In vivo myelin water imaging in rat spinal cord

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Introduction

Measuring myelin content in a rat model of spinal cord injury (SCI) can be an important marker of the cord pathology and can be used to monitor potential SCI therapies. Myelin water imaging has been shown to measure myelin content in normal and diseased brain and spinal cord tissue [1, 2]. This technique was successfully applied in excised rat spinal cords [3], however the requirements of very high SNR and spatial resolution makes it challenging to apply this technique in rat spinal cord in-vivo. Here we present preliminary results of high spatial resolution myelin water imaging in six normal rat spinal cords in-vivo. The objective of this pilot study was to determine the feasibility and inter-subject variability of myelin water imaging in in-vivo experiments.

Methods

All MRI experiments were carried out on a 7T animal scanner (Bruker, Germany). The implantable coil system [4], consisting of a rectangular loop (22x19 mm) surgically implanted over the lumbar spine and inductively coupled to a 3 cm diameter external pick up coil, was used for both pulse transmission and signal reception. Myelin water measurements were carried out 7 – 14 days following implantation using a single slice, multi-echo CPMG sequence [5] (256x256 matrix, TR/TE=1500/6.673ms, NA=6, 32 echoes). A 1.5mm slice was selected through the lumbar spine (L1) and an FOV of 3cm was used resulting in in-plane resolution of 117μm. T_2 distributions were calculated from the multi-echo data using non-negative least squares analysis [6]. Myelin Water Fraction (MWF) maps were generated by integrating the 7.75-20 ms range and divided by the total integral of the T_2 distribution in each pixel.

Results and Discussion

Figure 1 shows the first echoes of the CPMG data and the reconstructed MWF maps acquired from all six rat spinal cords. Figure 2 shows T_2 distributions for all six spinal cords extracted from the ROIs encompassing white matter (top) and grey matter (bottom). Table 1 summarizes the individual and average values and standard deviations of the SNR in the 1st echo of the CPMG data and the MWF and the T_2 values of the short and medium components from white and grey matter.

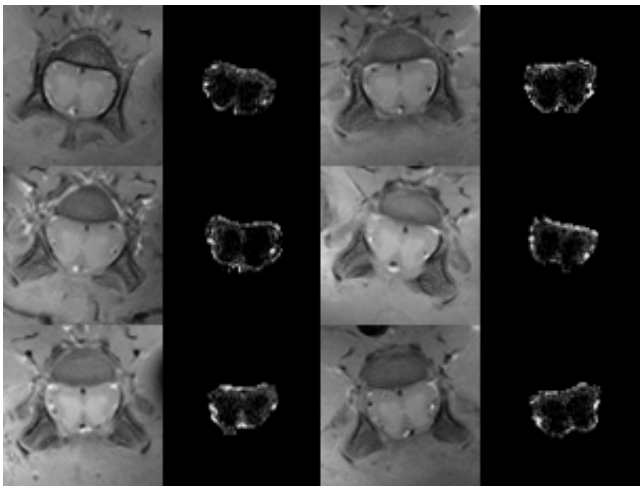

Fig. 1. First echo of the CPMG data and the reconstructed MWF maps acquired from six rat spinal cords in vivo.

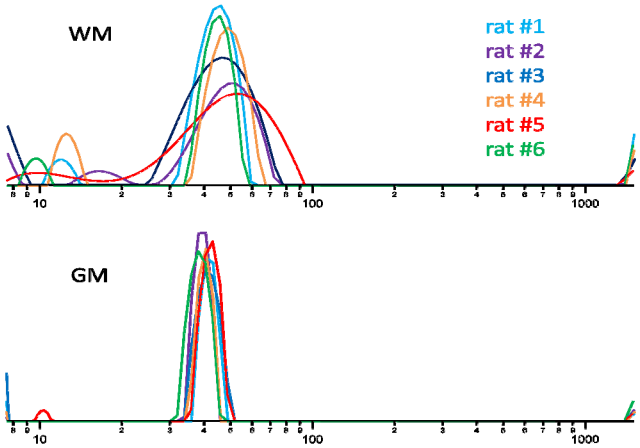

Fig. 2. T_2 distributions from the ROIs encompassing white matter (top) and grey matter (bottom) in CPMG data acquired from six rat spinal cords in vivo.

Table 1. Measurements of SNR in the 1st echo of the CPMG data and the MWF and the T2 values of the short and medium components from the white and grey matter.

		white matter			grey matter		
rat #	SNR (1st echo)	MWF	T2 short [ms]	T2 medium [ms]	MWF	T2 short [ms]	T2 medium [ms]
1	82	0.2	16.88	53.15	0.02	7.81	41.48
2	99	0.12	12.42	46.90	0.004	7.81	41.48
3	105	0.22	7.81	46.90	0.06	7.81	41.48
4	79	0.24	12.85	49.91	0.01	7.81	41.48
5	134	0.19	10.16	53.15	0.06	10.70	44.09
6	68	0.2	9.92	46.90	0		39.05
average	**94.5**	**0.195**	**11.68**	**49.48**	**0.026**	**8.39**	**41.51**
s.d.	**23.62**	**0.041**	**3.14**	**3.07**	**0.027**	**1.29**	**1.59**

All reconstructed MWF maps show details of the cord morphology. The relatively uniform intensity across each map suggests that the B_1 field produced by a small implanted coil is sufficiently uniform to acquire good quality CPMG data. T_2 distributions in the grey matter show small inter-subject variability. Increased variability in the white matter ROIs is likely due to signal contamination from CSF and the neighbouring blood vessels, and differences in myelin content between dorsal and lateral and ventral white matter. The quality of the in vivo data can be further improved by minimizing the cord motion. Although data acquisition was triggered to the respiration in this study and no obvious ghosting artefacts were present in the multi-echo images, signal decay curves from individual pixels showed increased variability most likely due to motion. We are currently working on developing a restrain system that would immobilize the spinal cord during MRI measurements.

Conclusions

In this pilot study we have shown that high resolution myelin water mapping in rat spinal cord in-vivo is feasible. The MWF maps show details of the cord morphology, and the average MWF values in WM and GM correspond well with previously published results and the expected amounts of myelin within the cord [2].

Acknowledgments

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