Quiescent-Inflow Single-Shot (QISS) Magnetic Resonance Angiography using a Highly Undersampled Radial K-Space Trajectory

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INTRODUCTION: We hypothesized that high undersampling factors could be used in conjunction with radial Quiescent-Inflow Single-Shot (QISS) MRA in order to accelerate the data collection and enable multi-slice and body coil acquisitions.

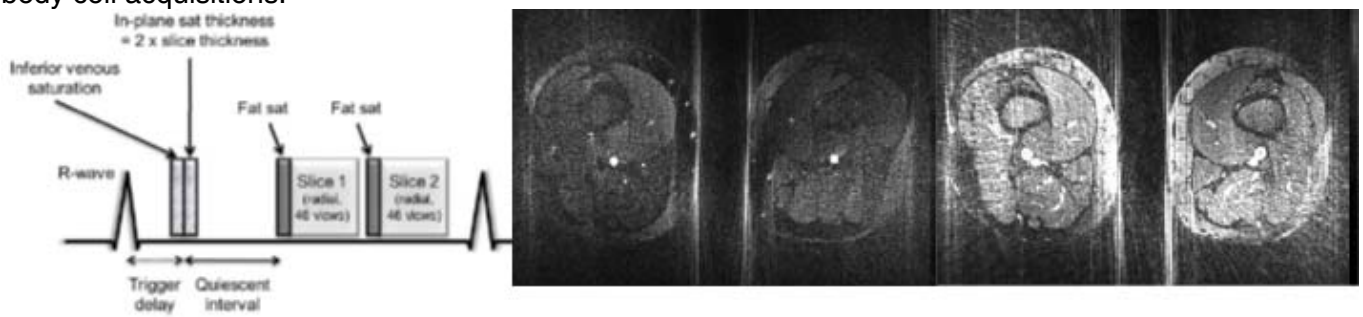

Fig.1. Left: Diagram of 2-slice radial QISS. Comparison of radial QISS (middle) with radial trueFISP (right) shows that the combination of fat suppression and in-plane saturation with QISS greatly reduces radial streak artifact (10-fold undersampling).

METHODS: The study was approved by the Institutional Review Board and used written, informed consent. Three healthy subjects and four patients with PAD were imaged on a 1.5T MRI system (Magnetom Avanto, Siemens Healthcare) using an eight station ECG-gated protocol. Cartesian QISS MRA was acquired as previously described (1). For single-slice radial QISS, 60-120 views were acquired with a matrix of 352 or 384 projections and 1-mm in-plane resolution. For dual slice radial imaging, 46 views were acquired with a matrix of 352 projections and 1-mm in-plane resolution. For triple slice radial imaging, 32 views were acquired with a matrix of 384 projections and 1.17-mm in-plane resolution. For multi-slice radial QISS, the concurrent slice acquisition order was foot to head. In two subjects, single-slice 60-view radial QISS MRA was acquired using just the body coil for signal reception using two signal averages and 1.3-mm in-plane resolution to compensate for the inherent SNR loss from not using phased array coils.

Fig. 2. Healthy subject. Maximum intensity projections of (a) Cartesian QISS with 93 lines and adaptive coil combination; (b) 2-slice radial QISS with 46 views and sum of squares coil combination; (c) 3-slice radial QISS with 32 views and sum of squares coil combination; (d) single slice radial QISS with 60 views, 2 signal averages, and large, single-element body coil for signal reception.

RESULTS: The mean (standard deviation) measurements for the intra-arterial signal-to-noise ratio were: Cartesian 1 slice - 29.3(5.5); Radial 1 slice, 92 views - 22.3(3.6); Radial 1 slice, 46 views - 18.5(2.0); Radial 2 slices, 46 views - 18.3(3.2); Radial 3 slices, 32 views - 21.7(3.9). Normalized for the larger pixel, the SNR for the 3-slice, 32 view acquisition was 15.8. Comparing Cartesian QISS (93 lines) with single slice radial QISS (92 views), the respective image quality scores were 2.6 ± 0.4 and 2.9 ± 0.2 ($p = 0.04$). Horizontal striping was present with multi-slice radial QISS MRA (especially with the 3-slice acquisition) but the image quality remained diagnostic.

DISCUSSION: We have demonstrated the feasibility of radial QISS MRA with much higher undersampling factors than are achievable using a Cartesian k-space trajectory and standard parallel imaging techniques. Using a three-slice acquisition (undersampling factor of 18.8), scan times of 2 minutes or less were obtained for coverage of the entire length of the peripheral arteries. Also, highly undersampled radial QISS can be acquired using a single-element body-coil receiver, not possible with Cartesian QISS and parallel imaging techniques.

REFERENCES: 1. Edelman RR et al. Magn Reson Med 2010; 63:951–958.