Measurement of magnetization transfer effects in the brachial plexus: comparison with T2 and Diffusion effects

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Introduction: Peripheral nerve disorders can result from Cervical Spondyltic Radiculopathy (compression of nerve roots exiting from vertebra due to osteophytes or herniated discs) or myelopathy (compression of spinal cord due to bulging discs). Both lead to similar functional symptoms and signs on EMG, specifically on DFL (distribution of F-latency, a recently introduced nerve conduction parameter [1[). MRI provides the opportunity to obtain more precise information about the location of the injury and quantitative biomarkers of the injury. However tracking the nerves and nerve roots can be difficult because of the complexity of the anatomy, making it hard to perform quantitative imaging in the area. Diffusion weighted whole body imaging with background suppression (DWIBS) has been previously proposed as a method of highlighting the nerve roots separately from background tissue [2]. **Aim:** to combine DWIBS with magnetization transfer preparation, varying b value and diffusion time and varying echo time to measure magnetization transfer ratio (MTR), diffusion time dependent diffusion coefficient (D) and T2 in the brachial plexus.

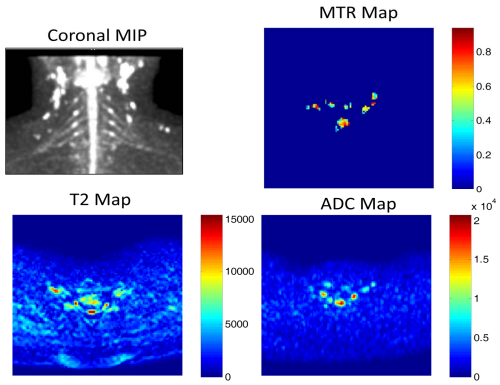

Figure 1 Coronal MIP of brachial plexus, MTR (off res = 0.4 kHz), T2 and Diffusion map (Δ = 18.3ms) of the spinal cord and nerve roots.

Methods: Scanning was performed according to local ethics committee approval on 4 subjects aged 33-49 y.o. (2 female) with no history of injury to the neck or arm. All scanning was performed on a Philips 3T Achieva scanner using the torso 16 channel array coil to provide adequate sensitivity across the brachial plexus. The basic sequence used for all measurements was an inversion recovery (TI=400 ms for fat suppression), pulsed gradient spin echo, single shot EPI sequence, (3mm isotropic resolution, 192×60×300mm FOV, fat-water shift=4.64 pixels), 18 transverse-oblique slices centred on C5-C6) generally with TE= 100 ms and diffusion encoding to suppress the signal from all tissues except the nerves to assist in image analysis. **For MTR** this was preceded by a train of 8 300° flip angle MT pulses played out at 20 ms intervals; the MT scan was repeated 9 times with off-resonance of ±1000, ±600 (optimal to detect NOE effect in nerves), ±400 and 0 Hz and finally no off resonance pulses, TR=6s, b=500 s/mm^2, Δ=28.3, δ=10ms. **For T2** 6 different echo times were acquired: TE=55,60,65,70,75,80 ms, TR=6s, b=500 s/mm^2, Δ=81.3ms, δ=10ms. **For diffusion** measurements data was acquired for b=300,600 s/mm^2, with diffusion times Δ1=18.3 and Δ2=81.3ms, δ=10ms, TE= 100ms, to give sensitivity to restricted diffusion (b=0 not used due to IVIM contamination). Coronal MIPS were created to confirm the location of the brachial plexus. Sagittal images were reconstructed through the nerve roots. ROIs were selected over the nerve roots at C5/C6/C7/C8 and over the spinal cord, automatically based on their high image contrast by fitting with 2D Gaussian surface and selecting only those ROIs which are at least 2 times the standard deviation of the background (typically one voxel for each nerve location and five voxels for cord location). T2 and D were calculated using a linear fit to log(Signal) versus TE and b. MTR was calculated from the difference between the saturated and non saturated signal, normalized to the saturated signal (only data for offset of ±600 Hz reported).

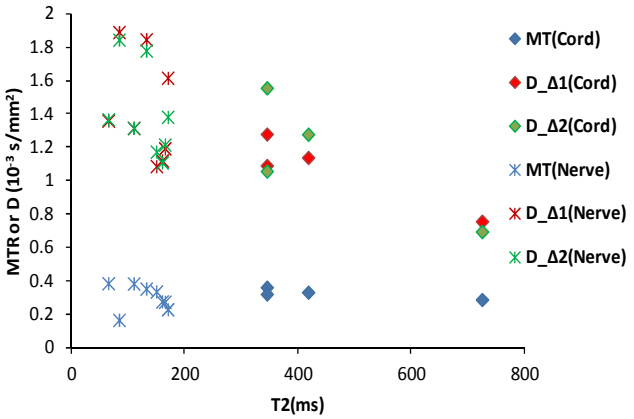

Figure 2 Relationship between D, MTR and T2 values from both sides nerves and cords for all subjects (Δ1=18.3ms, Δ2=81.3ms).

Table1: MT, T2 and D values of cord and nerves

	MT	T2(ms)	DΔ1(mm²/s)	DΔ2(mm²/s)
Nerve	0.30±0.08	129±39	1.43±0.32	1.40±0.27
Cord	0.33±0.03	458±181	1.07±0.22	1.15±0.36

Results: Figure 1 shows a coronal MIP through the brachial plexus and MTR, T2 and ADC maps, Figure 2 shows the relationship between MTR, D and T2 measured in healthy volunteers for both the nerves and cord. There was a negative correlation between D and T2 measurements for cord and nerves (R^2 = 0.87, 0.12 for Δ1 and R^2 = 0.67, 0.23 for Δ2 respectively). The intersubject averages are summarized in Table 1. Across all subjects diffusion measured with Δ2 tended to be lower than that measured with Δ1.

Discussion: A protocol has been developed to allow the measurement of D, T2 and MT in the brachial nerves, with limited contamination from CSF or blood flow by the inclusion of diffusion weighting in the sequences. In this healthy group no particular trends are expected in the data. However, figure 2 suggests a negative correlation between D and T2, which seems to be similar across both nerve and cord. This is contrary to what might be expected due to CSF contamination (although the wide range of T2 values measured in the cord do suggest some csf contamination there). Alternatively this may reflect weighting of signal to different tissue compartments as T2 changes. The close correlation observed between independent measurements of D for different diffusion times indicate real biological variation between subjects. The tendency for D81<D18 suggests an effect of restricted diffusion is seen in the nerve. This set of sequences combining DWIBS with different quantitative imaging techniques provides method for comprehensive quantitative evaluation of the brachial plexus and it will now be applied to clinical groups. **References:** [1]Rabbani, BMC Research Notes, 2010 [2]Takahara, Radiat Med 2004. **Acknowledgment:** This work was funded by the Islamic Development Bank (IDB).