstrated higher spatial resolution and higher mean S/N (cartilage, 24.9; synovial fluid, 12.3; muscle, 20.7; meniscus, 21.6), with shorter acquisition times, than fat-suppressed 3D SPGR images. The signal-to-noise ratio of each tissue was analyzed by dividing the signal intensities of each tissue by the standard deviation (SD) of the background noise. Likewise, the contrast-to-noise ratio (C/N) between cartilage and other adjacent structures (meniscus, synovial fluid, muscle, fat tissue, and bone marrow) was calculated.

Methods

We analyzed MR images from six patients with osteoarthritis of the knee. The patient consisted of four males and two females, with ages ranging from 40 to 75 years (mean age 64.3 years). All MR images were obtained with a 1.5 T MR scanner (Signa, software version 8.3, GE Medical Systems, Milwaukee, WI) using a transmit-receive extremity coil. In each patient, sagittal fat-suppressed 3D SPGR images (TR/TE/flip angle = 660/9/20°) were obtained with continuous 1.5-mm section thickness, a partition of 64, an image matrix of 512x256, a 120 mm FOV, a 16.8 mm field of view (FOV), a band width of 15 kHz, and one excitation for a total acquisition time of 10 min 18 sec.

A 3D fast SPGR sequence (28.5/9/20°), in which only the water is excited in the volume during the excitation with a spatial-spectral pulse, was performed with 1.6 mm section thickness, 0.8 mm overlapping, a partition of 64, an image matrix of 512x256, a 120 mm FOV, a band width of 15.6 kHz, and one excitation for a total acquisition time of 7 min 20 sec. Zero fill interpolation was used to produce finer sampling in the section-select direction, and 120 sections were obtained with 3D fast SPGR imaging.

For quantitative analyses, the signal intensities of cartilage, synovial fluid, muscle, meniscus, fat tissue, bone marrow, and background noise were recorded from fat-suppressed 3D SPGR images and 3D fast SPGR images. The signal-to-noise ratio (S/N) of each tissue was analyzed by dividing the signal intensities of each tissue by the standard deviation (SD) of the background noise. Likewise, the contrast-to-noise ratio (C/N) between cartilage and other adjacent structures (meniscus, synovial fluid, muscle, fat tissue, and bone marrow) was calculated.

Results

In patients with osteoarthritis, 3D fast SPGR images demonstrated higher spatial resolution and higher mean S/N ratios (cartilage, 24.9; synovial fluid, 12.3; muscle, 20.7; meniscus, 21.6), with shorter acquisition times, when compared to fat-suppressed 3D SPGR images (cartilage, 22.3; synovial fluid, 10.8; muscle, 16.7; meniscus, 13.4). The mean C/N between cartilage and synovial fluid, fat, and bone marrow on 3D fast SPGR images showed higher values than those on fat-suppressed 3D SPGR images, while the mean cartilage-muscle C/N and cartilage-meniscus C/N on the 3D fast SPGR images showed lower values than those on the fat-suppressed 3D SPGR images.

Discussion

In this study, MR images of articular cartilage with water-excitation 3D fast SPGR sequences showed several advantages over those with fat-suppressed 3D SPGR sequences. The acquisition time of the 3D fast SPGR sequences is only approximately 72% of the fat-suppressed 3D SPGR sequence, with the parameters that were used in this study. Nevertheless, 3D fast SPGR images showed higher normalized S/Ns, and similar C/Ns and contrast between cartilage and surrounding structures. The truncation artifact was more subtle on 3D fast SPGR images. Judging from these advantages, 3D fast SPGR images have the potential to replace fat-suppressed 3D SPGR images for the evaluation of articular cartilage abnormalities.

However, there are several limitations to 3D fast SPGR images. First, they need more post-processing time than fat-suppressed 3D SPGR images because of the increased amount of data. Secondly, the high S/Ns of muscle and meniscus on 3D fast SPGR images cause lower cartilage-meniscus C/N and cartilage-muscle C/N. A possible remedy in this case may be to make the flip angle larger on 3D fast SPGR images. The current study was limited by the small patients number, although significant differences in S/Ns between both sequences were shown.

In conclusion, water-excitation 3D fast SPGR images of articular cartilage in osteoarthritic knees have been compared with conventional fat-suppressed 3D SPGR images. The images showed higher spatial resolution, and higher S/N images with shorter acquisition times compared to fat-suppressed 3D SPGR images. Therefore, 3D fast SPGR imaging is a promising imaging sequence that has the potential to replace standard SPGR sequence in evaluating articular cartilage in patients with osteoarthritis.

References
