Comparison of IVD-HYCR Sampling-Reconstruction with Clinical View-Shared MRA and DSA in Peripheral Vasculature

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TARGET AUDIENCE Scientists / clinicians interested in peripheral MR angiography.

PURPOSE To evaluate the performance of Interleaved Variable Density- HighlY constrained Cartesian Reconstruction (IVD-HYCR) technique for imaging patients with peripheral vascular disease (PVD) by comparing it to existing clinical view-shared methods.

INTRODUCTION X-ray digital subtraction angiography (DSA) is considered the reference standard for assessment of peripheral vascular disease. Recent advances in MR imaging, however, have established MR as a competitive, but far less invasive alternative. View-sharing techniques [1,2], although commonly used, suffer from limited spatial resolution and a broad temporal footprint. In this work, we used a pseudo-randomly undersampled IVD pattern [3] with data-driven parallel imaging [4] and HYCR to acquire high resolution, time-resolved, contrast-enhanced, mask-subtracted angiograms of the peripheral vasculature in a patient population referred for intervention.

METHODS Thirteen subjects with known PVD were recruited from our vascualr surgery department after IRB approval and obtaining informed consent. Patients were scanned using a 3T system (Discovery MR750, GE Healthcare, Waukesha, WI) and a commercially-available 32 channel body array coil (Neocoil, Pewaukee, WI). HYCR was qualitatively compared to a commercially-available time-resolved contrast enhanced view-shared method [2], and both methods were compared to X-ray DSA (Integris V system, Philips Medical Systems, Best, The Netherlands). The MR injection protocol included two separate injections (0.05mmol/kg each) of gadobenate dimeglumine (Multihance, Bracco, Princeton, NJ) each followed by a 20 ml saline flush, and all injections were administered at 2.5 ml/s. The MR injection order was randomized in different patients to minimze any related bias. The MR scans were perfomed prior to the X-ray DSA scans and any interventions .

Data-driven parallel imaging [5] was performed for each time-frame. Auto calibration lines were acquired during the mask acquisition and the same lines were used to reconstruct all subsequent time-frames. Sharing the auto calibration lines allowed acquisition of a larger effective central region in each time frame or, alternatively, a reduced view-sharing window necessary to reconstruct a fully-sampled composite image.

Figure 1 shows the acquisition order in the ky-kz plane. For every time-frame, the acquisiton starts at the edge of the ky-kz plane and every other readout line in the undersampled pattern is sampled in a reverse elliptic centric fashion. Once the center is reached, the order is reversed and the remaining half of the readout lines are sampled in a standard elliptic centric manner (collecting the lines that were skipped on the in-going trajectory). This reduces "flickering" artifact related to eddy currents caused by large jumps between the periphery of k-space in frame N to the center of k-space in frame N+1.

RESULTS Figure 2 shows a) DSA image compared with b) IVD-HYCR MRA image of calf and foot arteries of a patient referred for surgery due to the presence of foot ulcers. Small arteries are visible in the IVD-HYCR image due to high spatial resolution (1 mm^3 isotropic) and SNR. Figure 3 is a comparison between DSA, HYCR and the view-shared method in another patient with PVD. The higher spatial resolution of the IVD-HYCR technique is apparent in figures 3b and 3c.

DISCUSSION Two experienced radiologists will grade the severity of stenoses and the diagnostic quality of the IVD-HYCR and view-shared images, and the agreement between the two MRA methods will be calculated. The accuracy of the stenosis classification will also be compared to the stenosis classification determined from the DSA reference images.

CONCLUSION Combination of the IVD sampling pattern, parallel imaging, and the HYCR sampling pattern provides higher resolution peripheral angiograms, and yields a smaller temporal footprint than the view sharing method used clinically at our institution. Qualitative comparisons with DSA show improved image quality compared to existing clinical practice, reduced artifacts and good diagnostic correlation.

REFERENCES [1] Rieder et al. MRM, 1988:1. [2] Korosec et al. MRM, 1996:345. [3] Wang et al. MRM, 2011:428. [4] Griswold et al. MRM, 2002: 1202. [5] Brau et al. MRM, 2008:382.

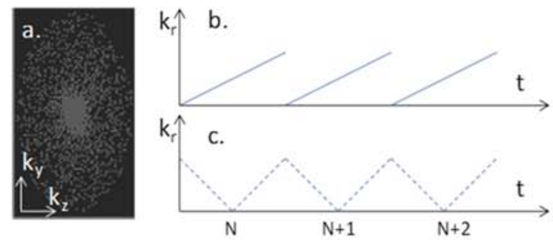

Figure 2: a) IVD sampling pattern in k_y-k_z plane with data-driven parallel imaging for one of the time-frames. b) Distance from the center of k-space in elliptic centric ordering. c) Distance from center of k-space in out-in-out ordering.

Figure 2: a) X-Ray DSA image of distal calf and foot arteries of a patient with PVD. b) Reformatted IVD-HYCR MRA of the same patient.

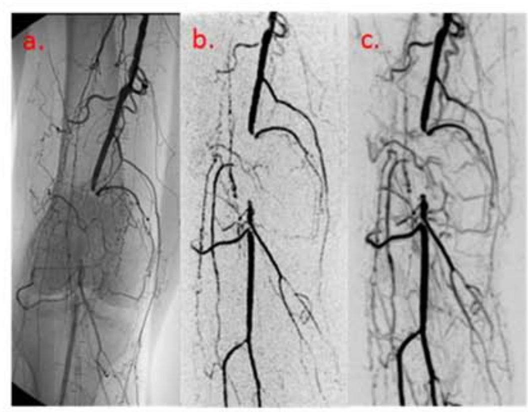

Figure 3: a) X-Ray DSA image of a patient showing occlusion of popliteal artery. b) IVD-HYCR MRA image. c) Conventional clinical view-shared MRA image.