Non-Subtraction Dynamic Contrast Enhanced MR Angiography at 3T using IVD Sampling, Parallel Imaging and 2-pt Dixon

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TARGET AUDIENCE: MR physicists and clinicians who are interested in time-resolved imaging, MR angiography and water-fat imaging.

PURPOSE: Conventional subtraction-based dynamic contrast-enhanced (DCE) MR Angiography (MRA) is susceptible to patient motion between the pre-contrast mask and the contrast phases. Recently, a 2-point Dixon based non-subtraction method for CE MRA has been proposed and improved motion robustness has been shown [1,2]. However, it was demonstrated with single phase MRA; no temporal information was obtained. In this work, we combined 2-pt Dixon with fast dynamic imaging techniques and applied it to DCE MRA at 3T, eliminating the need for bolus timing or monitoring and gathering temporal information.

METHODS: A previously reported Interleaved Variable Density (IVD) [2] sampling was modified in this study. First, no pre-contrast mask was acquired to shorten patient's time on the table, and the calibration region for data-driven parallel imaging (PI) [3,4] was only acquired in the first phase, with all other phases fully PI accelerated and IVD-undersampled, as shown in Figure 1. Second, a dual-echo bipolar readout was implemented with each ky-kz view to collect signal at both fat-water out-of-phase and in-phase echo times. In the reconstruction, view-sharing [5] was first used to remove IVD undersampling. Parallel imaging calibration was performed only once using calibration data from the first phase, and the obtained unaliasing weights were applied to all phases. A 2-pt Dixon [6] method with an improved phase correction algorithm was used to avoid water-fat swaps.

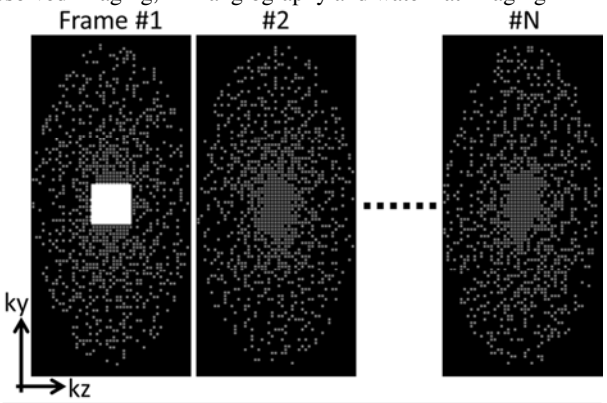

Figure 1. Example of the sampling pattern used. Each sampled point represents a dual-echo bipolar readout at in-phase and out-of-phase echo times. Note that the calibration lines are only acquired in the first phase to speed up the temporal frame rate for the rest of the scan.

Four healthy volunteers were consented and scanned on a 3T clinical scanner (Discovery MR750, GE Healthcare, Waukesha, WI) with a 32-channel torso array. FOV = 480(S/I) × 384(L/R) × 156(A/P) mm^3, with 1.3 mm isotropic resolution. Parallel imaging acceleration R = 3(L/R) × 2(A/P). $TE_1/TE_2/TR$ = 1.2/2.4/4.6 ms. Temporal frame rate = 5.9 sec/frame.

RESULTS: Figure 2 shows the results from a healthy volunteer. The filling-in of the peripheral arteries was well depicted using the time-resolved technique, and the best arterial phase can be chosen retrospectively, eliminating the possibility of bolus timing error. Arteries can be well visualized in 3D with isotropic spatial resolution, as demonstrated in coronal (Fig. 2a-c) and sagittal Maximum Intensity Projection images (Fig. 2d).The background fat was removed with the 2-pt Dixon algorithm.

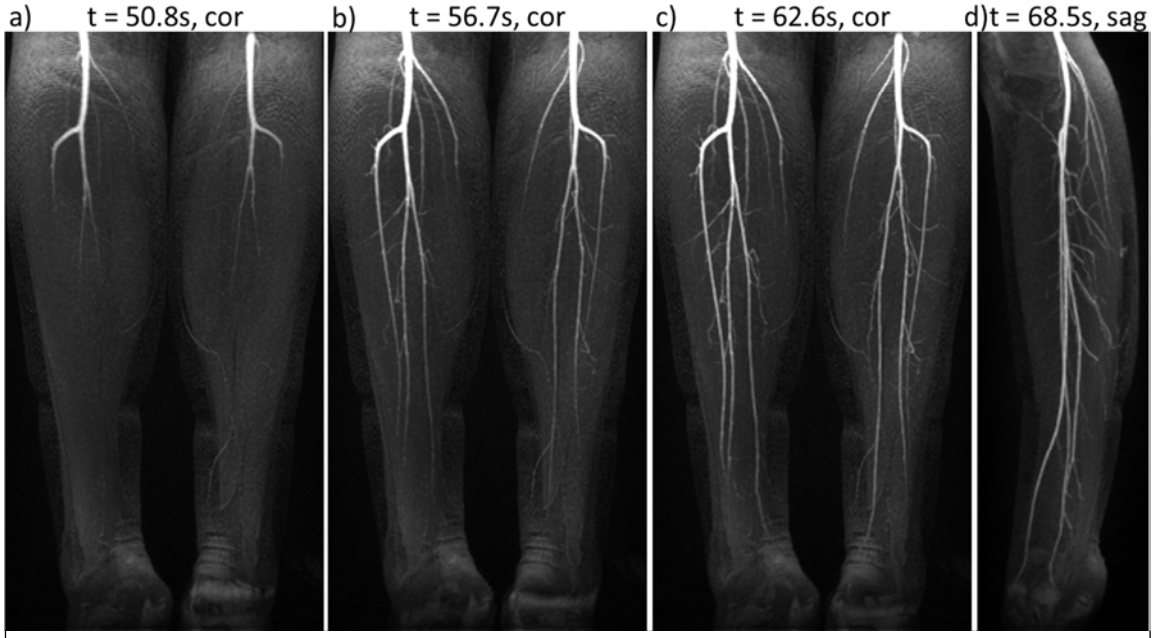

Figure 2. Example of a time-resolved 2-pt Dixon non-subtraction peripheral MRA exam for a healthy volunteer, with 48cm FOV, 1.3 mm isotropic resolution and 5.9 sec/frame at 3T. (a-c): Three consecutive MIP images in coronal plane. (d): next frame in sagittal plane, showing isotropic spatial resolution.

CONCLUSION: In this work, we demonstrated the feasibility of performing dynamic 2-pt Dixon based non-subtraction MRA at 3T. Bolus timing was not needed with the time-resolved technique, and mask acquisition and subtraction was eliminated to improve robustness to motion and workflow.

REFERENCES: [1] Michaely et al. Invest. Radiol. 2008;43(9):635-641 [2] Leiner *et al*., Eur Radiol (2013) 23:2228 [3] Wang et al., MRM (2011) 66: 428 [4] Griswold et al., MRM (2002) 47:1202 [5] Brau et al., MRM (2008) 59:382 [6] Riederer et al., MRM (1988) 8:1 [7] Ma *et al*., MRM (2004) 52:415