T1, T2, and ADC of the rat retina at 7T

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INTRODUCTION: The highly structured retina with multiple well-defined layers provides an excellent model to test high-resolution anatomical, physiological and functional MRI techniques. There have been increasing interests in retinal MRI, including layer-specific structural (1-6), physiological (1,5) and functional (1,7) MRI. While MRI has lower spatial resolution and longer acquisition time compared to optical imaging techniques, MRI of retina: 1) has no depth limitation, 2) has large field of view, 3) is non-invasive, 4) is not limited by opacity of the media (such as cataract and vitreal hemorrhage), 5) measures blood flow and blood volume at the tissue level (as opposed to large vessels), and 6) can image anatomy, physiology and function in a single setting. High-resolution MRI up to 23x23x500 µm in vivo has been reported, but contrast-to-noise ratio among different layers remains a significant challenge. Knowledge of quantitative T1, T2, and ADC would help to systemically optimize structural, physiological and functional MRI contrast in the retina. The goal of this study is to measure T1, T2, and ADC in the rat retinas at very high spatial resolution.

METHODS: Four repeated measurements were made on two normal rats (~300g) paralyzed and mechanically ventilated under 1.1% isoflurane anesthesia. The images were acquired on a 7T Bruker system with the common parameters of: FOV = 6.4x6.4 mm, matrix=128x128, resolution=50x50x800 µm. T1 was measured using saturation recovery technique with gradient-echo EPI, TE=31.1 ms and variable TR=100, 200, 400, 800, 1600, 3200, and 6400 ms. T2 was measured using spin-echo EPI with TR=2000 ms and variable TE =31, 41, 51, 61, 81 and 101 ms. ADC was measured using conventional spin echo sequence with b=0 and 3 orthogonal diffusion directions with b=500 s/mm^2. Non-linear least squared fitting was used to obtain the quantitative maps.

RESULTS & DISCUSSION: **Figure 1** shows a typical Mo (from T1 data), T1, T2 and ADC maps of a rat eye at 50x50x800 µm. **Table 1** summarizes T1, T2 and ADC values obtained from ROIs carefully drawn on the whole retina and the vitreous. These quantitative MRI parameters are similar to those of brain at 7T. These results are in overall good agreement with the T2 and ADC reported in the cat retina at lower spatial resolution at 4.7 T (2). Preliminary T2* measurements showed a whole-retina T2* values of 12.9 ± 0.35 ms at 7T, compared to the brain T2* of 25 ms. This may be due to the retina is located in region of high magnetic susceptibility.

Figure 2 shows the detailed profiles of histology, T1, T2 and ADC across the retinal thickness. T1, T2 and ADC of the vitreous were high compared to the retina as expected due to its more fluid-like properties. Sclera and lens are more solid tissue with low water density and short T2 and their measurements were less reliable, given the ranges of TE used. The quantitative MRI profiles are relatively uniform within the retina, with high and low values on either side due to partial-volume effects.

CONCLUSION: This study presents detailed profiles of T1, T2 and ADC across the retinal thickness at high spatial resolution at 7T. T1, T2 and ADC of the retina are similar as those of the brain but differ markedly from those of vitreous and sclera. These data could be utilized to systematically optimize anatomical and functional contrast-to-noise ratio for imaging the retina.

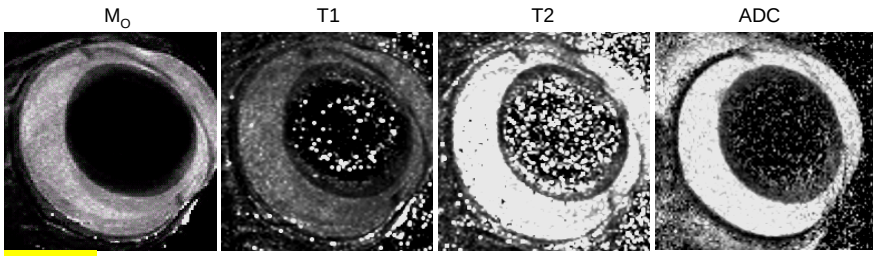

Figure 1. M_o (from T1 fitting), T1, T2 and ADC maps from a rat eye at 50x50x800 µm.

Table 1. Group-averaged T1, T2 and ADC data of the vitreous, retina and brain.

	Vitreous	Retina	Brain
T1 (s)	4.5 ± 0.3	1.5 ± 0.5	1.8
T2 (ms)	446 ± 84	59 ± 10	50 ± 2
ADC(x10^{-3} mm^2/s)	3.1 ± 0.03	0.80 ± 0.07	0.76 ± 0.03

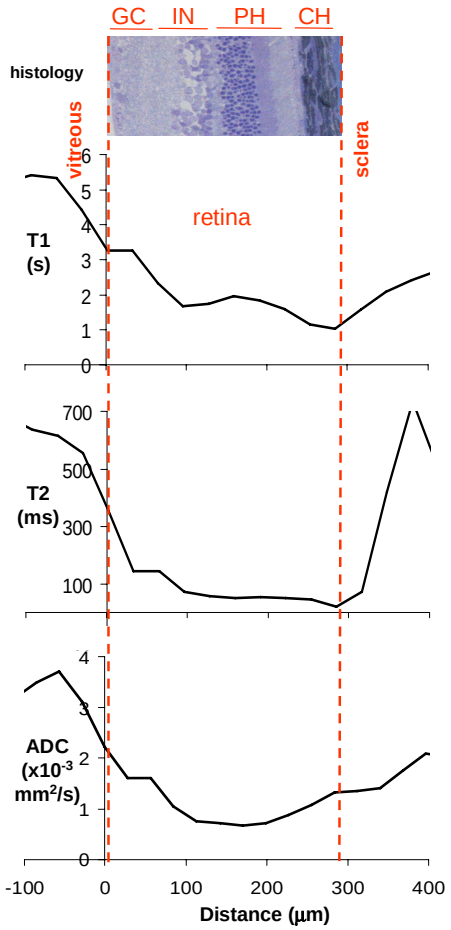

Figure 2. Group-averaged profiles of histology, T1, T2 and ADC across the retinal thickness. GC: ganglion cell layer, IN: inner nuclear layer, PH: photoreceptor layer, CH: choroidal vascular layer.

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