Isotropic Volumetric Imaging of Lumbar and Brachial Plexus using Outer Volume Suppression CUBE MSDE

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Introduction

Magnetic Resonance Neurography (MRN) provides useful information regarding nerve compression, displacement, swelling and injury (1). While fat-suppressed T2 weighted acquisition depicts the nerve elements in brachial plexus, lumbar plexus and sciatic nerves in the pelvis (2), significant technical challenges remain with respect to achieving satisfactory fat and vascular suppression, high spatial resolution and short imaging times. Most existing clinical protocols rely upon fat-suppressed 2D fast spin echo (FSE) acquisition in three planes, a practice that results in long acquisition times on the order of 18-20 minutes. We have developed a reduced field-of-view, volumetric FSE sequence (3) that permits high-resolution MRN in a short acquisition time, with isotropic acquisition that can be reformatted in any oblique plane and excellent fat and vascular flow suppression.

Methods

An Outer Volume Suppression (OVS) technique was developed for use with CUBE (a variable flip-angle, long echo train 3D sequence) to suppress signal from outside of a prescribed FOV in the phase encoding (PE) direction. A series of quadratic RF pulses (TBW=40, Bandwidth=5 KHz) were used to achieve sharp edge profile (Figure 1) at reduced peak B1 (4-5). Cosine modulation made it possible to saturate regions on either side of the phase FOV when bilateral suppression was required for the image prescription (6). Previously, MSDE with 90_x 180_y 90_{-x} RF pulses with motion sensitizing gradients (7) for suppressing signal from the blood vessels has been shown to improve nerve visualization with the CUBE sequence (8). We used OVS prior to MSDE excitation, followed by CUBE volumetric acquisition (Figure 2). Because multiple air, bone and soft tissue interfaces make spectral fat suppression challenging in areas like the brachial plexus, we applied 2-point Dixon technique (9) with OVS CUBE MSDE.

MRN was performed on subjects after informed consent in accordance with the IRB approval of the site. All scans were performed on a Discovery MR 750w scanner (GE Healthcare) using GEM coil suite. Nerve imaging using CUBE MSDE was compared to OVS CUBE MSDE in the brachial and lumbar plexus. For MSDE, motion-sensitizing gradients were empirically set with velocity encoding of 10 cm/sec, and the duration between 90x and 90-x pulses was approximately 8.2ms. For OVS, 3 pulses were added and the total duration of the OVS segment was around 30ms.

In the brachial plexus CUBE MSDE was acquired in the coronal plane with FS covering both sides of the plexus. The acquisition parameters were: FOV 240*240mm^2; Nx*Ny = 256*256; slice thickness 2mm; no of slices 90; TR 2000ms; ETL 96; TE 60ms; No Phase Wrap; NEX 2; Phase Acceleration 2; scan time 6:35 minutes. CUBE MSDE with OVS was acquired in Sagittal plane with 2-point Dixon for Fat Suppression covering one side of the plexus. The acquisition parameters were: FOV 240*192 mm^2; Nx*Ny = 256*224; slice thickness 2mm; no of slices 90; TR 2000ms; ETL 80; TE 60ms; Phase Acceleration 2; scan time 5:07 minutes.

In the lumbar plexus CUBE MSDE was acquired in the coronal plane with FS. Acquisition parameters were: FOV 280*280 mm^2; Nx*Ny = 284*284; slice thickness 1.2mm; no of slices 90; TR 2000ms; ETL 96; TE 60ms; Phase Acceleration 2; scan time 6:35. CUBE MSDE with OVS was acquired in Sagittal plane with FS. The acquisition parameters were: FOV 280*112 mm^2; Nx*Ny = 284*128; slice thickness 1.2mm; no of slices 220; TR 2000ms; ETL 80; TE 60ms; scan time 3:47 minutes.

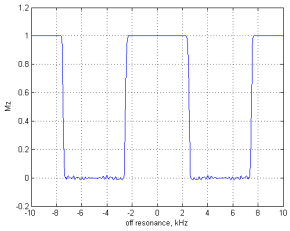

Figure 1: Edge profile of the suppressed region

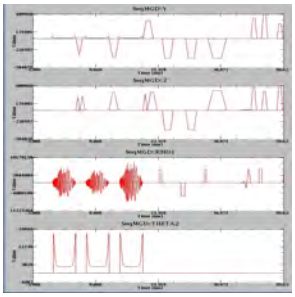

Figure 2: Sequence Diagram

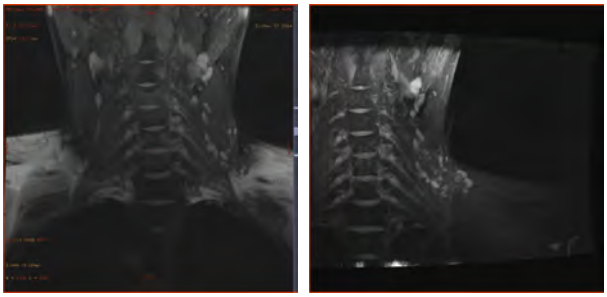

Figure 3: 20 mm thick maximum intensity projections of the brachial plexus using CUBE MSDE FS and CUBE MSDE with Dixon and OVS.

Results

In the brachial plexus, where fat suppression is most challenging, the 2-point Dixon technique allowed uniform saturation of fat signal (Figure 3). The scan time using the Dixon technique was twice as along as standard chemical fat saturation because two echoes are acquired in two separate TRs. Combining the 2-point Dixon with OVS reduced the acquisition time and improve nerve visualization compared to conventional fat suppression. In Figure 3 the lateral extent of the plexus is seen better with CUBE MSDE with Dixon and OVS technique.

In the lumbar plexus, isotropic resolution of the nerves could be achieved with OVS technique in less than 4 minutes. Figure 4 compares lumbar plexus MIP images acquired with CUBE MSDE FS and CUBE MSDE FS OVS. OVS images were acquired in sagittal plan and reformatted to coronal plane.

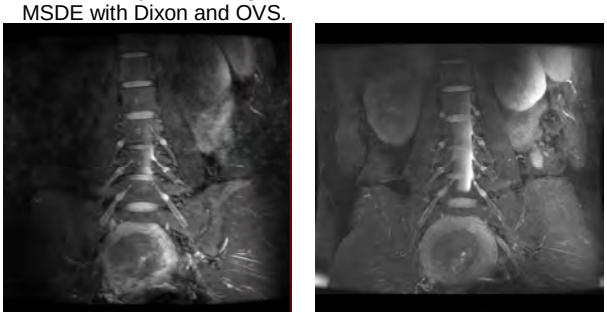

Figure 4: 20 mm thick maximum intensity projection images of the lumbar plexus using CUBE MSDE FS and CUBE MSDE OVS FS

Conclusion

CUBE MSDE with OVS and Dixon technique enables volumetric isotropic acquisition with uniform fat suppression within a clinically acceptable acquisition time for imaging the brachial and lumbar plexus.

References

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