A 16 Element Phased Array Surface Coil for Time-Resolved CE-MRA at SENSE Accelerations up to 12

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Introduction: 3D Contrast Enhanced MR Angiography (CE-MRA) of the calves has previously been demonstrated using 2D SENSE acceleration [1] as high as R = 8 with a custom eight-element receive array to provide 1 mm^3 resolution images with a 5.0 sec update time and temporal footprint as short as 19.6 sec [2]. Although this technique is useful in visualizing pathology [3], improved technical performance is desirable. For example, further reduction in frame time and temporal footprint would be useful in multi-station peripheral MRA studies in which acquisition time per station is limited by the need to keep pace with the advancing contrast bolus. The purpose of this work is to describe a new 16-element receive array which provides improved performance for current 2D SENSE accelerations as well as even higher (R=12) acceleration.

Methods: The coil array was designed to have six anterior elements fixed to a semi-rigid form, and similarly for six posterior elements. For each set of six, the two medial coil elements are attached to a "V," giving each a slight sagittal angle. Two-element combinations are additionally used on each side and flexibly attached to the semi-rigid form to allow patient-specific adjustment and slope from the wider knee to the more narrow ankle area. These detachable side coils may also be replaced with wider elements and the array repurposed for thigh imaging. All elements are 40 cm long vs. the 27 cm long elements of the 8ch coil of [2]. The 16-element array is pictured in Fig. 1A. Fig. 1B is a schematic from the superior right side, and Fig. 1C shows a superior-to-inferior view. The angled center coils improve sensitivity to the inner legs. A g-factor comparison between the standard 8ch array [2] using $R = R_Y \times R_Z = 4 \times 2$ and the new 16ch array with $R = R_Y \times R_Z = 6 \times 2 = 12$ was conducted using scans from one volunteer on a 3T GE Discovery MR750 MRI system. A second volunteer was imaged on the same MRI system with the following scan parameters: 1mm^3 isotropic resolution on a FOV of 42(S/I) × 33.6(L/R) × 13.2(A/P) cm^3 using $R_Y \times R_Z = 6 \times 2 = 12$ 2D SENSE acceleration, TR/TE of 5.9/2.8ms and the N4 CAPR technique of Ref. [4], yielding an update time of 3.5 seconds with a temporal footprint of 12.4 seconds. A patient with a suspected vascular malformation (VM) was also imaged using the 16ch array with 1mm^3 resolution, R = 8 2D SENSE, and an FOV of 40(S/I) × 40(L/R) × 13.2(A/P) cm^3.

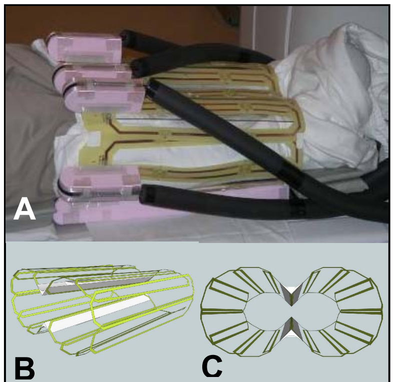

Fig. 1: Fitted coil array and two axis schematic depiction

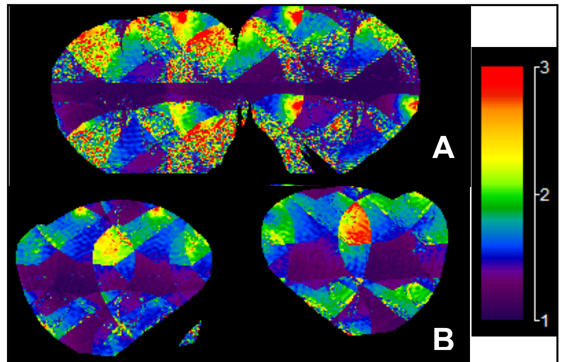

Fig. 2: g-Factor comparison between 8ch R=8 (A) and 16ch R=12 (B). Single axial slice through the calves

Results: Figure 2 shows a single axial slice through the calves of the first volunteer of the g-factor maps for both coils. Even with 50% higher acceleration (12 vs. 8), the g-factor for the 16ch coil (B) is comparable to that of the 8ch coil (A). Figure 3 shows the coronal MIPS from the CE-MRA study of the second volunteer. Due to the high frame rate and short temporal footprint, multiple arterial frames are generated prior to any start of venous contamination. Inset (C) is a sagittal subvolume of the dashed box in (A) and illustrates the high A/P resolution. Inset (D) is an enlargement of the box of (B) and shows the communicating branch of the fibular artery, illustrating the high resolution even at the distal end of the 42 cm long FOV. Figure 4 shows a coronal MIP from the patient study.

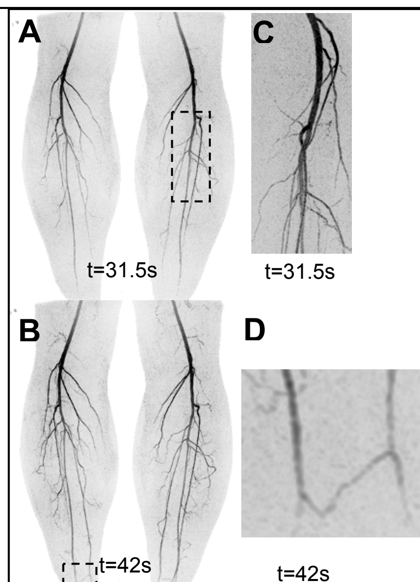

Fig. 3: (R=12). Coronal MIPs from a CE-MRA study in a volunteer (A,B) with post-injection time indicated. (C,D) Sub-volumes are described in text.

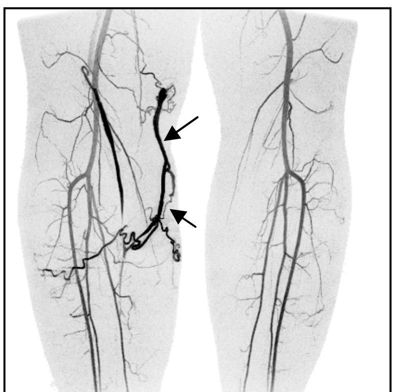
Fig. 4: (R=8). Coronal MIP of patient with suspected VM. Large, fast filling lesion with tortuous veins is visible (arrows).

Conclusions: We have shown that increasing coil element count, moving the elements close to the anatomy under study, and effectively positioning the elements has made CE-MRA of the calves feasible at 2D SENSE accelerations as high as R = 12, an acceleration heretofore not routinely attained. The resultant reduction in frame time and temporal footprint may be critical in improving the performance of peripheral MRA such as with fluoroscopic tracking [5]. Although not shown here, the new 16ch coil provides improved g-factor performance vs. the 8ch coil at R=8, providing improved SNR for current spatial and temporal resolution. We are beginning to construct a companion 16ch foot array for use with the array described here for two-station bolus chase calf-foot MRA.

References: [1] Weiger M, MAGMA 14:10(2002); [2] Haider CR, Radiol 253:831(2009); [3] Young PM, ISMRM 87(2011); [4] Haider CR, MRM 60:749(2008); [5] Johnson CP, MRM 64:629 (2010)