Comparison of Continuous Arterial Spin Labeling Perfusion MRI at 7T and 3T

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Introduction

At high field, arterial spin labeling (ASL) studies are expected to benefit from higher image SNR and longer T_1 relaxation times of blood and tissue. These benefits have been simulated and observed at field strengths up to 4T (1,2). Although several groups have demonstrated ASL data at 7T, comparison with ASL data obtained at lower fields have not been performed. This work compares continuous ASL (CASL) perfusion data obtained at 7T and 3T on the same subjects.

Method

CASL perfusion studies were conducted under NIH approved IRB protocols using 7T and 3T MRI scanners (GE Healthcare, Signa Excite). Four volunteers were scanned at both field strengths using the similar experimental settings. Close fitting 8-channel brain array coils (Nova Medical Co.) of similar design and size were used for signal reception. Transmit RF pulses were applied using a volume coil at 7T (Nova Medical Co.) and the standard body coil at 3T. At both field strengths, CASL data were acquired using a separate surface labeling coil placed on the neck (3,4). RF power to the neck labeling coil was applied to using the second transmit RF channel of the scanner modified to include a gated, low power RF amplifier and an inline power monitor.

CASL data were acquired using a single shot, 2D gradient-echo EPI sequence with following parameters: labeling duration 3s, average labeling power 4.7W at 7T and 1.7W at 3T, labeling gradient 0.3G/cm along S/I direction, labeling RF frequency offset ~20kHz depending on the position of the labeling coil, post-labeling delay 1.5s, acquisition of 5 axial slices in 0.5s (effective TR 5s), TE 11.2ms (partial-k acquisition), slice thickness 3.0mm, gap 6mm, FOV 19.2cm, matrix 96 X 96, and an ASSET factor of 2. At both field strengths slices were positioned such that the middle slice was at the top of the corpus callosum. The peak SAR due to the labeling RF pulse was calculated to be 2.5W/kg at 7T and 1.2W/kg at 3T. Fifty pairs of arterial spin labeled and control images were acquired alternatively by turning on and off RF power to the labeling coil. The total scan time was 8min 40sec. Cardiac and respiratory waveform data were collected during all scans.

Data were motion corrected, detrended (2^{nd} order polynomial) and corrected for physiological noise (RETROICOR) using AFNI software. Detrending and physiological corrections were applied to control and labeled images separately. The perfusion signal (ΔM%, 1-label/control) and the intrinsic (SNR0-ΔM) and temporal SNR (TSNR-ΔM) of the average difference (ΔM, control-label) images were calculated and averaged within a gray matter mask over all slices. The intrinsic SNR was calculated using a noise scan acquired using the same imaging parameters but without excitation RF pulse power.

Results

Figure 1 shows the CASL images of the same subject at 7T and 3T. Perfusion data form all subjects are shown in Fig 2(left). The measured perfusion signal (range 1.3-1.6%) is similar at the two field strengths. The SNR0 and TSNR of the perfusion difference images are shown in Fig 2 (middle and right). It is seen that the SNR0-ΔM (range 4.2-5.7 at 7T and 2.5-3.1 at 3T) is 55-95% better at 7T compared to 3T. However, the TSNR-ΔM (range 0.7 - 1.6) is similar at both field strengths.

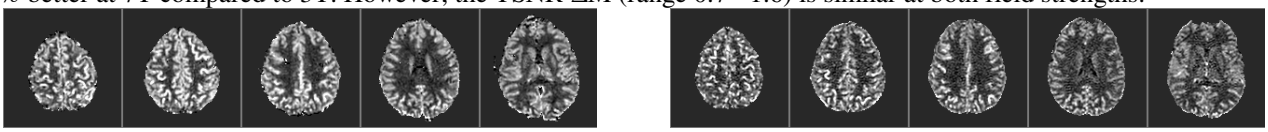

Fig. 1: CASL perfusion images (ΔM%) of the same subject acquired at 7T (left) and 3T (right). Data from subject #3 (Fig 2, left).

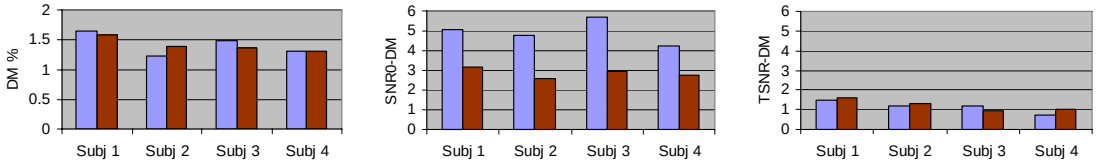

Fig. 2: ΔM% (left), SNR0-ΔM (middle) and TSNR-ΔM (right) data for all subjects at 7T (blue) and 3T (red).

Discussion

Although good quality the CASL perfusion could be obtained at 7T, the perfusion signal was not consistently better at 7T for all subjects. This may be due to lower blood labeling efficiency at 7T because of insufficient labeling RF power and inaccuracy of the labeling RF frequency offset setting due to field nonlinearity near the neck region. Since the same TE was used at both field strengths, the TSNR-ΔM at 7T is reduced due to shorter T2*. However, lower TSNR-ΔM compared to SNR0-ΔM indicates that uncorrected signal fluctuations remain at both field strengths. These results indicate that 7T CASL data may be further improved by optimization of labeling efficiency and reduction of signal fluctuations by using background suppression pulses (5).

References

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