High Acceleration Quiescent-Interval Single Shot Magnetic Resonance Angiography at 1.5 and 3T

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Introduction: Quiescent-Interval Single Shot (QISS) is a non-contrast MRA technique with proven clinical utility as an alternative to contrast-enhanced MRA (CE-MRA) at 1.5T [1,2]. Increased SNR at 3T potentially provides improved image quality and higher parallel imaging acceleration (PAT) factors to maintain single shot imaging with high heart rates. The purpose of this study is to determine 1) the effect of field strength on QISS image quality and 2) the potential to accelerate imaging at 3T using higher PAT factor in a study with 12 healthy volunteers. In addition, the diagnostic quality of QISS at 3T in patients with peripheral artery disease (PAD) was evaluated. All scans used CE-MRA as the reference standard.

Methods: Twelve healthy subjects (9 males age 22-49, 3 females age 26-43) were each scanned on both 1.5T and 3T scanners (MAGNETOM Aera and Skyra, Siemens AG, Healthcare Sector, Erlangen, Germany) and two patients with lower extremity PAD were scanned at 3T. Data were acquired using an ECG-gated QISS sequence (TE/TR 1.7/3.7 ms, 7 or 8 groups of 70 axial 3 mm slices, 20% overlap, 1x1 mm in-plane resolution, flip angle 90 deg., 5/8 partial Fourier acquisition, 40x32 mm FOV, bandwidth 658 Hz/pixel). For each scan session, three QISS scans were acquired in randomized order with GRAPPA PAT factors 2, 3 and 4. Each volunteer was scanned at 1.5 and 3T within one week. In addition, CE-MRA was acquired at 3T (8.4-10mL at 2 mL/sec, Ablavar, Lantheus Medical Imaging, N. Billerica, MA). Two volunteers and one patient were unable to receive contrast due to low GFR. Two blinded radiologists scored image quality in the pelvis for venous contamination, arterial conspicuity and arterial artifacts using a 4-point scale (0-poor, 1-fair, 2-good, 3-excellent) and inter-observer reliability was measured using the kappa statistic. SNR estimates were calculated by dividing mean vessel signal in the thigh by mean signal of an ROI in the background, and CNR estimates were calculated by subtracting muscle SNR from that of the vessel. Estimates of SNR, CNR and diagnostic scores were assessed with multi-factor within subjects ANOVA using SPSS.

Results: Examples are shown for a representative volunteer (Fig. 1: 1.5/3T QISS, CE-MRA) and a patient with PAD (Fig. 2: 3T QISS). Estimates of SNR and CNR were significantly higher at 3T than 1.5T ($p<0.001$) but neither estimate was significantly affected by the PAT factor. QISS arterial conspicuity and artifact scores were comparable to CE-MRA regardless of field strength or PAT factor and conspicuity was slightly higher at 3T (2.8±0.1) relative to 1.5T (2.5±0.2) but differences were not significant. Venous suppression was better for CE-MRA, and slightly improved at 1.5T relative to 3T for QISS but differences were also not significant. Inter-observer agreement was moderate for 1.5T QISS ($\kappa = 0.426$) and substantial for 3T QISS ($\kappa = 0.759$). Overall, QISS performed comparably to CE-MRA, at both field strengths even with a high PAT factor of 4.

Conclusion: This study complements previous studies showing high sensitivity and specificity for QISS at 1.5T. SNR and CNR estimates, while confounded by spatially varying noise amplification, suggest improved clinical performance at 3T relative to 1.5T. 3T QISS is currently being assessed in a patient cohort with claudication and critical limb ischemia.

Fig. 1. Healthy volunteer: Comparison across field strength and PAT Factor

Fig. 2. Patient case

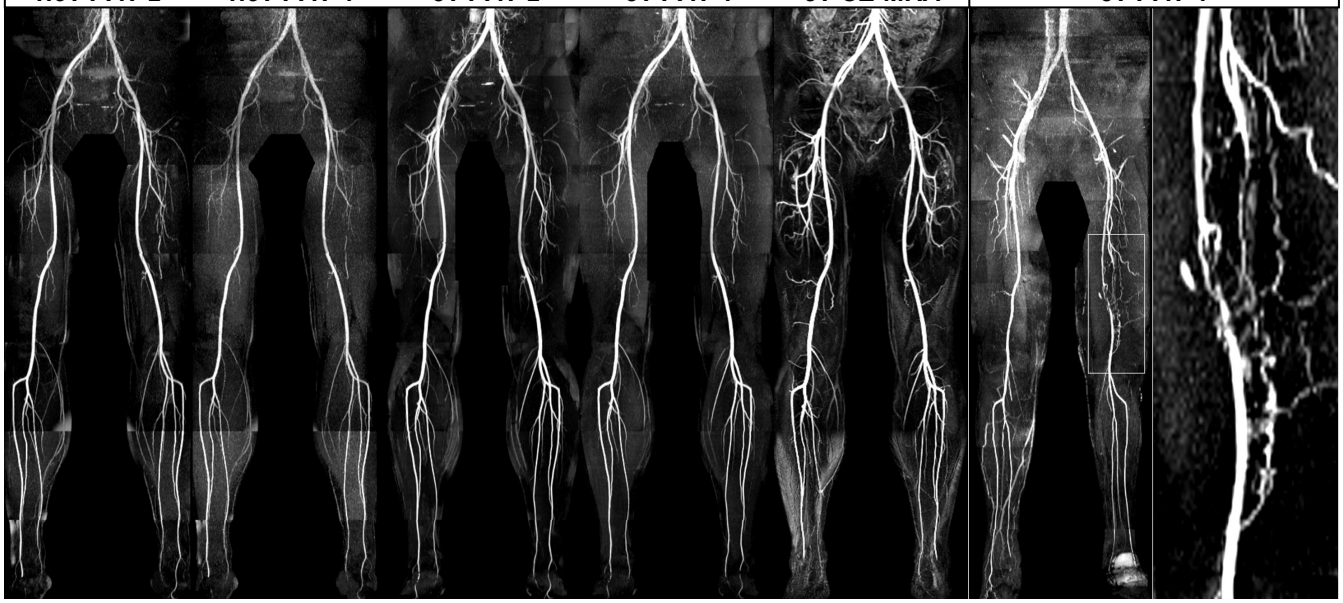

Fig. 1(left): QISS demonstrates improved image quality at 3T with high PAT factors. Fig. 2 (right): 3T QISS with high acceleration factor (PAT 4) in patient shows segmental occlusion in the adductor canal with reconstitution in the profunda femoral collateral. This high acceleration enables single shot acquisition even at high heart-rates.

References: [1] Edelman RR et al. MRM 2010; 63:951-8. [2] Hodnett et al. AJR Am J Roentgenol (in press).

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