Magnetization Transfer Modeling of White Matter in the Myelinated and Unmyelinated Mice

T. Andrews[1], S. J. Dodd[2], J. Lancaster[1], P. T. Fox[1]

[1]Research Imaging Center, University of Texas Health Science Center at San Antonio, San Antonio, TX, United States, [2]NIH/NINDS, Bethesda, MD, United States

Introduction

Recent progress in MR microscopy has made it possible to study a variety of mouse models with MR using new sequences and theoretical models [1]. This work compares magnetization transfer (MT) imaging results and calculated model parameters for shiverer mice to those of its wild-type.

Methods

All data were acquired using a Tecmag console with a 7T Oxford magnet and a custom-made 25mm diameter bird-cage coil. MT experiment parameters: Matrix size = 256 x 104 (zero-filled to 256 x 128) with resolution 0.09 x 0.12 mm in-plane. Slice thickness was 0.5 mm. Pulse duration was 6s. Imaging sequence was gradient-echo with TR/TE = 6.3s/6 ms. 6 offsets were used: 2,3,5,8,14,24 kHz and pulse powers of 170, 330, and 660 Hz. One shiverer and one wild type were imaged at each power setting. Total scan time = 2.5 hours. T_2 experiment parameters: 3D slab-select spin-echo sequence. 18 echoes were acquired with TE in steps of 6ms. Matrix-size = 180x 108x 8, 6 averages, TR = 2.2s, scan time = 3 hours, in-plane resolution = 0.13 x 0.125 x 0.45 mm. T_1 experiment: spin echo saturation recovery, TR=8,3,2,1.5,1,0.6 sec. ROI data from white matter (corpus callosum) were used. M_z^a/M_0^a values were fit to a 2-pool MT model [1].

Results and Analysis

For the shiverer longer T_1 and T_2 were noted (T_1=1550ms, T_2=58ms) compared to wild type (T_1=1380ms, T_2=42ms). M_z^a/M_0^a values for shiverer (Figure 1) were higher for all corresponding settings than they were for the wild type. The MT model (Table 1) found a smaller value of f and T_{1A}/T_{2A} in the shiverer than in the wild-type, but the shiverer and wild-type were not significantly different in T_{2B} and $RM_o^B T_{1A}$. The data was fit again to the model with the effect of MT removed by setting R=0 and M_0^b=0 and the resulting fit was poor (Figure 1).

Discussion

Fitted parameters (Table 1) obtained for the wild-type mouse are similar to those previously reported for normal rats at 4.7T [2]. Like the previous rat study [2], the value for T_{1A}/T_{2A} obtained from the model is much larger than the value obtained from separate T_1 and T_2 measurements. In the shiverer, model parameters for white matter were similar to previously reported values for gray matter in rats [2]. The poor fit of the model without MT effects shows that the model does not specifically describe MT effects due to myelin in the tissue. The non-zero value of f indicates that it is not a specific measure of myelin.

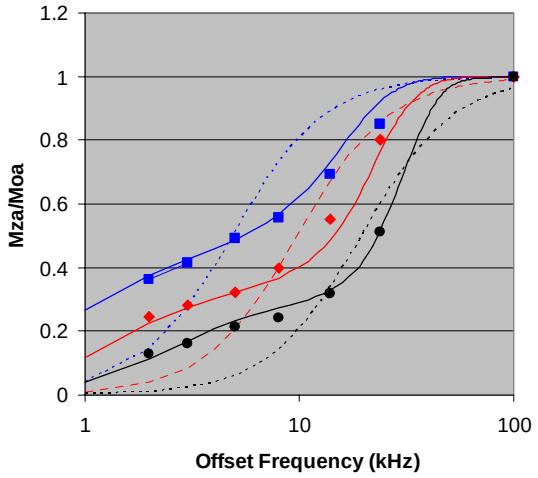

Fig. 1 M_z/M_0 for corpus callosum of shiverer. Points are measured data, solid lines are for the model with MT effects, dashed lines are for the model without MT effects.

Conclusions

Significant magnetization transfer was observed in severely hypomyelinated white matter, which presents an obstacle to the use of MT to quantify myelin. This suggests that either the methods or the model may have to be modified to discriminate between different sources of MT effects. Despite this, two of the model parameters were sensitive to the amount of myelin present.

References

[1] Morrison, et al, MRM 33, 475-482 (1995).
[2] Quesson, et al, MRM 38, 974-980 (1997).

Parameter	wild-type	shi
$RM_o^B T_{1A}$	2.48 (0)	2.73 (0)
T_{1A}/T_{2A}	99 (1420)	48 (876)
T_{2B} (μs)	10 (2)	8 (2)
f	0.215 (0)	0.063 (0)

Table 1 Fitted model parameters for corpus callosum. Fit values to model without MT effects are in parentheses.