Effects of slice orientation and parallel acquisition on EPI-based PASL Perfusion Imaging in areas with susceptibility artifact

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***Purpose*:** Gradient-echo EPI is commonly applied for acquiring perfusion MRI with arterial spin labeling (ASL) (1). Although a short echo time is usually used, the long echo training still causes problems in image quality, particularly in areas near air/tissue interfaces, due to the susceptibility artifact. Therefore, studies in brain areas such as the orbitofrontal cortex (OFC) may suffer from signal dropouts and spatial distortions. Previous fMRI studies investigated the optimal slice tilt as a simple method to reduce the signal dropout caused by susceptibility gradient in the phase encoding direction (2). For the ASL scans, however, one must consider whether applying the slice tilts would affect signal contrast, as most ASL perfusion imaging acquire slices perpendicular to the blood inflow direction. Aside from the slice orientation, the parallel imaging (PI) technique, which is widely available on clinical MRI scanners, can be used to reduce intra-voxel dephasing during the course of the acquisition by faster image sampling and shorter EPI training. (3). This study is aimed at determining the optimal gradient EPI condition for the OFC by adjusting slice angle, both with and without the parallel imaging technique in ASL.

***Methods*:** The study was performed on six healthy volunteers using a 3-T MRI scanner. FAIR combined with a single-shot GE EPI was applied with TI = 1400 ms, TR/TE/FA = 3000 ms /20 ms /900, 5mm slice thickness, 7 slices, NEX = 15, FOV = 220 mm and matrix = 64. The slice tilt was set from -30°, 0 to +30° (in 5 steps of 15°) relative to the AC-PC direction with phase-encoding in anterior-posterior direction. For each slice angle, images were obtained both with and without applying the SENSE (factor = 2) technique for parallel receiving. Signal-to-noise ratio (SNR) was calculated from the nonselective inversion image (MNS) (using a condition of 0° slice tilt without PI) and contrast was calculated from dividing the selective and nonselective difference by the nonselective inversion image (DM/ MNS). For each subject, regions-of-interest (ROI) were determined within the intersectional area of the OFC and normal region, where the field is homogenous near the tilted slices of the OFC (Fig.1). All conditions were normalized to a brain template using SPM2 for comparison.

***Results*:** Figure 2(a) and (b) show the SNR in the OFC and normal region, respectively. The SNR without using PI for each degree of slice tilt was higher than using PI, particularly in -15°. The SNR decreased with increase in slice tilt and became more slice-angle dependent in the area of the OFC. This indicated that slice tilt had a greater effect on SNR without PI than that with PI in the OFC region. On the contrary, the SNR is less sensitive to the change of the susceptibility gradient with different slice tilt in the normal region. The ratio of SNR without PI to that with PI in the OFC were smaller than that of in the field homogenous regions, which meant that using parallel imaging could reduce the susceptibility-induced signal losses. Figure 2(c) and (d) demonstrated contrast at different slice orientations measured in the OFC and normal region both with and without using parallel imaging. The highest contrast value can be obtain at +30° slice tilt in the OFC; otherwise, slight variations in contrast between different degrees of slice tilt in the normal region were measured.

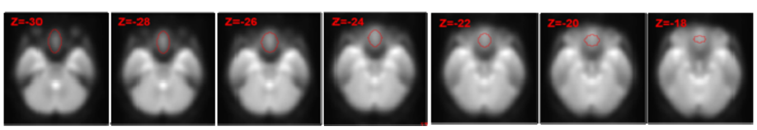

Figure 1. Common VOI of the OFC, obtained from different slice orientation, illustrated on the MNI EPI template.

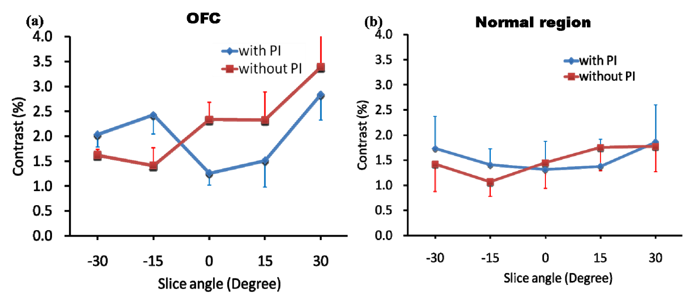

Figure 3. Contrast of OFC (a) and a field-homogenous region (b) in images acquired

***Conclusion*:** For the purpose of reducing signal losses in the OFC, the SNR with PI in the OFC is slightly higher than the field homogenous region in most of slice tilt because of the reduced susceptibility effect. However, both SNR and contrast are much higher without using parallel imaging. That means that the SNR recovered by paralleling is less than the signal losses caused by susceptibility. Parallel imaging may reduce SNR in the intrinsic, but it doesn't compensate for signal losses in the OFC, which caused lower SNR than without using parallel imaging. However, the SNR is less sensitive to the change of the susceptibility gradient with different slice tilt when parallel imaging is used. Even though the SNR and CNR are not the highest, parallel imaging may be still preferable because it was less subject to slice orientation.

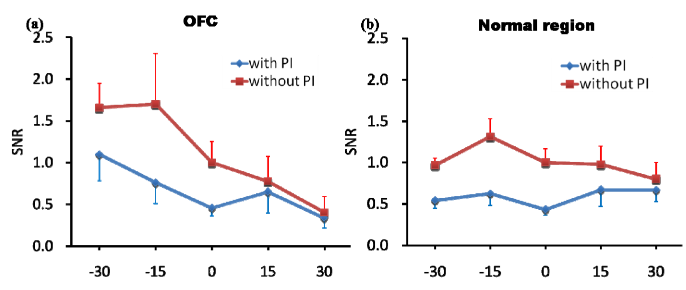

Figure 2. Normalized SNR of OFC (a) and a field-homogenous region (b) in images acquired with and without PI and at different slice angles.

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