Spinal Cord Diffusion Tensor Imaging (DTI) and 1H-MR Spectroscopy (MRS) at 1.5T and 3T.

V. Callot[1], Y. Le Fur[1], J-P. Ranjeva[1], G. Duhamel[1], and P. J. Cozzone[1]
[1]Centre de Résonance Magnétique Biologique et Médicale (CRMBM), CNRS, UMR 6612, Faculté de Médecine, Marseille, France

Introduction

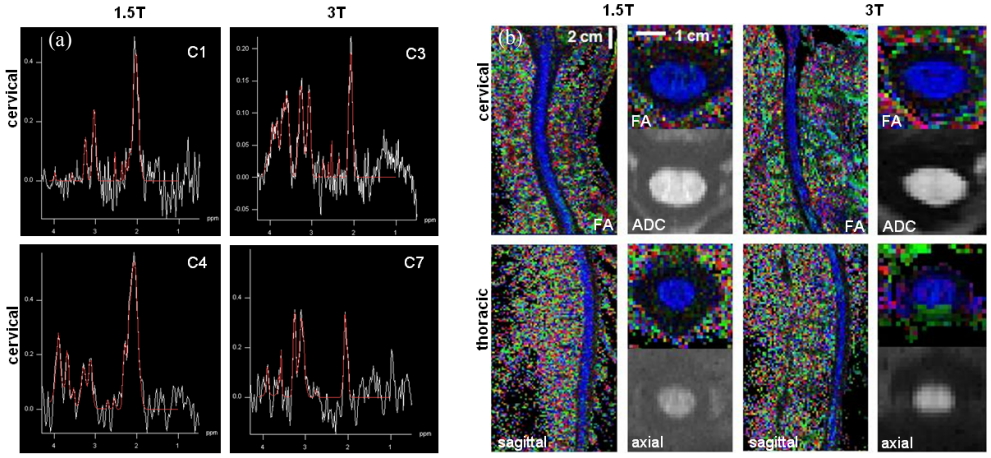
MRI is an important modality in the assessment of spinal cord (SC) diseases. Conventional examinations are based on anatomic T_1 and T_2-weighted images but new techniques such as Diffusion Tensor Imaging (DTI) and single-voxel 1H-MR spectroscopy (SV-MRS) tend to be used in order to better described the pathology and understand the underlying mechanisms. Several difficulties, including strong magnetic field inhomogeneities, respiratory and cardiac movements, and the small size of the spinal cord, may nonetheless limit the quality of the acquisitions.
Whereas several studies have shown promising results [1-5], there is scant literature comparing 1.5T and 3T MRI and MRS. Our purpose was therefore to investigate the efficiency, in terms of image/spectra quality and metrics, of the available manufacturer MRS and DTI sequences at both 1.5T and 3T. Experiments were performed at different spinal cord locations (thoracic and cervical levels) and for different imaging plane orientations (sagittal and axial).

Materials and Methods

Experiments were performed on healthy volunteers, on a 1.5T Avanto and a 3T Verio MR systems (Siemens Healthcare, Erlangen), using different coil combinations (12-channel phased-array head coil + 4-channel neck coil or 24-channel phased-array spine coil + 16-channel flexible body coil).
DTI experiments were performed using a single-shot monopolar EPI sequence, with b=600 s/mm², 6 directions, fat saturation, PAT 2, shortest TE. For the sagittal acquisitions, FOV=180x180 mm², in-plane resolution=1.4x1.4 mm², slice thickness=1.5 mm, 12 slices. For the axial acquisitions, FOV=100x100 mm², in-plane resolution=0.7x0.7 mm², slice thickness=6mm, 8 slices. MRS was performed with a Point RESolved Spectroscopy (PRESS) sequence (TR/TE 2000/30 ms, 1024 points, voxel size 6x9x30 mm^3). Both DTI and MRS acquisitions were triggered with the ECG signal in order to limit the effect of the cerebrospinal fluid pulsatility.

Results

Figure 1a shows typical spectra collected at 1.5T (C1, C4 levels) and 3T (C3, C7 levels). Figure 1b illustrates sagittal and axial FA maps, along with axial ADC maps at both cervical and thoracic levels. Table 1 summarizes the fractional anisotropy (FA) derived from the DTI measurements at both fields, at different locations (cervical/thoracic) and for different imaging plane orientations (sagittal/axial). Identical FAs were found independently of the magnetic field, for all configurations, except for the sagittal orientation at 3T for which significantly lower values were observed.



FA	sagittal	axial
Cervical / 1.5T	0.80±0.07	0.79±0.05
3T	0.61±0.04	0.81±0.03
Thoracic /1.5T	0.78±0.07	0.80±0.04
3T	0.67±0.07	0.76±0.09

Table 1 – FA measurements in the white matter for different configurations (magnetic fields, slice orientation and SC levels).

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Fig. 1 – (a) Typical ^{1}H-MR spectra, and (b) sagittal and axial FA maps (color) and axial ADC maps (grayscale) acquired at the cervical (top) and thoracic (bottom) levels on healthy volunteers, at both 1.5 and 3T.

Discussion:

In this preliminary study, 1.5 and 3T single-voxel MRS and DTI acquisitions were performed on healthy volunteers at various levels of the spinal cord. Despite challenges due to CSF motion and the small size of the voxel (1.62 ml, which is almost half of the voxel size used in the brain), MRS of the spinal cord could be performed at the cervical level, for both magnetic field strength. As expected, higher spectral resolution was obtained at 3T. However, no accurate acquisition could be obtained at the thoracic level, independently of the magnetic field.
In the sagittal plane orientation, which may be valuable to rapidly evaluate the spinal cord structural integrity or to map a diffuse disease, the quality of the DTI acquisitions were sufficient to allow tractography (data not shown). However, the DTI metrics derived from the measurements at 3T presented systematic lower values, attributed to more prominent magnetic field inhomogeneities and signal dephasing. For this particular imaging plane orientation, other strategies have to be used in order to further reduce the echo train [6].
In the axial plane orientation, identical FA values were observed at 1.5 and 3T. These values were consistent with literature data [7]. Furthermore, higher spatial resolutions were reached for both magnetic field (0.7x0.7 mm²), therefore offering a chance to discriminate the tiny gray matter structure (butterfly-shaped area with lower FA) and access to measurements (data not shown) rarely investigated although they may lead to additional information in pathologies such as traumatism, lesion, lateral amyotrophic sclerosis and even multiple sclerosis [8].

Conclusion

In this abstract, a comparison of the DTI images and single-voxel spectra that could be routinely acquired on clinical 1.5 and 3T scanners is proposed. Current investigations focus on the improvement of thoracic single-voxel MRS and sagittal DTI at 3T. The overall goal of the study is to provide accurate and reliable spectroscopic and DTI normal metrics, at different spinal cord levels, that could be referred to, when characterizing spinal cord pathologies.

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