Comprehensive arterial assessment in diabetic patients using combined quiescent interval single shot (QISS) imaging for leg imaging and QISS-arterial spin labeled MRA for pedal imaging: preliminary experience with comparison to DSA

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Target Audience

Clinicians and basic scientists with an interest in non-invasive imaging of peripheral arterial disease.

Purpose

Imaging diabetic patients with peripheral arterial disease (PAD) is critical for revascularization planning. PAD in diabetic patients is commonly distal, and imaging of the pedal arteries is desirable to identify potential bypass targets. Concomitant renal impairment may contribute to difficulties with conventional imaging[1]. Quiescent interval single shot (QISS) MRA[2] is a recently described non-contrast enhanced technique with high reported accuracy[3]. However, it is challenging to perform in the feet, due to inhomogeneous shim and slow arterial flow, with QISS with arterial spin labeling (QISS-ASL) described to improve pedal artery visualization[4]. The purpose of this study was to evaluate feasibility and accuracy of a combined QISS/QISS-ASL approach (cQISS-MRA) for evaluating diabetic patients with symptomatic PAD, using DSA as the reference standard.

Methods

15 diabetic patients (7M, 8F, mean 72y, range 42-91y, eGFR 7-91 ml/min/1.73m^2) with symptomatic PAD were prospectively recruited for cQISS-MRA at 1.5T (Siemens, Avanto) 0-36 days prior to clinically required DSA. Initially, pedal QISS-ASL MRA was performed with a 12-channel head coil. Subsequently, QISS MRA of infrarenal aorta to feet was performed with peripheral, body and spine array coils. Common parameters for QISS MRA and QISS-ASL MRA were: FA 90°, in plane resolution 1 x 1mm^2, BW 658 Hz/Px, acceleration factor 2 (GRAPPA). For QISS MRA: TR/TE 3.5/1.4ms, sl 3mm (additional 1.2mm imaging through calf), FOV 400 x 260, 9 stations, 48 sl, total acquisition 432 RR intervals, quiescent interval 350ms. For QISS-ASL: TR/TE 3.7/1.6ms, quiescent interval 228ms, FOV 400 x 240, sl 1.2mm, 2 stations, 128 sl, total acquisition 256 RR intervals. DSA was performed with iodinated contrast (n=14) or carbon dioxide (CO_2, n=1) with coverage determined by clinical indication. MRA and DSA images were anonymized and evaluated by a cardiovascular and vascular/interventional radiologist respectively on a PACS workstation (Impax, Agfa). Diagnostic confidence (1=non-diagnostic, 3=diagnostic, 5=highly confident) was recorded and compared with the Wilcoxon signed rank test. MRA diagnostic confidence was compared between regions (pelvis, thigh, calf and foot) with the Mann-Whitney U test. Segmental stenosis was graded in up to 39 segments per patient. cQISS-MRA sensitivity and specificity for hemodynamically significant (≥50%) stenosis was calculated against DSA for all available segments.

Results

Imaging was completed in 13/15 patients with 2 incomplete studies (BMI 40 precluding imaging of pelvis and thigh, n=1; patient discomfort, n=1). DSA correlation (Fig 1) was available in 19 legs in 15 patients, with pelvic DSA only in 1 patient. For all segments where DSA was available, cQISS-MRA mean diagnostic confidence was 4.00±0.96, significantly higher than DSA 3.72±0.84, p<0.0001, with 12 non-diagnostic (score of 1) DSA segments at CO_2 angiography, and 5 non-diagnostic MRA segments (susceptibility from joint prostheses). For cQISS-MRA, there was significantly lower diagnostic confidence in the foot compared with other regions (pelvis 3.87±0.93, thigh 4.0±1.0, calf 4.2±0.77, foot 2.41±1.1, p<0.0001 for all regions compared to the foot). Factors negatively impacting MRA diagnostic confidence and accuracy were: for QISS-MRA, step artifact from motion/ mistriggering and inhomogeneous fat suppression; for QISS-ASL MRA, motion artifact and image noise. Excluding non-diagnostic DSA and MRA segments, 309 segments were assessed for stenosis, with 142 (46.0%) demonstrating hemodynamically significant stenosis. Overall, there was 74.7% sensitivity and 86.8% specificity for cQISS-MRA, highest for aortoiliac segments, and lowest for pedal segments (Table 1).

	Prev (%)	Sensitivity (%)	95% CI	Specificity (%)	95% CI
Pelvis	26.7	83.3	51.6-97.9	93.9	79.8-99.3
Thigh	47.1	75.6	59.7-87.6	84.8	71.1-93.7
Calf	47.7	71.2	59.45-81.2	88.8	79.7-94.7
Pedal	66.7	81.3	54.4-96.0	50.0	15.7-84.3
All	**46.0**	**74.7**	**66.7-81.6**	**86.8**	**80.7-91.6**

Table 1. Prevalence (Prev) of disease at DSA, and sensitivity and specificity of cQISS MRA for ≥50% stenosis

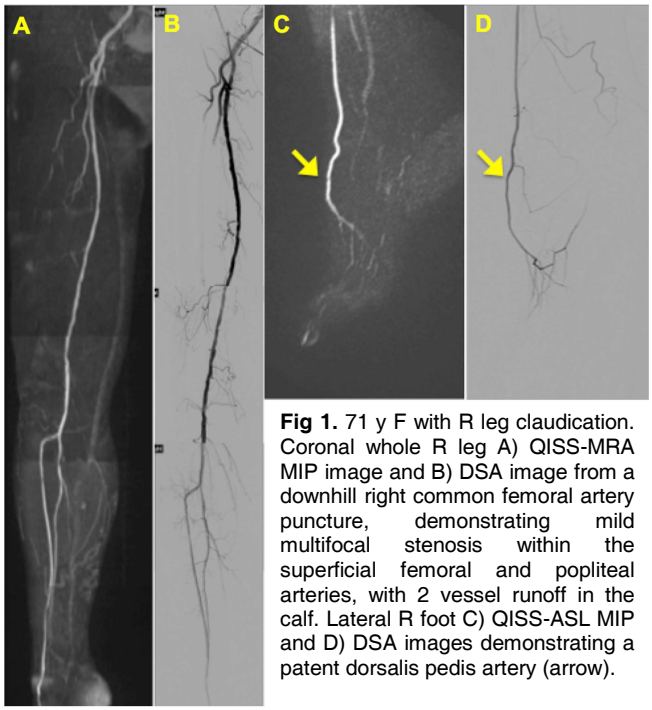

Fig 1. 71 y F with R leg claudication. Coronal whole R leg A) QISS-MRA MIP image and B) DSA image from a downhill right common femoral artery puncture, demonstrating mild multifocal stenosis within the superficial femoral and popliteal arteries, with 2 vessel runoff in the calf. Lateral R foot C) QISS-ASL MIP and D) DSA images demonstrating a patent dorsalis pedis artery (arrow).

Discussion/ Conclusion

A combined QISS MRA and QISS-ASL MRA approach is feasible for infrarenal aorta to pedal arterial assessment in diabetic patients with symptomatic PAD. There is good diagnostic confidence for pelvic to calf imaging and lower diagnostic confidence for pedal imaging. Accuracy of the technique is higher for proximal stations, with susceptibility artifact and inhomogeneous fat suppression impacting stenosis assessment. Pedal imaging is degraded by motion and relatively low SNR, however still enables identification of potential distal bypass targets in a patient population with a substantial burden of disease. This includes patients with end stage renal failure, where even DSA may be challenging. Assessment of potential clinical utility of cQISS-MRA for guiding management is planned. Further refinements to accelerate QISS-ASL MRA, and strategies to improve robustness to motion, including non-Cartesian acquisition, could improve test accuracy for pedal arterial stenosis.

References

1. Pomposelli F. *J Vasc Surg* 2010; 52: 81S-91S.
2. Edelman RR et al. *Magn Reson Med* 2010; 63: 951-958.
3. Hodnett PA et al. *Am J Roentgenol* 2011; 197: 1466-1473.
4. Edelman RR et al. *Proc Int Soc Magn Reson Med* 2014; 2521.

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