

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

E. J. Schmidt<sup>1</sup>, A. Shankaranarayanan<sup>2</sup>, S. Jaume<sup>1,3</sup>, G. Danagoulian<sup>1</sup>, S. J. Mukundan<sup>1</sup>, and K. S. Nayak<sup>4</sup>

<sup>1</sup>Radiology, Brigham and Womens Hospital, Boston, MA, United States, <sup>2</sup>GE Healthcare Applied Science Lab, Menlo Park, CA, United States, <sup>3</sup>Computer Science and Artificial Intelligence Lab, Massachusetts Institute of Technology, Cambridge, MA, United States, <sup>4</sup>Electrical Engineering, University of Southern California

## 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 a 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<sup>th</sup> and 1<sup>st</sup> 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<sup>2</sup> in the readout direction, when used with a narrow-receiver-bandwidth, as required to achieve a high-spatial resolution.

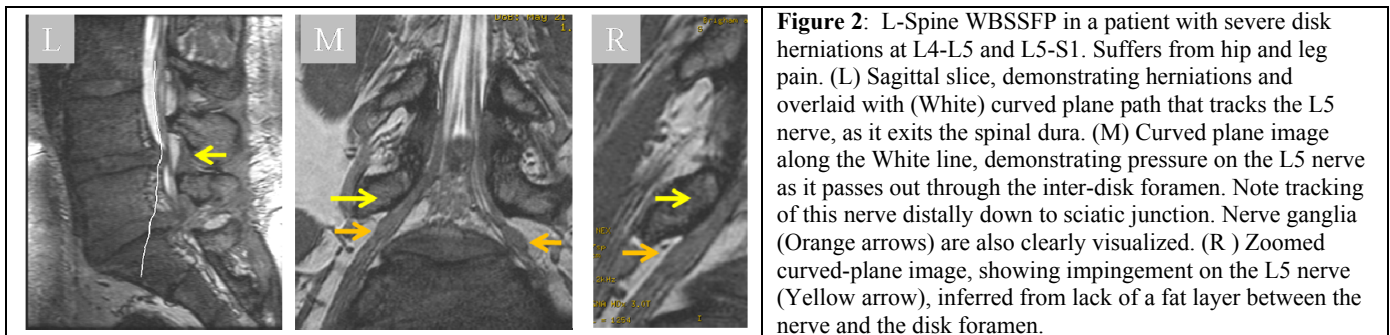
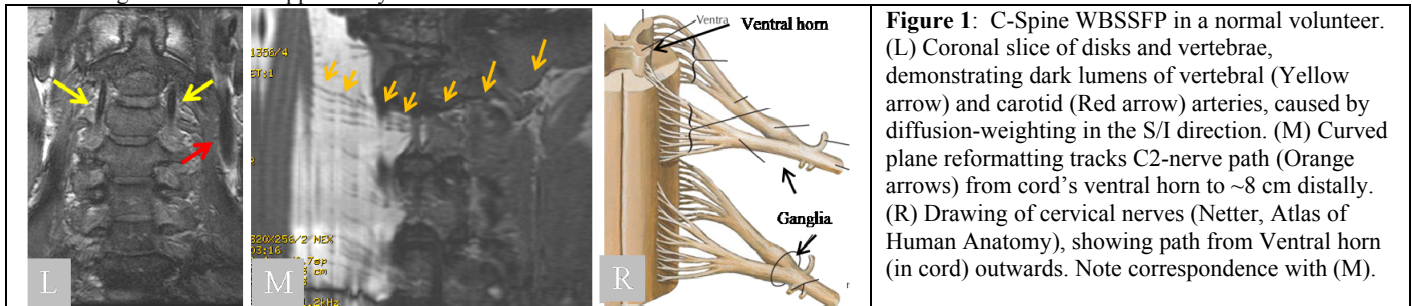
## METHODS

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 the Zoom (50 mT/m, 150mT/m/ms) gradients. Conventional imaging sequences included T1-weighted (TR/TE=600ms/12ms) and T2-weighted (TR/TE=4000ms/120ms) 2D Fast Spin Echo in the sagittal and axial planes, as well as axial T2\*-weighted RF-spoiled Gradient-Echo (TR/TE/θ=120ms/12ms/30°), 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/θ=6.4-6.9ms/2.1-2.4ms/25°, 2.2 ms WBSSFP Short-TR [5], ±32 KHz bandwidth, 80-100 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.

## RESULTS & CONCLUSION

WBSSFP (Fig. 1) demonstrated high SNR images of C-spine anatomy. Blood-vessels had dark-lumens, while the CSF signal was more uniformly bright, as compared with T2-weighted FSE, resulting from WBSSFP's mild diffusional weighting, which dephases flowing and pulsatile spins. The high spatial resolution and strong CNR allows tracking small nerve bundles as they exit the spinal cord. Off-resonance SSFP artifacts were relatively mild, due to WBSSFP's wider pass-band. In three patients with lower back pain (Fig. 2) WBSSFP demonstrated bone impingement on nerves ("nerve pinching") at points outside the spinal dura, seen due to the absence of a fatty-tissue lining on the impinging side of the nerve bundle. Conclusion: 3D WBSSFP provides contrast advantages for tracking the course of spinal nerves, and may aid in diagnosing pain sources.

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**REFERENCES:** [1] Gibson EG, 2003, *Evidence Based Medicine*; 8:62. [2] Boswell MV 2007, *Pain Physician*; 10: 7. [3] Takahara T, 2009, *Radiology*; 249:653. [4] Zhang ZW, 2008, *AJNR*; 29:1092. [5] Nayak KS, 2007 *MRM*;58:931.