Time-Resolved Contrast-Enhanced Radial Ghost MRA

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Introduction: A novel time-resolved contrast-enhanced MR angiography technique is introduced. The technique does not require subtraction and uses ghost images to separate the vessels from background tissues. The SNR loss resulting from subtraction of pre-contrast images from the post-contrast frames is prevented. Based on inducing ghost artifacts arising from inconsistency in *k*-space data, this technique is combined with radial sliding window reconstruction for time-resolved imaging.

Methods:

Theory

The set of even partitions in the 3D volume are first acquired prior to contrast agent injection. Following the injection, the set of odd partitions are repeatedly acquired. After acquisition, the data is combined so that for each repeated acquisition of odd partitions, the even pre-contrast set is used to fill the missing lines (See Figure 1). This creates sinusoidal modulations in *k*-space in partition direction for voxels where contrast is present. The modulation in *k*-space creates a copy separated by one half field of view. For voxels with no contrast (i.e. background), no modulation exists. Therefore, no copy is made for static tissue, effectively separating blood vessels from background tissues.

Imaging Protocol

A radial "stack of stars" 3D spoiled gradient-echo sequence is used. The field of view was set to be twice the size of the anatomy of interest to leave room for the ghost. The images were acquired on Siemens 3T Trio or 1.5T Avanto scanners (Siemens Medical Solutions, Erlangen, Germany). Typical imaging parameters were as follows: TR=2.8ms, TE=1.4ms, FOV=220x220, N_{slices}=60 (3mm thickness), $N_{repetitions}$=6, $N_{projections}$=192, $N_{Readout}$=192. Magnevist (Berlex, Wayne, NJ) was injected intravenously using a power injector (Medrad, Indianola, PA). The head and lower extremities were imaged on different volunteers. This technique was compared to radial sliding window MRA without ghost technique for SNR and temporal resolution.

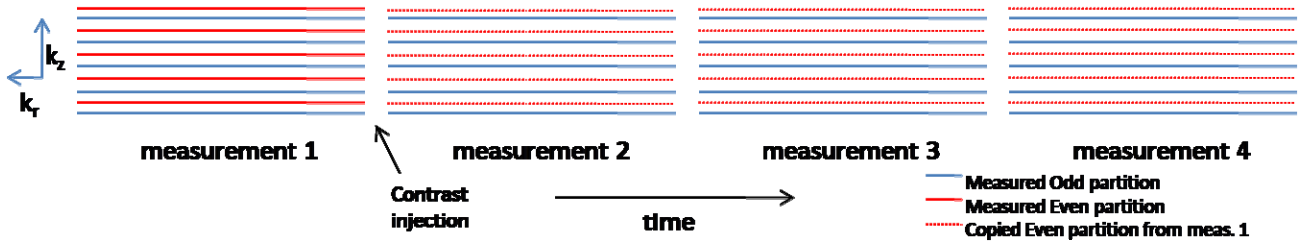

Figure 1: Time-resolved radial ghost MRA. A complete measurement is acquired for the first measurement. A contrast injection follows immediately after measurement 1, and only even partitions are acquired for the subsequent measurements. Even partitions from measurement 1 are copied to missing even lines.

Results: Figure 2(a)-(h) shows a time series of maximum intensity projections (MIPs) from the legs of a volunteer. Partial MIPs of slices containing only the ghost images of the vessels were created. The vessels were separated from the tissue without any subtraction and a dynamic angiogram was obtained. The ghost of the blood vessels forming outside the leg shows the separation in the sagittal MIP in Figure 2(i).

Discussion: MRA images of excellent quality were acquired using the time-resolved ghost technique. The technique requires that the field of view to be twice the region of interest in the slice direction, but the imaging time remains the same because only the odd partitions are acquired after contrast injection. This allows time resolved imaging without the need for subtraction with high SNR

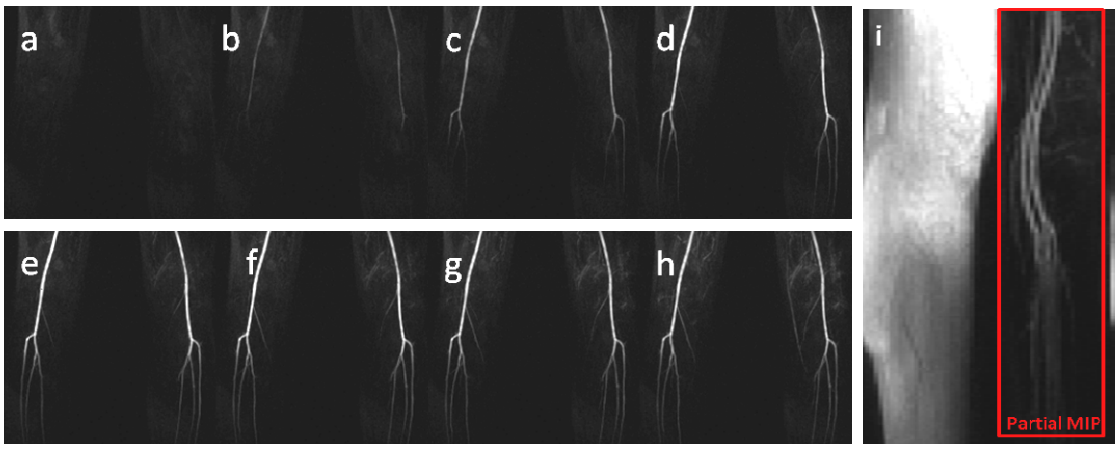

Figure 2: Time-resolved ghost MRA of lower extremities: (a)-(h) Time series reconstructed using radial sliding window (i) Sagittal MIP showing induced ghost of blood vessels separated from the background tissue. Slices with ghost vessels are used for the final image.

References: 1. Riederer et al. Magn Reson Med 1988. 2. Cashen et al. Magn Reson Med. 2007