Modular Coil Array for Highly Accelerated 2D Parallel Acquisition

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Introduction: Within the last several years 2D parallel acquisition has been increasingly used with 3D contrast-enhanced MR angiography (CE-MRA). The combination of these methods is synergistic for several reasons. First, it is well accepted that for a given acceleration R, a 2D vs. 1D approach for acceleration causes far less noise amplification. Second, CE-MRA acquisitions are typically performed in the sagittal or coronal format; i.e. the two phase encode directions are within the transverse plane. This means that some coil elements can be placed with their central axes along the right/left direction and other elements with their axes along the anterior/posterior direction. That is, coil element orientation can be well tuned to both directions of acceleration, and in effect all coil elements contribute to the inversion. Recently high quality 2D R=8 SENSE-accelerated images of the calves have been demonstrated using an eight-element coil placed circumferentially around the calves [1]. The purpose of this work is to describe how this coil design can be extended into a class of receiver coils, namely modular multi-element coil arrays designed for circumferential placement around the body, applicable to 2D parallel acquisition.

Methods: There were several design considerations for the receiver coil arrays. First, it was desirable that the arrays be modular. That is, the number of elements in the array could be adjusted to match the patient. Second, the array elements needed to be mechanically flexible to allow circumferential wrapping around the patient. Third, the basic element size needed to match the targeted vascular territory. Allowance was made for different sized elements for, say, imaging the hands vs. the abdomen. Finally, addition or removal of coil elements needed to be practical in the clinical practice. We then designed a basic element size for each of several anatomic regions as summarized in Table 1: calves, feet, hands, brain, thighs, and abdomen. Because the long side of each coil element would be aligned in the longitudinal direction of the patient, the coil width was nominally chosen to provide 1/e falloff of sensitivity over a distance matched to the typical FOV in that territory. Individual elements of a given size were then constructed and then hard attached in pairs, with overlap chosen to minimize mutual inductance effects. Hard clasps were then placed on the element pairs, allowing multiple pairs to be attached into an arbitrarily long linear array with mutual inductance minimized. The patient is placed onto this open linear array. Finally, by attaching the last element back to the first, a circumferential array is created which encloses the targeted region.

Region	Element Size (cm^3)	# of Coils	S/I FOV (cm)	L/R FOV (cm)	AP FOV (cm)
Abdomen	14.3 x 27.2	8 to 12	25 to 40	35	25 to 32
Calf	10.5-14.3 x 27.2	8	40	32	13.2
Foot	8.3 x 27.2	12	30	20	30
Hand	6.2 x 25	6 or 12	30	21	10.8
Head	6.2 x 25	12 to 16	20 to 25	17.6	20 to 25
Thigh	14.3 x 27.2	8 or 10	40	32 to 40	13.2 to 20

Table 1. Description of vascular coil arrays.

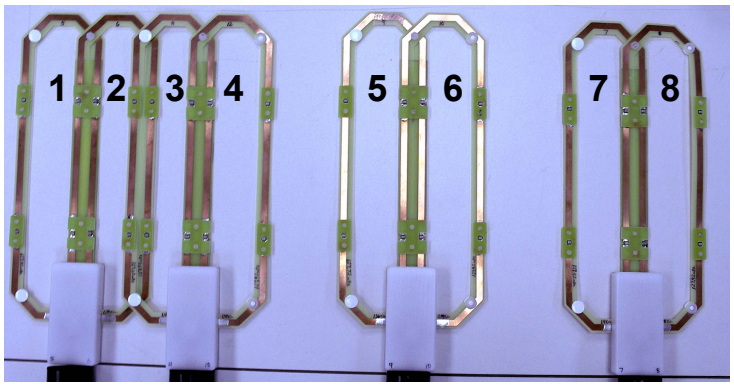

Figure 1. The first 8 channels of the modular hand array described in Table 1.

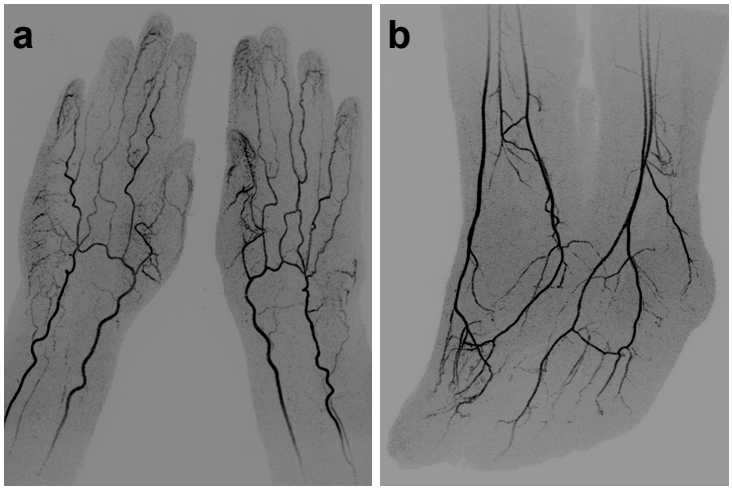

Figure 2. Still frames from time-resolved studies of the hands (a) and feet (b) acquired with 12x and 8x 2D SENSE and with 12 channel hand and foot arrays described in Table 1. In both examples the acquired resolution is finer than 1 mm isotropic.

Results: Eight elements of a 12-element hand array are shown in Fig. 1. Elements 5-6 and 7-8 comprise two individual pairs, while Elements 1-4 illustrate the attachment of two, two-element modules. Six such pairs were attached and used in a 12-element array. Fig. 2a shows a 3D CE-MRA of the hands made using R=12 2D SENSE using the array of Fig. 1. Fig. 2b shows images of the feet acquired using R=8 2D SENSE using a similar 12-element array. Comparable results have been obtained in CE-MRA studies of each of the other regions identified in Table 1.

Conclusion: The use of modular coil arrays allows highly accelerated (R=8) 2D SENSE to be exploited and provides high quality 3D contrast-enhanced MR angiograms in multiple vascular territories across a broad range of patient sizes.

References: [1] Haider CR, Radiology (2009) epub.