MR Nerve Imaging using Blood Suppressed 3D T2 Weighted Imaging with Uniform Fat Suppression

A. Shankaranarayanan1, X. Xiao2, H. Shen2, and A. Madhuranthakam3

Introduction: Magnetic Resonance nerve imaging (1) is the direct imaging of nerves, in which the resonance signal arises from the nerve itself rather than from surrounding tissues or from fat in the nerve lining. MR nerve imaging has been shown to be useful in evaluation of major nerve compressions such as those affecting the sciatic nerve (e.g. piriformis syndrome), the brachial plexus nerves (e.g. thoracic outlet syndrome), the pudendal nerve, or virtually any named nerve in the body.

Fat-suppressed T2-weighted methods (2), DW EPI (3) or DW SSFP (4) have been commonly shown to detect the nerves. Conventional fat suppression can suffer from non-uniform saturation in the presence of B0 and/or B1 inhomogeneities, when used with T2-weighted methods. It is also difficult to delineate nerves from vessels because of their similar signal intensity in T2-weighted and SSFP images. Moreover, current DW methods suffer from artifacts due to, image distortions (when used with EPI acquisitions) and can be very sensitive to magnetic field inhomogeneities.

To image the tortuous nerves, it would be desirable to acquire volumetric T2-weighted images with uniform fat suppression and minimized signal from the surrounding blood vessels. In this work, we have developed such an imaging sequence by integrating a modified 2-point chemical-shift technique (5) with 3D FSE based acquisition (6), to achieve uniform fat suppression and motion-sensitizing driven equilibrium (MSDE) preparation (7,8) to suppress blood vessel signal. Results have been obtained from various parts of the body to reconstruct high-resolution 3D MR nerve images.

Methods: An investigational version of 3D-FSE, using variable rephasing flip angles and extended echo trains (6), was used in this study. The sequence was altered to acquire two echoes (in-phase and out-of-phase respectively) in two sequential repetitions. The two echoes were then processed with a modified 2-point Dixon method (5) to reconstruct separate fat and water images. This reconstruction uses an efficient and robust phase-correction algorithm and has been shown to produce images with uniform fat and water separation even in the presence of B0 inhomogeneities (9). Blood suppression was achieved with an MSDE preparation module (7) using 90°, 180°, 90° RF pulses and motion sensitizing gradients, inserted in front of the modified 3D-FSE acquisition.

MR nerve imaging was performed on normal volunteers with IRB approval and informed consent. Images were acquired on Signa HDxt 1.5T and a 3T scanners (GE Healthcare) using Neuro-Vascular (MedRad Inc) array coil, 8-channel cardiac coil was used for abdomen and pelvis scans. Scans were performed to image nerves originating from C-spine, T-spine and L-spine levels. Respiratory gating was used for performing nerve imaging in the T-spine. The motion sensitizing gradients were empirically set to induce a velocity encoding of 4.9 cm/sec, such that the signal from the vessels near the nerves were sufficiently suppressed. The duration between 90°, and 90°, was approximately 8.2 ms. The acquisition parameters were: Coronal orientation, FOV = 300×300 mm², TR = 3000ms (~3900ms with respiratory gating), scan time = 6:28min (increased to ~8min with resp gating) with an auto-calibrated parallel imaging (10) factor of 2 along the phase encoding and slice encoding direction. The modified Dixon technique allowed 4 different sets of images to be obtained from single acquisition (in phase, out of phase, fat and water). All these images were qualitatively evaluated for usefulness in detection of nerves.

Results: Initial results have shown that the water-only images provided the maximum information for nerve imaging, while the remaining contrast images provided additional information regarding the surroundings of the nerves. Targeted MIPs from the brachial plexus, abdomen and the pelvic regions acquired on a 1.5T system are shown in Figure 1a, 1b and 1c respectively. Note that even in difficult regions like the brachial plexus (Figure 1a), fat suppression was found to be uniform thus allowing visualization of great lengths of the brachial plexus nerves.

Discussion: This technique provides both fat-suppressed (water-only) and non-fat-suppressed images from the same acquisition, which allows for perfect co-registration, while simultaneously providing high-resolution MR nerve images. In addition, this technique also generates unsuppressed images that could be used for additional information. Enhancements to acquire both in-phase & out-of-phase images in the same repetition could further decrease the total acquisition time or increase the spatial resolution.