Unilateral 8ch Receiver Array for Ultra High Resolution Time-Resolved 3D CE-MRA of the Hand

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Introduction: MRA of the upper extremities including the hands and forearms requires high spatial resolution due to the small vessels of interest [1]. This presents a particular challenge to time-resolved imaging, as certain pathologies result in very short arterial-to-venous transit times. Previous work has shown update times in 3D time-resolved contrast-enhanced MRA (CE-MRA) in the 3 to 4 second range for bilateral studies with voxel volumes of around 0.5mm^3 [2]. However, depending on the specific indications it is often possible to limit the imaging to only one hand or arm. Such a unilateral study would allow additional flexibility in patient positioning and potentially less discomfort and motion artifact, permit reduction in acquired field-of-view (FOV), and facilitate selection of an oblique acquisition orientation for improved efficiency in filling the FOV with anatomy. The purpose of this work was to develop a dedicated 8ch receiver array targeted to unilateral upper extremity imaging but also compatible with high (R≥8) acceleration 2D SENSE as used in 3D time-resolved CE-MRA.

Methods: The receiver array is composed of eight flexible rectangular elements, each 24.7 cm by 6.2 cm in size. Each pair of elements is combined into a two-element module. When placed around the patient's arm, they flatten slightly, resulting in a somewhat asymmetric left/right vs. anterior/posterior (L/R vs. A/P) field-of-view (Figure 1). For large subjects the array can be expanded by snapping in additional modules. The new array was evaluated in a volunteer imaged using two different CE-MRA acquisitions, both with R = $R_Y \times R_Z$ = 8 2D-SENSE acceleration and four-fold view-sharing [2]. The first acquisition used a 400 × 176 × 112 matrix with 0.75mm isotropic voxels (0.42 mm^3) with a TR/TE of 5.8/2.7ms, resulting in an update time/temporal footprint of 2.7/9.2 seconds. The second acquisition, performed several days later to allow complete contrast clearage, was done with the same coverage but higher spatial resolution 0.6mm isotropic voxels (0.21 mm^3), requiring a TR/TE of 6.8/3.2ms and providing an update time/temporal footprint of 5.2/17.7 seconds utilizing a 500 × 224 × 160 matrix. Imaging was done on a GE Signal HDx v 16.0 3T MR System (GE Healthcare, Waukesha, WI) with 20 mL MultiHance (Bracco Diagnostics, Princeton, NJ) contrast with a follow-up 20 mL saline flush all injected at 3 mL/s for each study.

Figure 1: Unilateral 8ch receiver coil array. 8 linear elements arranged circumferentially around the hand/wrist

Results: Figure 1 (top) shows three consecutive times frame for the 0.75mm isotropic resolution and the temporal resolution clearly dominant radial artery vs. ulnar artery flow in this subject. Filling progressed to the venous phase with sustained high quality. In the higher resolution case (bottom) a receiver coil problem caused reduced signal in the tips of the fingers, but high quality arterial and venous frames were acquired throughout the remainder of the FOV. The 0.6mm acquisition demonstrates very fine small vessel detail, whereas the 0.75mm acquisition provides both high spatial and temporal resolution. . Because of the high SNR in both results, it is very likely that the contrast dose can be markedly reduced if desired.

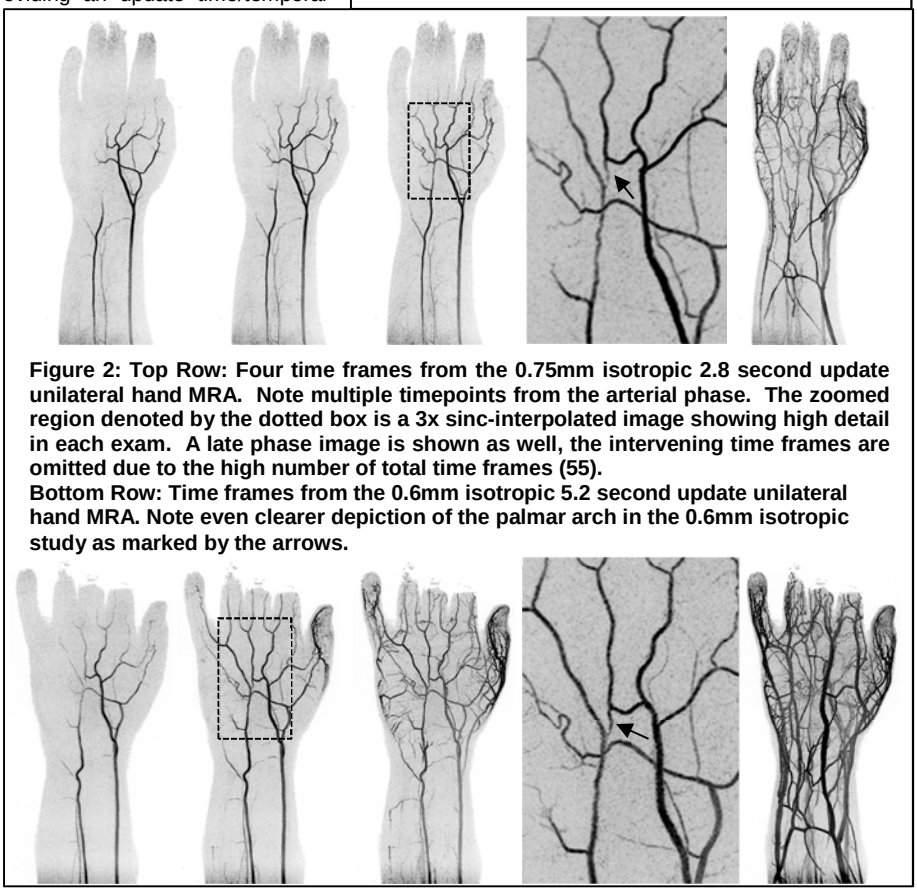

Figure 2: Top Row: Four time frames from the 0.75mm isotropic 2.8 second update unilateral hand MRA. Note multiple timepoints from the arterial phase. The zoomed region denoted by the dotted box is a 3x sinc-interpolated image showing high detail in each exam. A late phase image is shown as well, the intervening time frames are omitted due to the high number of total time frames (55).
Bottom Row: Time frames from the 0.6mm isotropic 5.2 second update unilateral hand MRA. Note even clearer depiction of the palmar arch in the 0.6mm isotropic study as marked by the arrows.

Conclusion: For cases in which unilateral coverage of the upper extremity is desired, we have shown that a new eight-channel coil array provides the expected improvements in temporal and/or spatial resolution over bilateral imaging allowed by the reduced FOV while retaining high image quality. Study #1 above demonstrates a reduction of voxel volume by 25% with a decrease in update time by 30% relative to previously reported work, allowing an additional freedom in MRA protocol selection. Study #2 demonstrates the potential for unprecedented spatial resolution for arterial phase CE-MRA of the hand owing to sampling of very extensive k-space while contrast signal is high.

References: [1] Dobson, MJ, Clin Radiol 52:595(1997); [2] Haider, CR, JMRI 34:2(2011);