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Degenerative disc disease of the lumbar spine: a prospective comparison of fast T1-weighted fluid-attenuated inversion recovery and T1-weighted turbo spin echo MR imaging☆

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Abstract

Objective: To compare fast T1-weighted fluid-attenuated inversion recovery (FLAIR) and T1-weighted turbo spin-echo (TSE) imaging of the degenerative disc disease of the lumbar spine.
Materials and methods: Thirty-five consecutive patients (19 females, 16 males; mean age 41 years, range 31–67 years) with suspected degenerative disc disease of the lumbar spine were prospectively evaluated. Sagittal images of the lumbar spine were obtained using T1-weighted TSE and fast T1-weighted FLAIR sequences. Two radiologists compared these sequences both qualitatively and quantitatively.
Results: On qualitative evaluation, CSF nulling, contrast at the disc–CSF interface, the disc–spinal cord (cauda equina) interface, and the spinal cord (cauda equina)–CSF interface of fast T1-weighted FLAIR images were significantly higher than those for T1-weighted TSE images ($P < 0.001$). On quantitative evaluation of the first 15 patients, signal-to-noise ratios of cerebrospinal fluid of fast T1-weighted FLAIR imaging were significantly lower than those for T1-weighted TSE images ($P < 0.05$). Contrast-to-noise ratios of spinal cord/CSF and normal bone marrow/disc for fast T1-weighted FLAIR images were significantly higher than those for T1-weighted TSE images ($P < 0.05$).
Conclusion: Results in our study have shown that fast T1-weighted FLAIR imaging may be a valuable imaging modality in the armamentarium of lumbar spinal T1-weighted MR imaging, because the former technique has definite superior advantages such as CSF nulling, conspicuousness of the normal anatomic structures and changes in the lumbar spinal discogenic disease and image contrast and also almost equally acquisition times.

Keywords: FLAIR technique; Fast spin echo; Lumbar spine; Degenerative disc disease

1. Introduction

Degenerative disc disease of the spine is one of the most common clinical entity and the lumbar spine region is among the most commonly involved site with severe primary spinal degenerative changes [1]. Sagittal T1-weighted and T2-weighted sequences are a basic starting point for spinal discogenic disease [2]. T1-weighted and T2-weighted images can be performed with conventional spin echo (SE) or, preferably with fast spin echo (FSE) technique [3]. FSE MR imaging has a shorter acquisition time than SE imaging. T1-weighted FSE imaging has been widely used to study anatomic detail and abnormalities of the lumbar spine; however, the image contrast of this technique is often poor [2].

Previous reports show that fast T1-weighted fluid-attenuated inversion recovery (FLAIR) provides improved contrast between lesions and normal anatomical structures and at acquisition times comparable to those of T1-weighted TSE imaging [4,5]. However, T2-weighted FLAIR technique has not been proven as useful for spinal imaging, as for brain imaging [3]. These sequences retain T2-weighting while nulling the CSF signal. The T2-weighted FLAIR technique

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is theoretically promising in detecting spinal cord surface lesions, but recent articles have reported disappointing results [6,7].

There are few studies in the clinical applications of fast T1-weighted FLAIR technique [4,5,8,9], and only one of them is related with the various spinal abnormalities [4] and the others are with brain tumors [5,8,9]. Accordingly, in the present sudy, our aim was a prospective comparison of T1-weighted TSE and fast T1-weighted FLAIR imaging in the degenerative disc disease of the lumbar spine, which, to best of our knowledge, has not been reported previously.

2. Materials and methods

Thirty-five consecutive patients (19 females, 16 males) with degenerative disc disease of the lumbar spine were prospectively studied. The patients' mean age was 41 years (range 31–67 years). The degenerative disc disease of the lumbar spine was suspected by plain films and clinical evaluation. MR imaging protocol was included T1-weighted TSE (TR/TE/ETL/NSA: 500/11 ms/4/3, matrix size = 384 × 512, scan time = 2.38 min) and fast T1-weighted FLAIR (TR/TI/TE/ETL/NSA: 2000/862/6 ms/6/3, matrix size = 288 × 1024, scan time = 2.28 min) sequences in the sagittal plane, during the same imaging session on 1.5 T MR system (Philips Medical Systems, Gyroscan Intera, Best, The Netherland) using by synergy body phase-array surface coil. The remaining parameters of the fast T1-weighted FLAIR sequence were identical to the sagittal T1-weighted TSE lumbar spine imaging protocol used at our institution: Flip angle = 90°, Slice thickness = 4 mm, Slice = 11, Gap = 0.4, FOV = 405 mm × 70 mm. L1/S1 disc spaces were included for all MR imaging.

Ten patients were initially tested for parameter optimization of fast T1-weighted FLAIR sequences before the onset of the study.

2.1. Quantitative analysis

Quantitative analysis was performed for the first 15 patients. In the quantitative analysis the following items were analyzed: the signal-to-noise ratio (SNR) of the spinal cord and CSF, the contrast-to-noise ratio (CNR) between the CSF and spinal cord, and CNR between the normal bone marrow and disc. For calculating these values, the signal intensity (SI) of the spinal cord, CSF, normal bone marrow, disc and standard deviation (S.D.) of background noise were measured by placing regions of interest (ROIs). The ROIs for each patient were basically placed at an identical position and size on T1-weighted TSE and fast T1-weighted FLAIR images. When the positions of ROIs were moved in some cases because of patient motion, ROIs were selected from the relative position to adjacent tissues. The SNR was calculated as: $SNR = SI_{tissue}/S.D.$ of background noise. The CNR was calculated as: $SI_{tissue\,1} - SI_{tissue\,2}/S.D.$ of background noise. SI_{tissue} defines the SI of the corresponding tissue.

2.2. Qualitative analysis

T1-weighted TSE and fast T1-weighted FLAIR images were compared as quantitatively in all of 35 patients. All of MR images of T1-weighted TSE and fast T1-weighted FLAIR were evaluated independently at two separate sittings with 3 weeks interval by two radiologists who reached a consensus. The images from two sequences, filmed at optimal window and level settings. The radiologists graded on a 5-point scale (0, non-visualization; 1, poor; 2, average; 3, good; 4, excellent) for each of the following image characteristics: (1) overall image quality, (2) CSF nulling, (3) conspicuousness of the morphologic abnormalities in the discovertebral junction, (4) conspicuousness of the nerve roots in the neural foramen, (5) contrast at the disc–CSF interface, (6) contrast at the disc–spinal cord (cauda equina) interface, and (7) contrast at the spinal cord (cauda equina)–CSF interface. The readers also evaluated presence of image artifacts using by separate score (0, minimum; 1, slight; 2, moderate; 3, severe; 4, maximum). Morphologic abnormalities in the discovertebral junction were included thinning, irregularity, and Schmorl nodes and signal intensity changes (fatty replacement, edema, and sclerosis), were evaluated on both of MR sequences [1].

2.3. Statistical methods

Statistical analysis was carried out using SPSS for Windows, version 11.0. The statistical significance of quantitative and qualitative data were determined by using a Wilcoxon's signed-rank test, for paired samples and P values < 0.05 were considered to be statistically significant. Our study method has been modified from the previous MR studies [4,5,10].

3. Results

There were three normal patients, 32 patients with lumbar degenerative disc disease, including disc herniation ($n = 26$), discovertebral junction morphologic abnormalities ($n = 9$), including Modic tip II fatty marrow replacement, Schmorl's nodes, thinning and irregularity and spondylolisthesis ($n = 2$) (Figs. 1–4). Both T1-weighted TSE and fast T1-weighted FLAIR imaging were effective for all patients in demonstrating the normal anatomical structures and the changes due to degenerative disc disease of lumbar spine.

3.1. Quantitative results

The results of the quantitative analysis were obtained from the first 15 patients are represented as mean ± S.D. in Table 1. SNRs of CSF obtained with fast T1-weighted FLAIR imag-