Full brain coverage perfusion measurements at 3T using pulsed arterial spin labelling (PASL) and parallel imaging

S. Volz[1], M. Wagner[2,3], C. Preibisch[2], and H. Lanfermann[2]

[1]Brain Imaging Center, J.W. Goethe University, Frankfurt, Hessen, Germany, [2]Institute for Neuroradiology, J.W. Goethe University, [3]Institute for Diagnostic and Interventional Radiology, Henriettenstiftung

Introduction

Pulsed arterial spin labelling (PASL) allows a fully non-invasive and repeatable cerebral blood flow (CBF) measurement in resting state as well as during activation (fMRI). As method with an inherently very low SNR it profits from a higher field strength due to a larger SNR in the raw images as well as a higher T1 relaxation time, thus making it more attractive for many potential clinical and neuroscience applications. Since imaging acquisition is performed with an echo planar imaging sequence (EPI) this technique suffers from susceptibility artefacts due to $T2^*$ effects especially in the frontal base and frontal pole. Using parallel imaging techniques the echo train length and thus also the susceptibility artefacts can be reduced. The shorter echo time also provides a higher signal intensity and increased SNR in the EPI raw data. On the other hand parallel imaging yields a lower SNR due to the reduction of readout time and noise enhancement due to geometric properties of the coil and possible unfolding artefacts. In this study we therefore compared the quality of full brain PASL at different acceleration factors of parallel imaging evaluating slice coverage, SNR and artefacts.

Materials and Methods

The MR-measurements where performed on a 3T whole body MR scanner (Magnetom TRIO, Siemens) equipped with a standard circular polarized (CP) transmit/receive Head coil as well as an 8-channel (receive-only) array coil. 14 healthy human volunteers (20 to 36 years old, 7 male and 7 female) gave written informed consent before participating in this study and underwent the following procedure. At the beginning of each session a high resolution 3D anatomical data set of the brain was acquired for segmentation of grey and white matter. Brain perfusion was measured with a PASL sequence (Q2TIPS combined with PICORE labelling [1]) capable of quantitative analysis. A labelling time (time from Inversion to saturation pulses) of TI1=700ms and an inflow time (time from labelling to start of image acquisition) of TI2=1400ms were used. One measurement was performed with the standard CP head coil without parallel imaging and an echo time TE=17ms. After that another 3 scans with different acceleration factors (R) and maximum number of reference lines were acquired using the 8-channel array head coil and GRAPPA[2]: R=1 (no GRAPPA, TE=17ms), R=2 (TE=11ms) and R=3 (TE=8ms). One scan consisted of the acquisition of 50 difference images with an effective TR of 2×2.5ms=5ms (control +label image) plus one M0 image with long TR for quantitative analysis resulting in an effective scan time of about 4.5 min. Up to 15 slices with a thickness of 5mm, 25% distance factor and 240mm FoV were acquired.

The analysis of MR-data was done offline using Brainvoyager QX (www.brainvoyager.com) and a custom written plugin (Microsoft Visual C++ 6.0) for calculation of difference and SNR images as well as ROI analysis. Calculation of SNR was performed voxelwise as standard deviation of the time series of difference images. For SNR data evaluation a grey matter ROI generated with Brainvoyager was used. The extent of image artefacts were analyzed and rated by two radiologists using a scale from 0 to 4 (0 = no artefacts).

Results

Fig. 1 shows the perfusion images of the whole brain including the cerebellum acquired within 4.5min. The evaluation of the grey matter ROI in the central part of the difference images resulted in an overall SNR of 10.1±2.7 for the CP head coil. For the 8-channel head coil without parallel imaging a value of 12.4±4.7 was determined. With increasing acceleration factors the SNR decreases as expected (GRAPPA2: 9.3±2.1 and GRAPPA3: 8.3±2.1).

The rating of susceptibility artefacts in the frontal base and frontal lobe resulted in 2.5±0.9 (no GRAPPA), 1.6±0.8 (GRAPPA1) and 0.8±0.6 (GRAPPA3). Figure 2 shows the clear reduction of the artefacts in one subject with increasing acceleration factor in the EPI raw images.

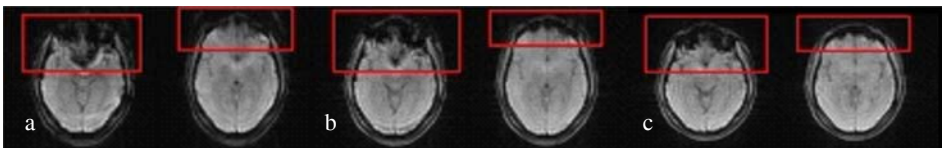

Fig. 2: Reduction of susceptibility artefacts with increasing acceleration factor R (a: R=0, b: R=1, c: R=3)

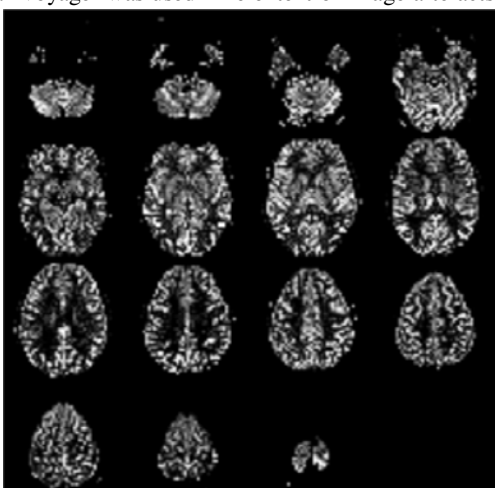

Fig. 1: perfusion images of whole brain

Discussion

The combination of PASL and parallel imaging results in a noticeably improved assessment of frontal base and frontal lobe due to reduced susceptibility artefacts which could make the technique more attractive for many clinical applications. At the same time it is possible to quantify perfusion of the whole brain. Full k-space PASL with the 8-channel head coil resulted in a clearly improved SNR when compared to the CP head coil. Using parallel imaging results in a decrease of SNR which in part diminuishes the advantages of reduced image distortions. However, our measurements show that using an acceleration facto of 2 yields almost the same SNR as using the CP head coil without parallel imaging.

References

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