Effective in-plane distortion correction for 3DGRASE ASL acquisitions

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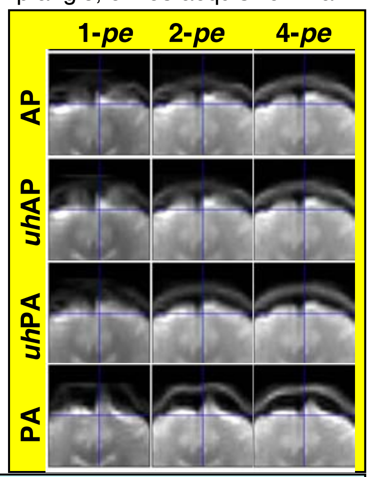
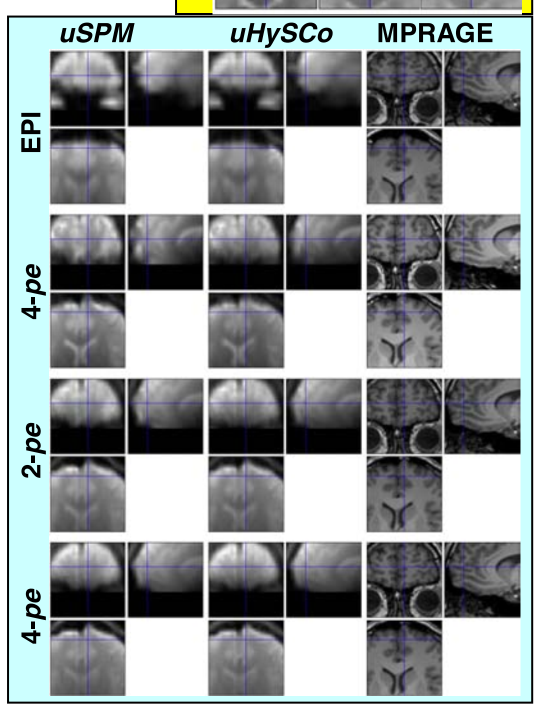
Purpose. 3DGRASE is as an extremely efficient acquisition strategy for ASL[1,2]. Blurring in the slice/partition direction, related to echo trains excessively long in relation to T2 decay, is an issue in single-shot acquisitions that can be reduced with multi-shot acquisitions[3-5] or using a reduced refocusing flip-angle. Geometric distortions related to the in-plane EPI readouts and caused by magnetic susceptibility variations across the brain can still be a nuisance. We tested the efficiency of an in-plane susceptibility distortion correction based on B0-field maps, similarly to what is routinely done in DTI or fMRI[6]. We demonstrate how 2 simple M0 acquisitions repeated by inverting the direction of the in-plane phase encoding can be used for distortion correction[7] as a quick alternative option to the more standard double echo GE-2DFT B0-map acquisition.

		epi	*3DGRASE*		
Total shots (N_{shots})		1	*4x1*	*4x2*	*4x4*
***pe*-shots**		1	1	2	4
Turbo Factor			7	7	7
PEpoints/shot		64	65	33	17
Readout duration	ms	26.88	32.5	16.5	8.5
TE	ms	16	38.4	24.1	18.6
Echo Train duration	ms		288	181	140
TR	s	3.66	4.2	4.2	4.2
FatShift	pixels	11.7	14.1	7.2	3.7
M0 acquisition time	s		25	42	76

Methods. We scanned 2 healthy subject on a Siemens 3T Tim Trio (32-channel head-coil). 3DGRASE[5] had isotropic 3.2mm resolution, 20 partitions with 10% oversampling, TR= 4.2s, 130° refocusing flip angle, 64x63 acquisition matrix and a variable number of phase encoding (*pe*) shots (see **Table**). An EPI readout (resolution 4x4x6mm^3) was also used for comparison. For both, PCASL had 1.5s tagging, background suppression, and 1.5s post-labelling delay. MPRAGE wa acquired at 1mm isotropic resolution. Standard B0-field map based correction, was done with the FieldMap toolbox in SPM8 (double GE acquisition, 2.6x2.6x3mm^3 resolution, 1'53" acquisition time). The distortion correction based on blip-up/blip-down acquisitions, used the HySCo method (ACID toolbox) developed for DTI data[7]. The time required for the extra M0 acquisition depends on the total number of shots used (see **Table**).



Results. The top **Figure** shows for M0 images an axial view of a small area in the frontal lobes where the difference in distortion when flipping the *pe* direction between anterior-posterior (AP) and posterior-anterior (PA) can be easily appreciated (also see Fat Shift values in the **Table**). The middle rows are corrected with the HySCo method (*uh*). As expected the geometric distortion decreases as the number of *pe*-shots increases but the correction method is equally successful even when only 1-*pe* is used. The bottom **Figure** shows for 3 orthogonal views, M0 images corrected with SPM (*uSPM*) and HySCo (*uHySCo*) alongside MPRAGE registered to the undistorted images. The distortion correction derived from the B0-map or the blip-up/blip-down M0 acquisitions can be applied to the Tag and Control ASL images to achieve a similarly good anatomical match (not shown).



Discussion and Conclusions: The 2 methods utilised here for within-plane susceptibility distortion correction provide extremely similarly results and a allow matching of 3DGRASE data with structural images. The blip up/blip down approach is more time efficient than the B0-map based approach as only one extra M0 image is necessary to estimate the necessary correction for control and tag images and this extra image can also be used to increase the SNR on the M0 estimation. The actual time saving depends on the N_{shots} used for the 3DGRASE acquisition. For anybody using 3DGRASE readouts, together with the potential application of post-acquisition deblurring procedures[8,9] the addition of in-plane distortion correction allows to obtain ASL images and quantitative maps that may only require straightforward affine registration to the corresponding structural images. This method can also be applied to non-ASL 3DGRASE acquisitions.

References. **1**. Gunther, MRM 2005, 54:491; **2**. Fernandez-Seara, MRM 2008, 59:1467; **3**. Feinberg, ISMRM 2009, 622. **4**. Vidorreta, NeuroImage 2012; 66C:662; **5**. Balteau, ESMRMB 2013, 333; **6**. Hutton, NeuroImage 2002, 16:217; **7**. Ruthotto, Physics in Medicine and Biology 2012, 57(18), 5715; **8**. Chappell, MRM 2010, 63:1357. **9**. Boscolo Galazzo, ESMRMB 2013, 332.