MRI Methods at 4.7 T for Imaging Parkinson's Disease

R. M. Lebel[1], A. Eissa[1], M. Gee[1], M. Wieler[2], W. R. Martin[2], and A. H. Wilman[1]

[1]Biomedical Engineering, University of Alberta, Edmonton, Alberta, Canada, [2]Neurology, University of Alberta

Introduction – Parkinson's disease (PD) is an inexorably progressive disorder associated with a worsening motor deficit. Iron content in portions of the basal ganglia is known to increase with disease severity and may serve as a biomarker of PD (1). To this end, our group has been studying PD patients for many years (2) using a battery of tests including quantitative T2* mapping of the basal ganglia at 3.0 T (3). While this approach offers quantitative results, the spatial resolution is limited and the method may not be sufficiently sensitive to small changes in iron content. To increase spatial resolution and sensitivity to iron in our PD study, we have begun using a higher field 4.7 T system as well as 3.0 T. However, the quantitative T2* imaging approach of multi-gradient echo imaging is less effective at 4.7 T because the T2* times are significantly shorter, which leads to minimal signal and increased air-tissue susceptibility artifact in later echoes. In this work we investigate both qualitative and quantitative alternatives to T2* mapping for iron measurement in PD at 4.7 T. Specifically, we take advantage of the increased iron sensitivity of 4.7 T in three separate pulse sequences: apparent T2 mapping using fast spin echo (FSE), high resolution T2-weighted FSE, and phase susceptibility-weighted (SW) imaging. These approaches are studied in normal volunteers and in PD.

Methods – Ten normal volunteers and a PD patient were imaged at 4.7 T using a circumscribing 27-diameter birdcage transmitter and a 4-element reception array. Each subject received a 4.7 T MRI brain exam using a combination of the sequences described below.

High resolution fast spin echo: 1.75 mm slice thickness, 22 slices, TE/TR 44/6250 ms, flip angle 90° excitation followed by 160º refocusing pulses, 8 echoes, in-plane matrix 700 x 512, FOV 20 x 17 cm yielding 0.19 mm^3 true voxel volumes.

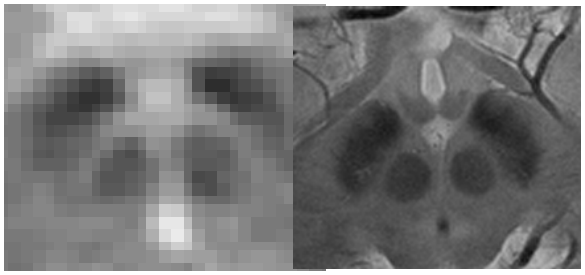
Apparent T2 mapping: 2D multi-echo multi-slice spin echo, 16 echoes, 8 ms interecho spacing, 2 mm slice, 256 x 256 matrix, 90° excitation followed by 180º refocusing pulses, 3 slices only owing to RF heating, 6 min total acquisition.

Susceptibility-weighted imaging: TE/TR 20/70ms, 20º excitation, 22 slices per slab, 3 mm thickness, 512 x 256 in-plane matrix, 6.6 minutes per slab. Processed into 3 images: magnitude, unwrapped and filtered phase, and thresholded phase multiplied 4-fold into magnitude to create SW image (4).

***Image Analysis*:** The T2-weighted images were used to precisely define structural boundaries in the basal ganglia and to make regional ROI measurements that serve as a qualitative indicator of iron concentration. An apparent T2 map was calculated from the multi-spin echo pulse sequence with ROI measurements providing quantitative mean apparent T2 values. From the SWI phase images ROI measurements were performed to determine the mean phase angle, in addition the T2* contrast was measured from the magnitude image.

Results – Fig 1 illustrates substantia nigra and red nucleus using T2* mapping at 3.0 T and T2-weighting at 4.7 T. Note the higher spatial resolution and good contrast of the T2-weighted approach, which offers precise boundary assessment. Fig 2 shows T2-mapping.from 4.7 T. Note the increased R2 in the iron laden structures of this normal volunteer. Fig. 3 illustrates SWI and T2 –weighting from a PD patient at 4.7T.

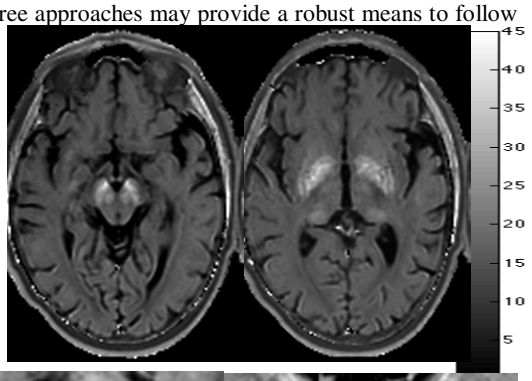
Conclusions – We have developed three separate approaches to follow PD patients at 4.7 T using T2-weighted FSE, apparent T2 mapping, and phase measurement in SWI. Compared to T2* mapping, the T2 approaches offer higher spatial resolution and improved image quality, while the phase SWI approach offers higher sensitivity to iron than T2* quantification. Together these three approaches may provide a robust means to follow longitudinal changes in PD.

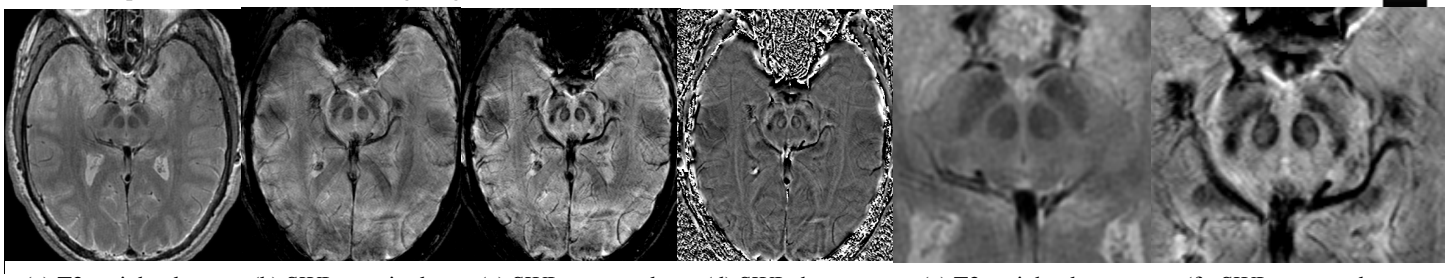


T2* map at 3.0 T T2-weighting at 4.7 T

Fig. 1 (left) Midbrain using T2* map at 3.0 T and T2- weighting at 4.7 T from a normal subject.

Fig 2 (right) Apparent T2 maps (presented as 1/T2) at 4.7 T in a normal subject. The maximum T2 was 22ms (1/T2=45 s^{-1}) in the substantia nigra.





(a) T2-weighted (b) SWI magnitude (c) SWI processed (d) SWI phase (e) T2-weighted (f) SWI processed

Fig 3 4.7T images from a 52 yr old Parkinson's patient using T2-weighted FSE and 3D SWI. The midbrain is enlarged in (e,f).

References 1.Schenck *NMR Biomed.* 2004; 17:433–45. 2. Ye *Movement Disorders* 1996; 11:243-9.
3. Wild *Magn Reson Med* 2002; 48: 867-76. 4. Haacke *Magn Reson Med* 2004;52: 612-8.