Apparent anisotropy in a LES model of demyelination observed by QSI: Effect of experimental parameters

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Introduction

Although water diffusion in neuronal tissues was found to be anisotropic more than a decade ago[1], the relative importance of myelin in determining the observed water anisotropy is still under debate.[2] It is well known that at sufficient high diffusion weighting, more than one diffusion component can be observed in neuronal tissues.[3] Recently, high b-value q-space diffusion MRI, which emphasizes the slow diffusing component, was used to study CNS morphology and pathology.[4] In the present study we used both low and high b-value q-space diffusion MRI at different diffusion times to characterize the diffusion characteristics of long evans shaker rats (LES)[5] spinal cords, characterized by low myelin content, and their age matched controls.

Methods

MRI experiments were performed using an 8.4T NMR spectrometer (Bruker, Germany) equipped with a micro5 imaging gradient probe capable of producing pulsed gradients of up to 190 gauss cm^{-1} in each of the three directions. Formalin-fixed spinal cords of 33 days old LES (N=3) and age matched control (N=3) rats were used in this study. The MRI protocol included low and high b-values q-space MRI collected with a stimulated echo (STE) diffusion imaging pulse sequence with the following parameters: Three slices of 1.35 mm thickness with a 0.65 mm gap were acquired with a field of view (FOV) of 4.8*4.8 mm and 64*48 digital resolution reconstructed to 64*64 matrixes and TR/TE/δ = 2000/30/2 ms. The diffusion data was acquired with three different Δs of 22 , 50 and 100 ms, both perpendicular (x) and parallel (z) to the long axis of the fibers of the spinal cord. The q-space MR images were acquired by incriminating the diffusion gradients in 16 steps from 5-50 Gcm^{-1} resulting in maximal b- and q- values of 1320 s/mm^2 and 425.8 cm^{-1}, respectively, and also from 5-117.5 Gcm^{-1} resulting in maximal b- and q- values of 8139 s/mm^2 and 1000 cm^{-1}, respectively.

Results and Discussion

Figure 1 depicts the displacement maps obtained from low and high b-value q-space diffusion MRI experiments performed on representative control and LES spinal cords at the three diffusion times, when diffusion was measured perpendicular to the long axis of the spinal cord. Clearly, we found that for white matter, the mean displacement values were larger for the LES spinal cords as compared to that of the control spinal cords at all diffusion times. The difference in the mean displacement of the two groups increased with the increasing diffusion times and was more pronounced when higher b-values (or q-values) were used.

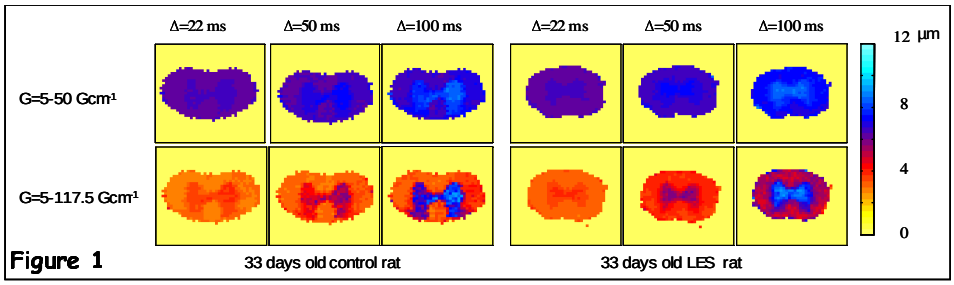

Figure 1

Figure 2A shows that for low b-values, the difference in the FA is statistically significant between the control and the LES groups only for the longest diffusion time (100 ms). However for the high b-values data, statistical significance is achieved for the FA even at the shortest diffusion times used (i.e. 22 ms).

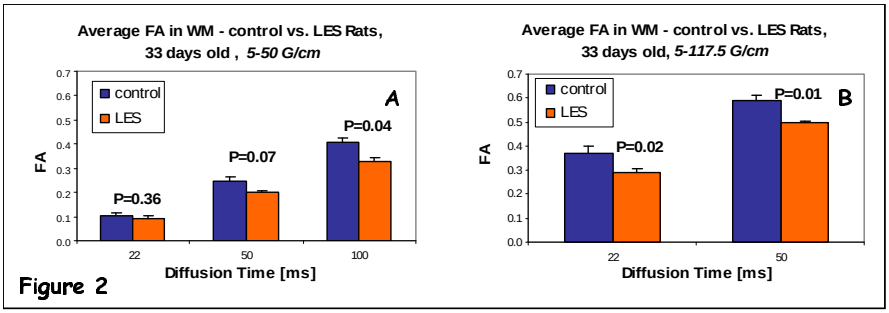

Figure 2

Summary

This study shows that the lack of myelin in the LES spinal cord significantly affects the diffusion characteristics and the diffusion anisotropy of water in white matter in a diffusion time-dependent manner. Also, the difference between the two groups is more apparent at high b values q-space imaging (QSI) and at longer diffusion times. Therefore we need to speak of apparent anisotropy (AA) and apparent fractional anisotropy (AFA).[6]

References

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