Time-resolved Dixon MR angiography of patients with peripheral vascular disease at 3.0 T

Courtney K Morrison[1], Mahdi S Rahimi[1], Kang Wang[2], James H Holmes[2], Peter Bannas[3,4], Utaroh Motosugi[3], and Frank R Korosec[1,3]
[1]*Medical Physics, University of Wisconsin-Madison, Madison, WI, United States,* [2]*Global MR Applications and Workflow, GE Healthcare, Madison, WI, United States,* [3]*Radiology, University of Wisconsin-Madison, Madison, WI, United States,* [4]*Radiology, University Hospital Hamburg-Eppendorf, Hamburg, Germany*

Target audience: Scientists and radiologists interested in non-subtractive or time-resolved peripheral MRA.

Purpose: Conventional contrast-enhanced peripheral MR angiography (MRA) typically uses subtraction-based methods, which are susceptible to misregistration from patient motion and suffer from decreased signal-to-noise ratio (SNR) relative to non-subtractive methods. Previous work has demonstrated the use of non-subtractive contrast-enhanced peripheral MRA at 3.0 T during the steady state[1] and at 1.5 T using a bolus-chase method[2]. This work investigates the clinical feasibility of using a contrast-enhanced, non-subtractive method for MRA at 3.0 T in patients with peripheral vascular disease using a novel time-resolved imaging method.

Methods: *Patients:* Eight patients with known or suspected peripheral vascular disease were scanned after obtaining informed consent in accordance with the institutional review board guidelines.
Pulse Sequence: A dual-echo spoiled gradient echo sequence with bipolar readout gradients was used with an interleaved variable density sampling pattern[3]. Images were reconstructed using view-sharing, and fat/water-separated images were generated using a two-point Dixon algorithm[4]. Data-driven parallel imaging was used to accelerate image acquisition. Patients were scanned on a clinical 3.0 T scanner (Discovery MR750 or MR750w, GE Healthcare, Waukesha, WI) using either a 32-channel torso array or a 20-channel peripheral vascular array. For all patients, a standard-of-care clinical scan and a Dixon scan of the calf station were acquired with separate injections of. For one patient, an additional clinical scan and Dixon scan of the thigh station were performed with two additional injections.
Data Analysis: Two radiologists with 14 and 6 years of experience independently assessed the image quality of the clinical and Dixon water images based on i) anatomical delineation of arteries using a 5-point scale, 5: excellent with delineation of small arteries, 4: diagnostic with good delineation of arteries, 3: adequate for diagnosis, 2: partially non-diagnostic, 1: non-diagnostic; ii) overall image quality/artifacts using a 4-point scale, 4: excellent image quality with minimal if any artifacts, 3: some artifacts but not interfering with assessment, 2: artifacts interfering with assessment, 1: non-diagnostic with severe artifacts; and iii) visualization of disease to detect or exclude presence of stenosis using 3 categories, 1: prefer the Dixon water images, 2: equivalent, 3: prefer the clinical subtraction-based images. For comparison with the Dixon water images, additional subtraction images were generated using the first and second echoes from the Dixon acquisition individually as well as summed, after mask subtraction. Using the best arterial frame, SNR was measured in the same regions-of-interest on water images and all three sets of subtracted images generated from the Dixon acquisition.

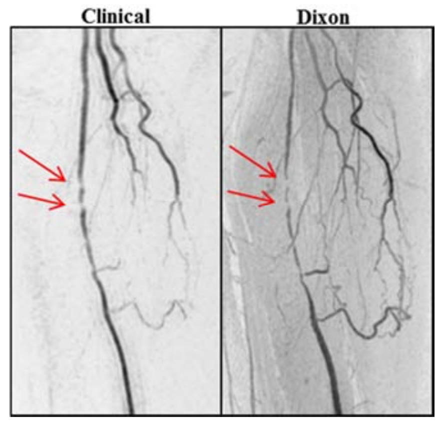

Figure 1. Clinical and Dixon water images of a patient. Shown are a MIP of the clinical images (left) and a limited MIP of the Dixon water images (right). The high-grade stenosis at the left femoral artery is better visualized in the Dixon water images (red arrows). Collateral arteries are also more clearly delineated on the Dixon water images.

Results: On average, the Dixon water images were scored higher than the clinical images based on anatomical delineation of arteries (4.9 vs. 4.3) and overall image quality/artifacts (3.9 vs. 3.7). Neither reader preferred the clinical images to the Dixon water images in any case. One reader preferred the Dixon water images to the clinical images in 4 out of 9 cases, while the other preferred the Dixon water images to the clinical images in 3 cases. All other cases were scored as equivalent. Figure 1 shows an example of the clinical images and Dixon water images in a patient. On average, the first-plus-second-echo subtracted images had 12% higher SNR than the first-echo subtracted images and 22% higher SNR than the second-echo subtracted images. On average, the SNR was higher in the Dixon water images than in the first-echo subtracted images (61%), second-echo subtracted images (74%), and first-plus-second-echo subtracted images (51%). A comparison of the Dixon water images and the echo subtracted images is shown in Figure 2.

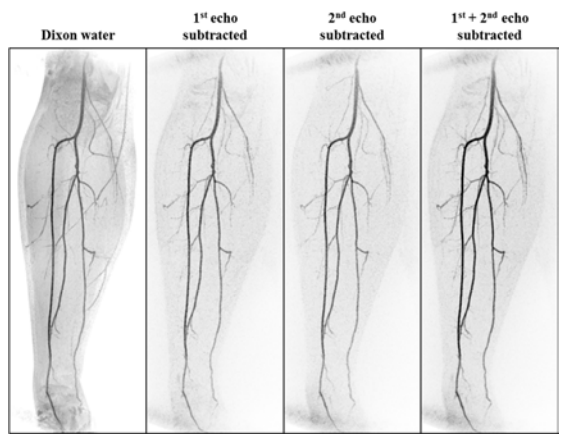

Figure 2. Dixon water images and subtraction images. Shown are MIPs of the best arterial phase from the Dixon acquisition. The first-plus-second-echo subtracted images have higher SNR than the individual-echo subtracted images. The Dixon water images have higher SNR than all three subtraction methods.

Discussion: We have demonstrated the clinical feasibility of a time-resolved, contrast-enhanced, non-subtractive method for peripheral MRA at 3.0 T in a clinical population. The Dixon water images were graded as equivalent to or better than the clinical images for all patients. In addition, the Dixon water images had improved SNR compared to the subtraction methods using the first and second echoes.

References: [1] Michaely et al. Invest Radiol. 2008;43(9):635-641. [2] Leiner et al. Eur Radiol. 2013;23(8):2228-2235. [3] Wang et al. MRM 2011;66(2):428-436. [4] Ma et al. MRM 2004;52(2):415-419.