Single-Shot Fast Spin-Echo Diffusion Imaging of the Liver

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Introduction:

Although still primarily used for brain applications, diffusion MR imaging is being increasingly used to detect microstructural changes for a variety of pathologies throughout the body. One major limitation of body diffusion MRI is that the EPI-based sequences typically used are very susceptible to artifacts from inadequate lipid suppression, ghosting, and spatial distortions due to magnetic susceptibility effects. In this study, we applied a single-shot fast spin-echo (SSFSE) diffusion tensor imaging sequence (1) to study liver diffusion values in normal volunteers and patients with non-alcoholic fatty liver disease (NAFLD). This sequence utilizes rf-refocusing and provides non-distorted images without the need for lipid suppression with only a small reduction in signal-to-noise ratio (SNR) as compared to EPI-based acquisitions.

Methods:

Conventional MR imaging and SSFSE-DTI was acquired from 7 healthy volunteers and 9 patients with non-alcoholic fatty liver disease (NAFLD) following an IRB-approved protocol with informed consent. The diffusion tensor SSFSE imaging was acquired in 2.5 minutes in the axial plane with a field of view (FOV) of 30cm, a 128x128 matrix, 2.3mm in plane resolution, 8mm slices, a receive-bandwidth of 62.5 kHz, 6 gradient directions with b-value=0, 600s/mm^2, TE=67ms, and typically 10-18 slices covering the liver. The diffusion tensor imaging data was analyzed using custom software to generate directionally-averaged apparent diffusion coefficient (mean diffusivity; <D>), fractional anisotropy, and eigenvalue maps. Quantitative diffusion parameter values were calculated from three standardized regions-of-interest (ROI).

Results:

The SSFSE-DTI sequence provided excellent diffusion tensor images with no observable spatial distortions and minimal motion artifacts (see figure 1). The fractional anisotropy maps were too low in contrast-to-noise and the analysis focused on the <D> values. The mean diffusivity value in the healthy volunteers was calculated to be 1.76$\pm$0.25 mm^2/s which agreed well with previously published ADC values of control subjects (1.79 mm^2/s) (2).

The patient SSFSE-DTI studies demonstrated significantly (p=0.003) decreased <D> values (1.21$\pm$0.30 mm^2/s) as compared to the healthy volunteers.

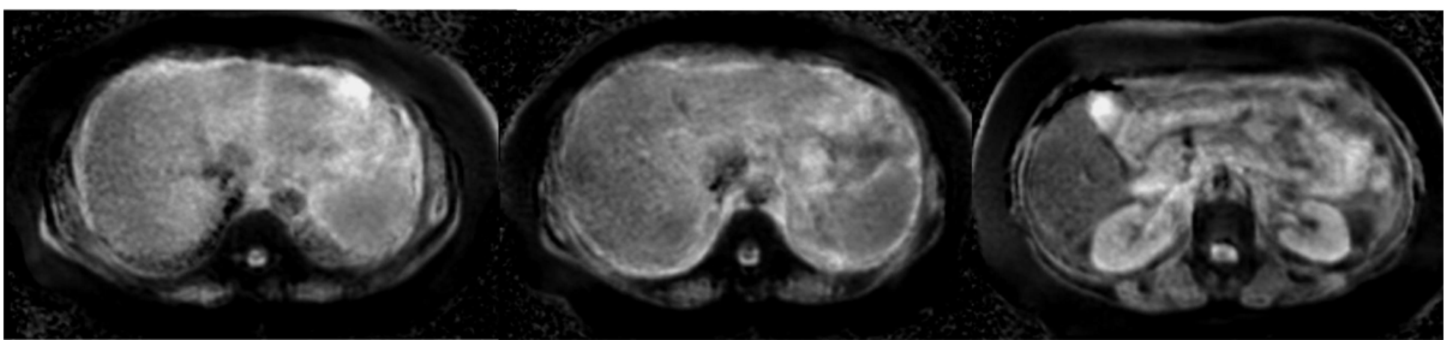

Figure 1. Mean diffusivity (<D>) images for three axial slices acquired from a patient with NAFLD using the DTI-SSFSE sequence. Note the excellent image quality with no observable spatial distortions.

Conclusions:

This study demonstrated the feasibility of obtaining non-distorted diffusion MRI of the liver using a single-shot fast spin-echo based DTI sequence. A significant (p=0.003) decrease in mean diffusivity was observed in patients with non-alcoholic fatty liver disease (NAFLD) as compared to healthy volunteers. Currently, the severity of liver disease is determined via histopathology of liver biopsies. Diffusion imaging may be able to reflect characteristics of the liver tissue such as fat infiltration, fibrosis and inflammation and may thus be able to provide a noninvasive assessment of the liver.

References:
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