Pulsatile motion artifact correction in multishot spiral PCASL

Li Zhao[1], Samuel W. Fielden[1], and Craig H. Meyer[1,2]
[1]*Biomedical Engineering, University of Virginia, Charlottesville, Virginia, United States,* [2]*Radiology, University of Virginia, Charlottesville, Virginia, United States*

Purpose: Arterial spin labeling (ASL) images are acquired by subtraction of control and label images. This subtraction and low SNR make ASL more sensitive to object motion. In addition to bulk motion which can be corrected by image registration, blood in the sagittal sinus pulsates with the cardiac cycle and the resulting small signal intensity change can cause inconsistent data artifacts in multi-shot data acquisition schemes. These artifacts can be reduced by signal averaging and background suppression, but averaging increases scan time and the results using these methods are subject dependent. Here, we exploit the redundant information in a multi-coil scan and use the SPIRiT [1] parallel reconstruction method to reduce motion artifacts in multi-shot spiral ASL.

Methods: All experiments were performed on SIEMENS Trio 3.0T scanners. A 3DTSE stack-of-spirals readout was used with centric phase encoding along the z direction. For each echo train, the same constant-density spiral interleaf was inserted between each pair of refocusing pulses. Three 6-ms spiral interleaves were acquired, resulting in an in-plane resolution of 4.0×4.0 mm^2. 12 slices were collected and the slice thickness was 5 mm. Slab excitation and averages were collected while alternating the phase of the refocusing pulses to eliminate out of slice signal.
Balanced PCASL tagging was used with a Hanning RF pulse train. The duration of each Hanning RF pulse was 500 us and there was a 500 us gap between pulses. The mean B1 amplitude was 1.7 uT. The RF phase was constant for the label and alternated between 0 and 180 degrees for the control. The mean gradient was 0.2 mT/m. Bolus duration = 2 s, post label delay = 1000 ms. Other parameters are: TR = 5 s, TE = 22 ms, 4 averages, FOV = 200 mm.
6 normal volunteers were scanned. The data was processed using MATLAB 2012a. A 1D FFT was performed along the slice direction prior to 2D spiral in-plane image reconstruction. SPIRiT reconstruction was performed on each interleaf of the component image separately and then the complex images from each interleaf were added together to form the final component image. The component images were subtracted using either complex or magnitude subtraction to form the perfusion image. For comparison, images were also reconstructed by gridding the data from the interleaves together.

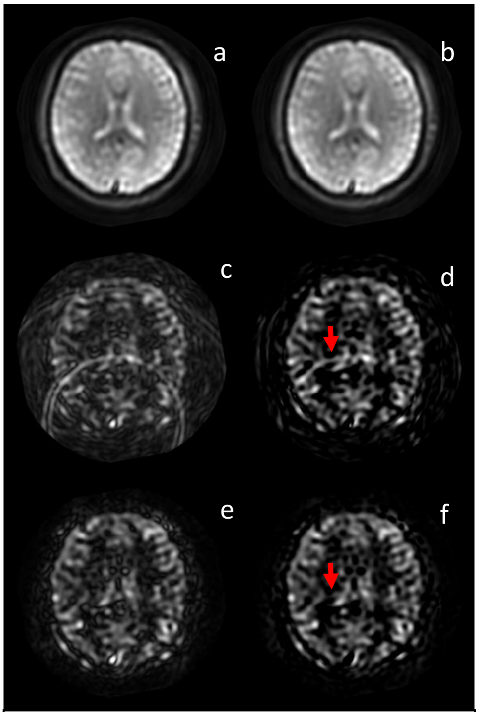

Figure 1. Gridding reconstruction: control image (a), label image (b), complex subtraction (c) and magnitude subtraction (d). SPIRiT reconstruction: complex subtraction (e) and magnitude subtraction (f).

Results and Discussion: As shown in the Fig. 1a and b, gridding yields component images with no visible motion artifacts from either bulk or venous motion. However, the subtraction images show the pulsatile motion artifact, which manifests as a ring artifact in a multi-shot spiral scan. The artifact is significant when using complex subtraction (c), because of phase inconsistency. The artifact is reduced when using magnitude subtraction (d), where negative values are ignored, but some artifact remains (red arrow). The subtraction images are significantly improved by using SPIRiT to reconstruct each interleaf separately. The artifact is largely eliminated when using both complex (e) and magnitude (f) subtraction.

Conclusion: By using SPIRiT parallel image reconstruction to reconstruct each spiral interleaf separately, the ring artifact resulting from pulsatile venous blood flow in multi-shot spiral ASL can be largely eliminated.

Reference: 1. Lustig M, Pauly J. SPIRiT: Iterative self-consistent parallel imaging reconstruction from arbitrary k-space. MRM. 2010; 64:457-471.