Magnetic Resonance Imaging of Articular Cartilage of the Knee: Comparison between Fat-Suppressed 3D SPGR Imaging, Fat-Suppressed FSE Imaging and Fat-Suppressed 3D DEFT Imaging and Correlation with Arthroscopy

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Abstract

The purpose of this study was to compare S/N and C/N in MR sequences including fat-suppressed (FS) 3D SPGR imaging, FS FSE imaging, and FS 3D DEFT imaging and to determine the diagnostic accuracy of these imaging sequences for detecting cartilage lesions in osteoarthritic knees and comparing with arthroscopic results. FS 3D DEFT images showed the highest S/N of synovial fluid, fluid-cartilage C/N, and fluid-meniscus C/N when compared with other sequences. Comparison between MR and arthroscopic grading showed that imaging using these sequences showed high sensitivity and high negative predictive values, but relatively low specificity.

Introduction

MR imaging is the most promising imaging modality for non-invasive evaluation of cartilage lesions and there are many MR pulse sequences applied to the diagnosis of cartilage defects and osteoarthritis. These sequences are useful clinically. Infat-suppressed three-dimensional (3D) spoiled gradient-recalled acquisition in the steady state (SPGR) images and T2-weighted fast spin-echo (FSE) images which have been shown to be accurate and reliable in the detection of articular cartilage diseases. Recently, driven equilibrium Fourier transform (DEFT) imaging has been shown to provide high contrast between cartilage and synovial fluid without loss of cartilage signal. 3D DEFT images with echo-planar readouts provide volumetric coverage in a clinically reasonable scan time and suggest that this sequence may be useful in clinical application.

Methods

We analyzed the MR images of 35 knees from 28 patients with osteoarthritis of the knee. Seven patients had two MR examinations with the second scan performed 3 months later. The patients consisted of 18 male and 10 female patients, with ages ranging from 40 to 73 years (mean age 55.6 years).

All MR images were obtained with a 1.5 T MR scanner (Signa, GE Medical Systems, Milwaukee, WI) and implemented up to 40 mT/m gradient amplitude and 75 ms slew rates. A transmit-receive extremity coil was used. In all 35 knees, sagittal fat-suppressed proton density-weighted FSE imaging, fat-suppressed T2-weighted FSE imaging, and fat-suppressed 3D DEFT imaging were evaluated quantitatively and to determine the diagnostic accuracy of these imaging sequences in detecting cartilage lesions of the osteoarthritic knee, and comparing with arthroscopic results which were used as the gold standard.

Comparison between MR imaging grading and arthroscopic grading

The S/Ns and C/Ns of the cartilage, meniscus, and muscle on fat-suppressed 3D SPGR images were the highest of all sequences and highly statistically significant (p < 0.0001). The S/N of synovial fluid on fat-suppressed 3D DEFT images also showed significantly higher values when compared with other sequences (p < 0.0001). Fat-suppressed FSE short TE images and fat-suppressed 3D DEFT images showed similar S/N values of cartilage. The C/N between synovial fluid and cartilage or meniscus showed the highest values on fat-suppressed 3D DEFT images (p < 0.0001). The values on fat-suppressed 3D SPGR images were negative. Fat-suppressed FSE long TE images showed significantly higher synovial fluid-cartilage C/N (p < 0.0001) and synovial fluid-meniscus C/N (p < 0.0001) than fat-suppressed short TE FSE images. However, the fat-suppressed FSE long TE images showed significantly lower C/N between cartilage and fat, bone marrow, and meniscus (p < 0.0001; bone marrow, p < 0.0001; meniscus, p < 0.01). The C/N between cartilage and fat, muscle, bone marrow, or meniscus was higher on fat-suppressed 3D SPGR images than on all other sequences and this was statistically significant (p ≤ 0.05 to p < 0.0001) except for the C/N between cartilage and meniscus.

Table 1: Comparison between MR imaging grading and arthroscopic grading

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Kappa value</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
<th>PPV</th>
<th>NPV</th>
<th>Accuracy (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FSE(short TE)</td>
<td>0.615</td>
<td>100</td>
<td>100</td>
<td>96.7%</td>
<td>96.7%</td>
<td>98.3%</td>
</tr>
<tr>
<td>FSE(long TE)</td>
<td>0.601</td>
<td>100</td>
<td>100</td>
<td>96.7%</td>
<td>96.7%</td>
<td>98.3%</td>
</tr>
<tr>
<td>3D-SPGR</td>
<td>0.583</td>
<td>99.5%</td>
<td>99.5%</td>
<td>93.5%</td>
<td>93.5%</td>
<td>94.3%</td>
</tr>
<tr>
<td>3D-DEFT</td>
<td>0.561</td>
<td>99.5%</td>
<td>99.5%</td>
<td>93.5%</td>
<td>93.5%</td>
<td>94.3%</td>
</tr>
</tbody>
</table>

Discussion

Each MR imaging sequence in this study showed high sensitivity in diagnosis of cartilage defects in the osteoarthritic knee when compared with arthroscopy. However, the specificity of all sequences, especially FSE and DEFT sequences, were relatively low. The reason is that some of the area designated grade 0 on arthroscopy were diagnosed as grade 2 lesions on MR images. The possibility of low specificity (high false positive values) on FSE and DEFT imaging was two-fold; (1) possibility of overgrading on MR imaging. The MRI readers might tend to grade the cartilage lesion as grade 2, whereas this is called grade 0 in arthroscopy. (2) possibility of undergrading by arthroscopy compared with MRI. Orthopedic surgeons might tend to score grade 0 in arthroscopy. Orthopedic surgeons might tend to score grade 0 in arthroscopy. Orthopedic surgeons might tend to score grade 0 in arthroscopy. Orthopedic surgeons might tend to score grade 0 in arthroscopy.

Fat-suppressed 3D DEFT images showed the highest S/N of synovial fluid, fluid-cartilage C/N, and fluid-meniscus C/N when compared with other sequence. However, bone marrow edema showed complex signal intensity due to T2/T1 relaxation mechanisms on fat-suppressed 3D DEFT images. Although fat-suppressed 3D DEFT images is a promising imaging technique in investigation of the osteoarthritits, further technical improvements and further studies evaluating other structures in the knee, will be needed.