Dynamic 3D Spin-Labeling MRA for Evaluation of Vascular Territory Inflow

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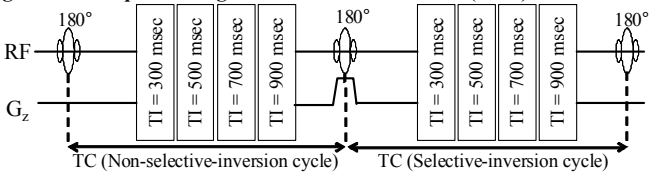
Introduction – Spin-labeling techniques [1-2] have primarily been used in perfusion imaging of the brain, but may be modified to provide angiograms with high signal-to-background contrast [3]. 2D cine versions of spin-labeling MRA methods have been attempted for evaluating aneurysms and vascular stenoses [4-5], providing temporally-resolved images without the use of contrast-agents. While both 3D spatial resolution and temporal resolution may be desired for an accurate depiction of vessel morphology and flow dynamics, the long inversion times used in spin-labeling inevitably lead to very long acquisition times.

Methods – We propose a modification of the 3D fast inversion recovery MRA (FIR-MRA) technique [6] to provide temporal resolution. Basic FIR-MRA employs inversion-recovery gradient recalled echo imaging, whereby labeling of arterial blood is performed by toggling slab-selection of the inversion pulses between consecutive inversion cycles. FIR-MRA incorporates segmented acquisition and parallel imaging for acceleration, and off-resonance inversion pulses for effective venous suppression. As shown in Fig. 1, each cine-FIR-MRA gradient echo train is segmented into *n* frames whereby the TI of each frame is defined by is first echo.

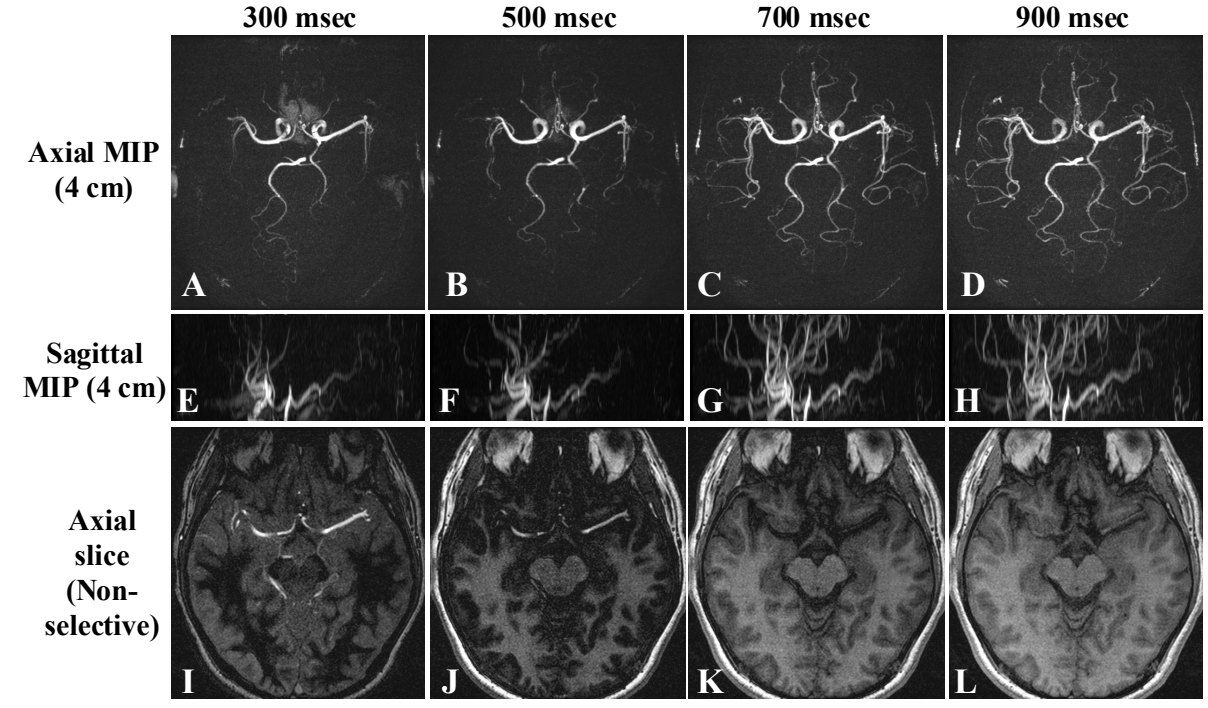
To show feasibility, 3D-cine FIR-MRA intracranial imaging of one normal subject was performed at 3.0T (GE Healthcare, 8-element coil) with a 5-minute, single-slab acquisition of $n = 4$ frames. The parameters were similar to standard FIR-MRA, except that a small flip angle was used to reduce signal saturation (TC/TR/TE = 1600/5.8/1.9 msec, flip angle = 8°, bandwidth = ±31.25 kHz, slab thickness = 8.4 cm, resolution = 1 mm^3, parallel imaging of $R = 2$).

Fig. 1: Pulse sequence diagram of 3D-cine FIR-MRA ($n = 4$).



Results – Fig. 2 shows progressive filling of the vascular distributions with each time frame in axial (A to D) and sagittal formats (E to H). Vessel signal in some proximal vessels was diminished in the last frame (D, 900 msec) due to magnetization recovery of blood. The unsubtracted, 'black-blood' images (I-L) from the non-selective inversion cycles show varying tissue contrasts with TI. White matter and gray matter tissue were nulled at time frames of TI = 300 msec (I) and 500 msec (J) respectively.

Fig. 2: 3D-Cine FIR-MRA of the four time frames (columns), their subtraction angiograms (first two rows) and the unsubtracted non-selective images (last row). Progressive filling of the vascular distributions was seen with each time frame (A to D, and E to H).



Conclusion – 3D-cine FIR-MRA provides both temporal and 3D spatial resolution in spin-labeled MRA within a 5-minute acquisition time. Temporal information allows evaluation of vascular territory inflow, useful in the setting of infarction, vascular stenoses, arteriovenous malformations (AVMs), and aneurysms. The differential tissue intensities may be useful for T1-mapping and accurate brain tissue classification. Higher temporal resolution and shorter acquisition times may be achieved through improved time- sampling [7] or with compressed sensing methods [8-9].

References – [1] Kim, MRM 1995; [2] Kwong, MRM 1995; [3] Nishimura, MRM 1988; [4] Warmuth, AJNR 2005; [5] Sallustio, Stroke 2008; [6] Tan, ISMRM 2009; [7] Tsao, MRM 2003; [8] Lustig, MRM 2007; [9] Trzasko, IEEE TMI 2009.