Pseudocontinuous Arterial Spin Labeling with Prospective Motion Correction (PCASL-PROMO)

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PURPOSE

Arterial spin labeling (ASL) scans usually run about five minutes in regular clinical setting of cerebral blood flow (CBF) measurements, and any motion that occurs during this scan time such as in disoriented or uncooperative patients can degrade the ASL image quality. Prospective motion correction (PROMO) is an image-domain-based motion correction method using low-resolution spiral navigators[1]. Previous work suggests that PROMO can be used to compensate for side-to-side motion of brain in ASL scans[2]. In this study, we incorporated PROMO into pseudocontinuous ASL (PCASL)[3] sequences to correct for all types of 3D rigid-body motion of brain. We demonstrate that PROMO reduces motion artifacts significantly while the navigator does not disturb ASL CBF measurements.

METHODS

<u>ASL–PROMO integration</u>: PROMO was incorporated into perfusion imaging with PCASL as illustrated in Figure 1. Navigator imaging is performed at the end of each TR to estimate a vector of motion parameters, Ψ = [tx, ty, tz, rx, ry, rz], which are translations and rotations along x, y, and z axes with respect to the reference position. These parameters are applied in the subsequent imaging segment to track the imaging slab. The imaging segment that is acquired before the navigator detects motions can be rescanned at the end of the scan if found to be corrupted.

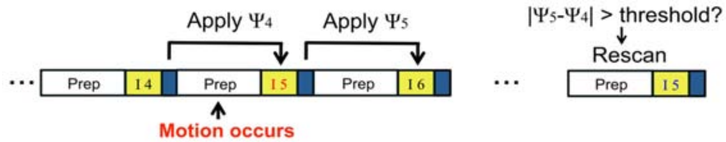

Figure 1. *Diagram of ASL combined with PROMO. Images from navigator (blue) are used to estimate a motion parameter vector Ψ. This vector is applied in the subsequent imaging segment (yellow) and used to determine rescanning of the data that is acquired before navigator detects the motion.*

<u>Disturbance to ASL</u>: To determine whether incorporation of PROMO alters the intrinsic CBF measurements, ASL–PROMO was performed without correcting for motions in a normal volunteer who remained as still as possible. This result was compared with ASL images acquired without PROMO in the same subject.

<u>Interleaved PROMO scan</u>: We implemented ASL–PROMO sequences where every TR is repeated twice but with and without PROMO, leading to a doubled scan time. Volunteer in this experiment was instructed to move randomly during the entire scan. Baseline ASL imaging without PROMO was also performed in the absence of any intended motion as a reference.

<u>Experimental setup</u>: ASL images were acquired using fast-spin-echo 3D stack of spiral with 8 interleaves. Imaging parameters were labeling duration = 1450 ms, post-labeling delay = 2025 ms, TE = 11 ms, TR = 5296 ms, matrix size = 128 x128, FOV = 220 mm, and slice thickness = 4 mm with 36 slices. In PROMO, navigator images were acquired using a single-shot spiral gradient echo sequence with flip-angle = 8°, TE = 7 ms, matrix size = 128x128, FOV = 320 mm, and slice thickness = 19 mm, with 1 image acquired in each plane. Five sets of navigators were acquired leading to a duration of 576 ms for each navigator block. Total scan times were about 5.5 min with PROMO (without rescan), 4.6 min without PROMO and 11 min for the interleaved scan. All imaging was performed on a GE MR750 3.0 T scanner.

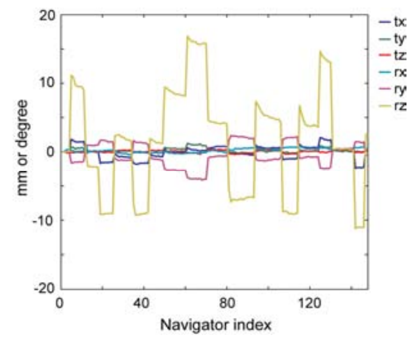

Figure 2. *Motion parameters recorded during interleaved scan. Most dominant motion was side-to-side motion (rotation along z-axis).*

RESULTS

<u>Disturbance to ASL</u>: The measured average CBF in all slices was 51.1 ml/100 g/min without PROMO and was 52.9 ml/100 g/min with PROMO but without motion correction. CBF was 3.5% higher with PROMO, which may reflect a physiological change and is within the typical error range of the measurement.

<u>Interleaved PROMO scan</u>: Figure 2 contains the motion parameters recorded from the interleaved scan. ASL images from segments with and without PROMO are compared with reference ASL images in Figure 3. Images without PROMO show significant blurring while images with PROMO look very similar to the reference images with no motion. Average CBF was 60.7 ml/100 g/min, 62.0 ml/100 g/min, and 62.1 ml/100 g/min for reference, PROMO on, and PROMO off, respectively.

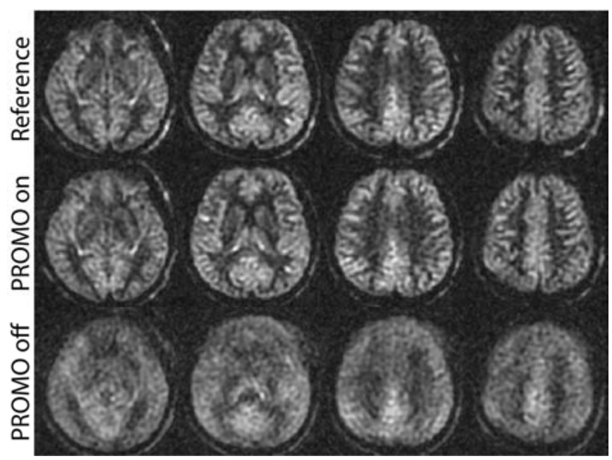

Figure 3. *ASL images acquired from segments with and without PROMO in the presence of random motion, and reference ASL images without PROMO without intended motion.*

DISCUSSION AND CONCLUSION

Because one cannot use the acquired tagged and control images to account for motion using a segmented 3D readout, a navigator approach, such as PROMO, is required. PROMO was successfully used in PCASL with minimal increase in scan time. Blurring artifacts with motion were dramatically removed using PROMO. ASL imaging was not disturbed by the navigators and the labeling efficiency was not compromised by motion based on the measured CBF values. The future work will include applying motion parameters in ASL preparation and playing the navigators during ASL preparation time, to avoid the associated small increase in scan time.

REFERENCES [1] White *et al*, MRM 63: 91, 2010. [2] Zhang *et al*, ISMRM p5034, 2010. [3] Dai *et al*, MRM 60: 1488, 2008.
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