Human Brain Perfusion MRI at 7T Using a Segmented True FISP ASL Method

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Introduction: Ultra-high field (7T) MR imaging, in principle, should benefit arterial spin labelling (ASL) methods due to increased signal to noise ratio (SNR) and longer T_1 relaxation times of blood and tissue. However, most ASL methods are based on echo planar imaging (EPI), which is prone to image distortion caused by B_1 and B_0 magnetic field inhomogeneity, an effect that increases at higher field strengths (1). It has previously been shown that through the use of a true FISP based ASL sequence (2-4) it is possible to measure local tissue perfusion with high spatial resolution and without the distortion artefacts commonly associated with EPI in high-field (3T) imaging (5). Here we present preliminary results showing that true FISP ASL is also a feasible alternative to EPI-based methods of perfusion imaging at 7T.

Methods: All data was acquired on a Siemens Magnetom 7T whole-body scanner. Six normal human subjects (3 male, 3 female, mean age = 25.8 years ± 1.3) were studied. A 24-element Nova 7T head array coil (Nova Medical, Inc, Burlington, MA) was used for this study. A FAIR ASL perfusion preparation was used (6, 7) in which the EPI sequence is replaced with a segmented true FISP data acquisition strategy. A FOCI inversion pulse was applied every 2.5-3 s to allow for recovery of longitudinal magnetization. The FOCI pulse had a slice thickness of 2 times the thickness of the imaging slice to compensate for imperfect slice profile. Imaging parameters were: TR/TE = 3.6/1.8, FA = 50deg, section thickness = 8 mm, matrix size = 192 x 192, and field of view = 240-260 mm with the use of 68% rectangular FOV. For all subjects, TI of 1200 ms was used for perfusion measurement. An M0 estimate was obtained from a separate scan that was performed in which the IR pulses were absent. A pair of images were also acquired at TI_0 = 175 ms to correct for the off-resonance effects using an approach described by Figueiredo et al. (8). Additional pairs of label and control image were also acquired at TIs of 250, 500, 700, 900, 1100, 1200, 1300, 1500, 2000, and 2400 ms to evaluate the change of ASL signal difference over time.

Results: An example of control and labelled (slice selective and non-selective inversion) images obtained with the current technique is shown in Figure 1A and 1B. Note the signal intensity in the control image is higher due to un-inverted blood flow entering the tissue space. A qualitative blood flow map, shown as the difference between control and labelled images, is displayed in Fig. 1C. Fig. 2 displays a relative signal intensity difference vs. TI for the same subject in an ROI placed in the front gray matter, showing an unusually earlier drop in ASL signal, possibly suggesting the duration of the tagging bolus was very short due to spatial limitations on the region over which the head coil was able to perform a slice non-selective IR. Fig. 3 shows signal intensity difference maps obtained from all 6 subjects. Note in 3 of the 6 subjects, banding artefacts associated with true FISP imaging were present (arrows).

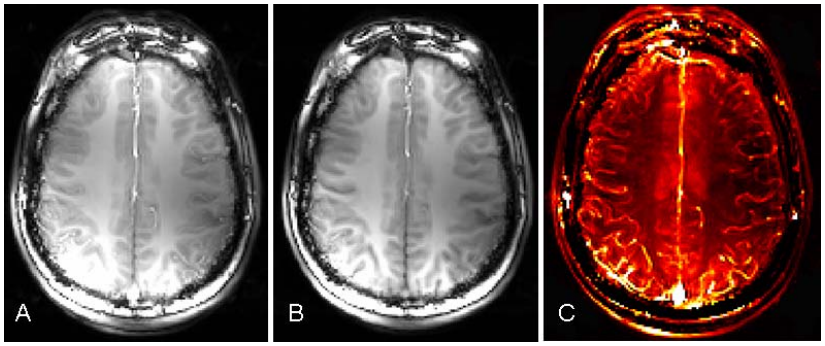

Figure 1. Images acquired with slice selective IR (A, control) and slice non-selective IR (B, label). The difference image (C) gives qualitative measure of local perfusion.

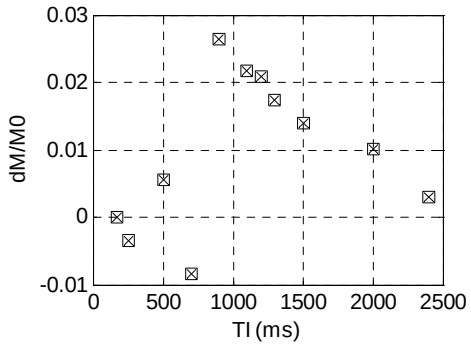

Figure 2. Relative signal difference vs. TI

Conclusions: We have shown the feasibility of using a segmented true FISP sequence for the measurement of human brain perfusion at 7T, which provides high spatial resolution and has no distortion artefacts. However, banding artefacts associated with true FISP imaging can sometimes degrade image quality. The lack of a suitable excitation coil for labelling spins over a larger region is another issue that needs to be overcome before we can fully take advantage of the benefits offered by ultra-high field (7T) MR imaging.

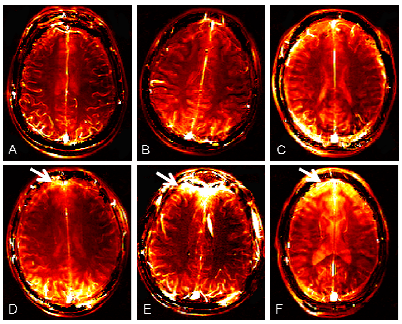

Figure 3. Signal difference maps (6 subjects).

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