MR NEUROGRAPHY USING A 3D T2-FFE SEQUENCE WITH BINOMIAL RF-PULSE SELECTIVE EXCITATION

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Introduction

MR neurography [1] is a technique which aims at selectively imaging nerves. This requires suppression of fatty tissues, blood and muscle tissue. Furthermore, a high and isotropic resolution and high SNR helps to find and follow even small nerves in the surrounding tissue. T2-weighted turbo spin echo (TSE) sequences, with either STIR or SPAIR for suppression of fat, have been the workhorses in visualization of nerves in various anatomical sites [2]. In addition, extra pre-pulses have been used to suppress muscle tissue [3]. Recently, there has been an interest in diffusion weighted (DW) SSFP sequences [4,5] as well as DWIBS [6] for nerve imaging. SPAIR and STIR as well as TSE sequences use long and SAR intensive inversion pulses, which becomes problematic at high field strength (>= 3T). Additionally, the inversion delays in these methods cause prolonged acquisition times and TSE sequence do not always provide black blood images. DW sequences do give good contrast between nerves and other tissues but necessarily operate at low resolution or lead to long scan times. We here propose to overcome these challenges using a 3D T_2-FFE sequence with binomial RF pulses for water-selective excitation.

Methods

Imaging was performed on a Philips Achieva TX 3T scanner. 16 and 32 channel coil arrays were used to obtain images of the neck area, the lumbar spine and pelvis respectively. Imaging parameters included a flip angle of 26°, T_R/T_E 8.7/3.0ms, partial echo. The ProSet method (1-2-1 pulse) was used for water-selective excitation.

The head and neck region of 6 volunteers was imaged with FOV 23x23x11.5cm^3, voxel size 0.48x.048x1.0mm^3, T_{acq} 9:55 min. Images of the sacral plexus as well as the pelvis where acquired in 2 male volunteers with FOV 40x40x8.5cm^3, voxel size 0.5x.05x0.75mm^3, T_{acq} 4:21 min. Additionally, we obtained T2-FFE and 2D T2w STIR FSE (slice thickness 4.4mm, in plane resolution 0.5x0.5mm^2, T_R/T_E 4591/50ms, ETL 23) images in a patient with a bone metastasis for the planning of stereotactic radiation treatment.

Results

Representative results obtained with the T_2-FFE sequence are shown in figures 1-4. In the neck, on both sides of the spinal cord, the anterior and posterior roots (AR/PR) with individual rootlets, the posterior root ganglion (PG), can be distinguished (figure 1). The posterior and anterior primary ramus (PPR, APR resp.) are clearly visible. Figure 1B shows a transverse view of these structures in the same dataset, illustrating the value of high and isotropic resolution. In figure 2 a coronal MIP of a lumbar plexus image is shown. L1 is marked to give an indication of the FOV placement. Ganglions and nerve roots can clearly be distinguished.

Figure 3 shows a 2D T2w STIR TSE and T_2-FFE image in comparison. The bone metastasis is clearly visible while the much higher and isotropic resolution compared to the TSE image gives additional information that may be used to improve diagnosis of spinal root involvement (figure 4).

Discussion

We have demonstrated that the use binomial RF-pulse fat-suppression in a T_2-FFE to acquire MR images of nerves at high resolution, in a large FOV within reasonable acquisition time is feasible.

Water-selective excitation using composite pulses gives an intrinsically higher SNR compared to the often used STIR approach, since the full excited magnetization of water proton spins is available for imaging. While fat-suppression quality does not depend on B_1-inhomogeneities when using composite pulses, it is susceptible to B_0-deviations. This problem can be mitigated by careful shimming around the region of interest. The use of a 3D sequence and near-isotropic resolution enables multi-planar reconstruction and adds diagnostic value compared to 2D images, as is illustrated by figures 3 and 4. Parallel imaging has not yet been applied, which might allow reduction of acquisition time.

Future work includes addition of a diffusion weighting preparation and application of the sequence to visualization of lymph nodes.

In conclusion we have presented a T_2-FFE based neurography sequence that yields images with high resolution, excellent background suppression and that enables detailed imaging of the nerves with excellent quality.

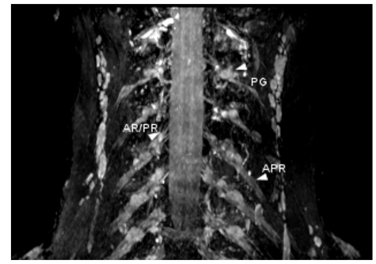

Figure 1A: coronal MIP of 5cm from image of neck area.

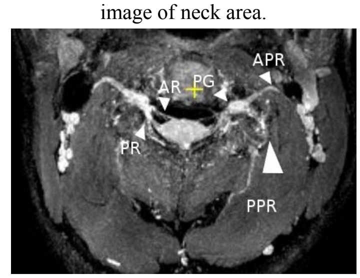

Figure 1B: transverse MIP of 2 cm from same dataset as in figure 1.

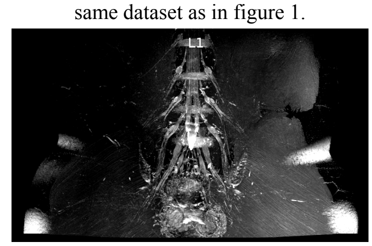

Figure 2: coronal MIP (5cm) of lumbar plexus image; note the incomplete fat suppression at the sides.

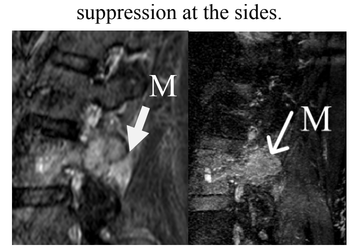

Figure 3: patient with metastasis; left 2D T2w STIR TSE, right T_2-FFE

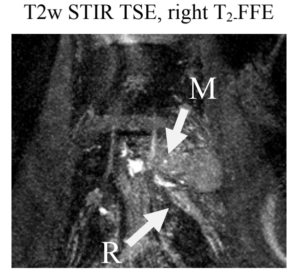

Figure 4: patient with metastasis, 3D T_2-FFE sequence; zoomed coronal view showing nerve root and metastasis.

References

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