3 T vs 1.5 T MR Diffusion and Perfusion Imaging in Hyper-Acute Ischemic Stroke

R. K. Kosior[1,2], M. D. Hill[3,4], J. C. Kosior[1,2], R. Frayne[2,3]

[1]Electrical and Computer Engineering, University of Calgary, Calgary, Alberta, Canada, [2]Seaman Family MR Research Centre, Foothills Medical Centre, Calgary Health Region, Calgary, Alberta, Canada, [3]Radiology and Clinical Neurosciences, University of Calgary, Calgary, Alberta, Canada, [4]Calgary Stroke Program, Foothills Medical Centre, Calgary, Alberta, Canada

Introduction:

Clinical 3 T MR imaging systems are becoming more widespread, but there is little study into the differences between 3 T and 1.5 T scanners for the assessment of hyper-acute stroke. This study compares diffusion and perfusion images of patients with hyper-acute ischemic stroke (*i.e.*, < 6 h from onset) from both 1.5 T and 3 T MR scanning systems. Kuhl CK *et al.* [1], previously assessed diffusion weighted images (DWI) at 1.5 T and 3 T and found 3 T to have diagnostic advantages over 1.5 T. Our study has a similar design except that the patients in this study were imaged hyper-acutely and perfusion weighted images (PWI) were also evaluated, as they have been shown to provide useful information about stroke [2]. We expected that although 3 T diffusion and perfusion images would suffer from greater susceptibility artifact, the 3 T images would be better than 1.5 T due to the increase in intrinsic SNR [3].

Methods:

We acquired SE-EPI DWI and GE-EPI PWI data for three patients imaged sequentially at 1.5 T (Sonata; Siemens, Erlangen, Germany) and at 3 T (Signa; GE Healthcare, Waukesha, WI) in random order. The DWI and PWI sequence parameters at 1.5 T were TR/TE/Flip= 6000 ms/105 ms/90º, 128x96 matrix, 24x24 cm FOV for b=0 and b=1000 sec/mm^2 and TR/TE/Flip = 2000 ms/45 ms/60º, 64x64 matrix, 24x24 cm FOV, respectively and at 3 T, they were TR/TE/Flip = 7000 ms/73.1 ms/90º, 192x115 matrix, 32x19.2 cm FOV for b=0 and b=1000 sec/mm^2 and TR/TE/Flip = 1850 ms/45 ms/45º, 160x96 matrix, 32x19.2 cm FOV, respectively. Apparent diffusion coefficient (ADC) and time-to-peak (TTP) maps were generated from these acquisitions. Prior rigid realignment of the perfusion volumes (using SPM2) was performed to reduce the presence of motion artifact in the perfusion data. All images and maps were spatially normalized by registering them to a template image (using SPM2), allowing for direct side-by-side comparison and pairing of quantitative measures. The images and maps were visually assessed according to apparent SNR, apparent resolution, distortion, artifact and overall quality. Image contrast on the ADC maps was measured as the difference between the mean signals in regions placed in ischemic and normal contralateral tissues $[(S_i - S_n)/S_n]$. The areas of infarct and ischemia were calculated from the DWI and TTP data, respectively, for a single slice.

Results:

Qualitatively, the 3 T images exhibited higher SNR and had better resolution, especially in the TTP maps where better feature definition was seen (Fig. 1). Greater susceptibility artifact was noted, however, in the more inferior perfusion images, though in these patients this had no effect on image assessment. ADC contrast and area measures obtained on both systems showed no significant statistical differences in terms of field strength or scan order (ANOVA, $p > 0.05$, Table 1). Because of the small sample size, these statistics were only taken as a first line of evaluation. The ADC contrasts – though not statistically different – appear to be greater for 3 T, with scan order also having an effect as might be expected with evolving strokes.

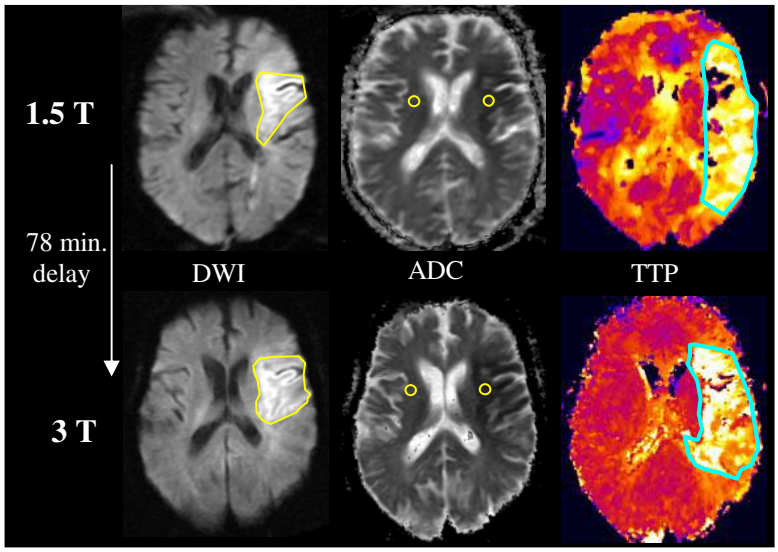

Figure 1. Registered 1.5 T and 3.0 T images with ADC regions and TTP abnormal regions for patient 2 (female, age: 74).

Conclusions:

The 3 T images show greater susceptibility artifact in some regions, but they have higher SNR and higher resolution while exhibiting good image contrast. The 3 T improvement in SNR and resolution is especially significant in the TTP maps. Some of the limitations include the small sample size and a delay between the 1.5 T and 3 T scans. Certain artifacts and insufficient perfusion tracking time in the 1.5 T images posed analysis limitations, but the methods of analysis reduced the influence of these factors. Overall, the results confirm that the 3 T scanner produces diffusion and perfusion images that are at least as good and in some ways superior, to those produced by the 1.5 T scanner when assessing hyper-acute stroke.

Table 1: ADC contrast and area measures.

Patient	Scanner (Order)		ADC Contrast (%)	Infarct Area (cm^2)	Ischemic Area (cm^2)
1	1.5 T	(1st)	-23.5	5.0	45.2
	3 T	(2nd)	-36.6	5.2	36.9
2	1.5 T	(1st)	-28.0	14.7	46.9
	3 T	(2nd)	-45.6	19.5	38.1
3	1.5 T	(2nd)	-44.3	19.7	22.9
	3 T	(1st)	-46.3	18.5	24.9
Field strength (p-value)			0.34	0.93	0.77
Scan order (p-value)			0.45	0.82	0.64

References:

[1]Kuhl CK, *et al. Radiol* 2005; **234**: 509 [2] Sunshine JL, *et al*. *AJNR* 2001; **22**: 915 [3] Frayne, R, *et al*. *Invest Radiol*, 2003; **38**: 385.