Wide-Band Steady State Free Precession with Small Diffusion Gradients for Spine Imaging: Application to Superior Nerve Visualization

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PURPOSE
MRI is the most sensitive diagnostic imaging tool for patients with back pain [1]. Nerve visualization within the spinal dura is robust using common MRI Myelographic sequences, such as Fast Spin Echo and T2-weighted Gradient Echo, a result of the strong contrast between Cerebro-Spinal-Fluid (CSF) and the nerve bundles. Imaging of the nerves outside the cord, however, is difficult. Nerve tracking outside the cord is extremely important, as spinal pain frequently arises from nerve compression within the foramen, or from inflammation outside the cord [2]. Recent reports have suggested use of diffusion-weighted EPI [3] or unbalanced SSFP [4] for visualizing nerves distal to the cord, although the techniques suffer, respectively, from low spatial resolution and high geometric distortion, or from flow-sensitivity and a low Signal-to-Noise ratio. We investigate use of high-resolution 3D Wide-Band (balanced to 0\textsuperscript{th} and 1\textsuperscript{st} order) SSFP (WBSSFP) [5] for nerve imaging outside the cord. WBSSFP may be applicable, based on its effective diffusional attenuation (B) of 40-60 s/mm\textsuperscript{2} in the readout direction, when used with a narrow-receiver-bandwidth, as required to achieve a high-spatial resolution.

RESULTS & CONCLUSION
12 subjects (6 with degenerative spine disease) had cervical spine (CS) or lumbar spine (LS) studies with both conventional imaging techniques and high-resolution WBSSFP on a GE (Waukesha, WI) 3T Twin HDX, using Zoom gradients. Conventional imaging sequences included T1- and T2-weighted 2D Fast Spin Echo in the sagittal and axial planes, as well as axial T2*-weighted RF-spoiled Gradient-Echo, acquired at 0.7x0.7x3 mm resolution. 3D WBSSFP was acquired in sagittal or coronal planes, covering a 14 cm Left to Right FOV, centered on the spinal cord. WBSSFP parameters: 0.44x0.55x1.4mm (interpolated to 0.27x0.27x0.7mm), TR/TE/\(\theta\)=6.4-6.9ms/2.1-2.4ms/25\textsuperscript{\circ}, 2.2 ms WBSSFP Short-TR [5], 32 KHz bandwidth, 100 slices/acquisition, 200-240 sec/acquisition. In WBSSFP scans, the readout direction was set to Superior-Inferior, generating an S/I diffusion gradient. A GE CTL spine coil was used (elements 123 for CS, 456 for LS). To track the nerve path outside the cord, curved plane reformatting (Volume Viewer, GE Advantage Windows 4.2) was performed by an experienced radiologist.

REFERENCES:
SYNOPSIS
3D High-resolution Wide-band Steady State Free Precession (WBSSFP) is utilized to track nerves as they exit the spinal cord. By placing the readout direction in the Superior-Inferior direction, diffusional effects contribute to improved contrast between the CSF and nerves, and remove the blood signal. In several patients with degenerative spine disease, WBSSFP has aided in the diagnosis of the sources of pain.