3D Flow-dephased Fast Spin Echo for MR Neurography: a Feasibility Study

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Introduction

Magnetic resonance neurography is a useful technique to non-invasively visualize the peripheral nerve anatomy. Fat-suppressed T2-weighted images are commonly used to detect and delineate disease. However, it is difficult to distinguish from vascular structures to nerves because of their similar signal intensity. The previous reports suggested using EPI based diffusion weighted imaging (DWI)[1], or using diffusion weighted SSFP [2] to provide improved contrast between the nerves and the surrounding tissues. However, both techniques have its limitations: the EPI-DWI method suffers from low spatial resolution and artifacts due to magnetic field inhomogeneities, e.g. image distortion; the SSFP technique is prone to off-resonance artifacts, especially at 3T. In this work, we implemented a 3D flow-dephasing prepared FSE sequence by adding a flow dephasing preparation pulse prior to 3D-FSE acquisition. This enables better blood signal suppression for isotropic high spatial resolution nerve imaging at 3.0T. In-vivo lumbosacral plexus results are shown to evaluate the proposed scheme. We show that flow-dephasing prepared image present significantly better blood vessel signal suppression with high spatial resolution.

Material and Method

CUBE[3] is a single-slab 3D-FSE imaging sequence which employs a series of variable low-flip-angle nonselective refocusing RF pulses to extend and reshape the signal decay curve. It enables volumetric coverage with high in- and through-plane resolution with acceptable scan time. The flow dephasing preparation pulse implemented in this study comprises a series of hard RF pulses with 90-180-180-90 degree flip angles. Flow dephasing gradients were placed symmetrically right before and after the 180 degree pulse in all three orthogonal directions, and spoilers were placed after the last 90 degree pulse to eliminate the residual magnetization [Figure 1]. If the total duration between the two 90 degree pulses is defined as TEprep, the delays between prepared RF pulses are TEprep/4, TEprep/2, TEprep/4, respectively. G and δ are the amplitude and duration of the trapezoidal flow dephasing gradient pulse. The CUBE acquisition module was placed after all preparation pulses and was used to acquire the signal. In the 3D nerve imaging design, the flow dephasing preparation was executed between a spectral-selective fat-suppression pulse and the CUBE acquisition.

Images of the lumbosacral plexus images were acquired from five healthy volunteers after informed consent. Images were acquired on a clinical GE Signa HDxt 3.0T scanner equipped with the standard 8 channel CTL/Spine array coil (GE Medical Systems, Milwaukee, WI, USA). The total duration of the preparation module is 15 ms and acquisition parameters were: TR/TE = 3000/134ms, echo train = 100, flow dephasing gradient amplitude G = 3.0mT/m, δ =1.5ms, FOV = 320×320×64mm^3, receiver bandwidth = 62.5 kHz , image size = 288×288×40, number of excitations (NEX) = 1, acquisition time = 4.5min.

Results

We evaluated the quality of depiction of the lumbosacral plexus on CUBE images reformatted in the coronal plane. Figure 2 illustrates images obtained from a healthy volunteer's lumbosacral plexus. Figure 2a is the original fat-suppressed CUBE without flow dephasing preparation. Figure 2b shows an image with flow dephasing preparation. The figure clearly shows that blood signals, indicated by the arrows in Fig 2a, are dramatically suppressed when flow dephasing is used.
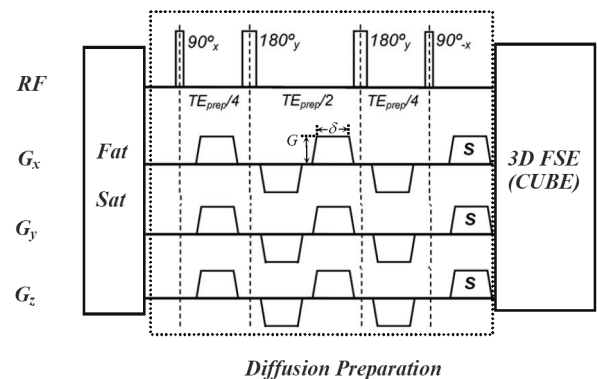

Diffusion Preparation

Figure 1. Diagram of the flow dephasing preparative CUBE pulse sequences. Fat saturation was placed before the flow dephasing preparation pulse. The CUBE acquisition module was placed after all preparation pulses and was used to acquire the signal.

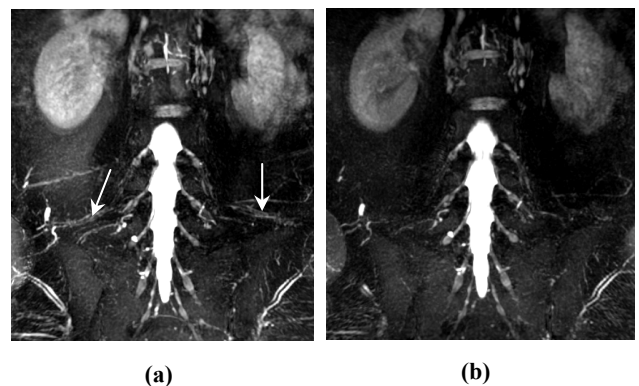**(a)**   **(b)**

Figure 2. Comparison of location-matched fat-suppressed CUBE (a) and flow dephasing prepared fat-suppressed CUBE (b) images acquired from a healthy volunteer using multiplanar reconstruction (MPR). The flow dephasing preparation can dramatically suppress the blood vessel signal (arrows) shown on fat-suppressed CUBE image.

Discussion

This study demonstrates that our flow dephasing preparation improves blood signal suppression in CUBE for isotropic high spatial resolution 3D nerve imaging at 3.0T. The superior spatial resolution and blood flow suppression along with high time-efficiency render this technique promising for 3D isotropic nerve imaging and potentially characterization.

References

[1] Takahara T, et al. Radiology, 2008; 249(2):653-60. [2] ZW Zhang, et al. 2008 Jun;29(6):1092-94. [3] Busse, R.F., et al. MRM, 2006; 55(5):1030-37.