Comparison of 1.5 and 3.0 Tesla MRI Diffusion Tensor Imaging (DTI) in patients with Multiple Sclerosis

M. J. Moser[1], R. K. Breger[1], B. O. Khatri[2], and Y. Liu[3]

[1]Radiology, Aurora St. Luke's Medical Center, Milwaukee, WI, United States, [2]Neurology, Aurora St. Luke's Medical Center, Milwaukee, WI, United States, [3]Medical Physics, St. Luke's Medical Center, Milwaukee, WI, United States

Background

Diffusion Tensor Imaging (DTI) is an MRI technique that takes advantage of the non-random, linear diffusion of water through certain structures in the brain and allows imaging of white matter tract orientation and integrity not visible normally with T1 and T2-weighted MRI sequences. One of the main DTI measurements of linear diffusion is called fractional anisotropy (FA). Quantitative evaluation of multiple sclerosis (MS) demyelinating plaque size has shown that FA measurements have increased sensitivity compared to conventional T2 techniques (1,2). Recent studies have shown that differences exist in the measurement of FA between different magnetic field strength MRI imaging (3). This study was designed to see if higher magnetic strength 3T MRI would have different FA measurements compared to 1.5T MRI in patients affected with MS.

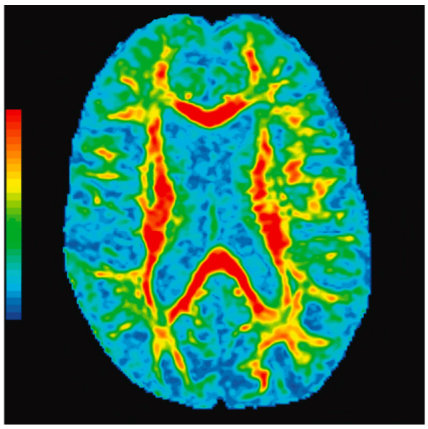
Methods

DTI (TR/TE 1700/min ms, b 1000, 25 directions) was performed on 18 patients affected with MS using both 1.5 and 3 Tesla MRI. FA was measured in different regions of normal-appearing white matter (NAWM) and included the splenium corpus callosum, genu corpus callosum, forceps minor, forceps major, cortical spinal tract and the midbrain. The mean FA values for each anatomical area and their differences were calculated for statistical significance.

Results

Eighteen patients with MS participated in the study. Ten NAWM regions were chosen and studied in these patients. For each white matter region, the mean FA values for both 1.5 and 3 Tesla studies were compared and determined for statistical difference. No statistical difference was found between mean FA values in 1.5 and 3 Tesla DTI studies for 8 of the 10 white matter regions studied. Two regions showed mild statistical difference, which may be attributable to random measuring variability or to a higher sensitivity in measuring FA with higher magnetic field strength, as suggested by previous studies (3).

Region	Side	Ave 1.5 T	Ave 3 T	Diff (3-1.5)	p-value
GCC	Center	0.652	0.629	-0.022	0.128
SCC	Center	0.729	0.694	-0.034	0.031
FMi	R	0.532	0.517	-0.015	0.145
	L	0.509	0.518	0.008	0.329
FMa	R	0.534	0.557	0.023	0.269
	L	0.543	0.550	0.007	0.602
CST	R	0.592	0.642	0.050	0.107
	L	0.631	0.654	0.023	0.044
MB	R	0.573	0.581	0.009	0.663
	L	0.556	0.544	-0.012	0.394



The table lists the average FA values for each white matter region, the difference in these values between 1.5 and 3 Tesla studies and the p-values for these differences.

The image shows the amount of FA within different regions of brain white matter. Red corresponds to the highest FA while dark blue corresponds to the lowest FA. Typically, the genu and splenium of the corpus callosum and the coritcal spinal tracts exhibit the highest FA, corresponding to the most linear, organized white matter tracts.

Discussion

Assessment of clinical diagnosis, natural history and treatment effects of patients with MS are evaluated with the help of MRI (4,5). While MRI is used to characterize disease state in MS patients, white matter (WM) may be disrupted in areas not apparent on conventional T2-weight MRI. Abnormalities of NAWM on T2-weighted MRI have been detected using DTI MRI and have been shown to identify larger MS plaque lesions when compared to conventional T2-weight MRI (1,2). In addition, it has been shown that DTI is sensitive to detecting damage in normal-appearing white matter (NAWM) that is associated with disability and progression in MS (6).

This study was intended to assess whether higher magnetic field strength DTI is more sensitive for detecting FA diffusion in the normal WM of patients affected by multiple sclerosis. While this study did not demonstrate overall improved sensitivity of measuring FA in MS patients, previous studies have shown that 3T DTI MRI detects higher FA in normal subjects and allows improved fiber tractography (3,7). As such, 3T DTI MRI may still be instrumental in early detection and assessment of MS patients.

References

1. Kealey SM, et al. Redefinition of multiple sclerosis plaque size using diffusion tensor MRI. AJR Am J Roentgenol 2004; 183(2): 497-503.
2. Kealey SM, et al. Determination of multiple sclerosis plaque size with diffusion-tensor MR Imaging: comparison study with healthy volunteers. Radiology 2005; 236(2): 615-20.
3. Fushimi Y, et al. Fractional anisotropy and mean diffusivity: comparison between 3.0-T and 1.5-T diffusion tensor imaging with parallel imaging using histogram and region of interest analysis. NMR Biomed 2007; 20(3): 743-8.
4. McDonald WI, et al. Recommended diagnostic criteria for multiple sclerosis: guidelines from the International Panel on the diagnosis of multiple sclerosis. Ann Neurol 2001;50(1): 121-7.
5. Polman CH, et al. Diagnostic criteria for multiple sclerosis: 2005 revisions to the "McDonald Criteria". Ann Neurol 2005;58(6): 840-6.
6. Ciccarelli O, et al. Investigation of MS normal-appearing brain using diffusion tensor MRI with clinical correlations. Neuology 2001;56(7): 926-33.
7. Okada T, et al. Diffusion-tensor fiber tractography: intraindividual comparison of 3.0-T and 1.5-T MR imaging. Radiology 2006;238(2): 668-78.