A 32-Element Cardiac Receiver-Coil Array for Highly Accelerated Parallel Imaging

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Introduction: Densely spaced many-channel MRI receiver-coil arrays offer the promise of significantly higher SNR and/or imaging speeds than smaller arrays. Any such array designed for cardiac MRI should facilitate parallel-imaging accelerations in any direction and should produce high SNR and low *g* factors in the left-anterior region of the chest cavity.

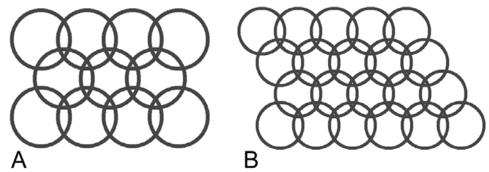

Figure 1. Coil arrangements for posterior (A) and anterior (B) portions of array.

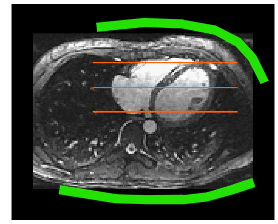

Figure 2. Coil position

Methods: A 32-element cardiac receiver coil array was constructed on two lightweight Lexan formers, with twenty-one 75 mm diameter circular rings mounted on the anterior former and eleven 107 mm rings on the posterior. The rings were placed in a hexagonal lattice and were overlapped so as to decouple nearest neighbors, as shown in Fig. 1. The two formers were curved to conform to an average chest and back, and rings were laid out to cover the left side of the torso (Fig. 2). Coils were omitted from the superior left side of the anterior array to make room for the upper arm (top right side of Fig. 1B), resulting in an asymmetric shape. The rings were cut from 0.5 mm thick copper sheet using a computerized water jet and were grouped into three layers separated by 1 mm thick Lexan sheets. Circular grooves cut in the Lexan sheets held the rings in place. The sheets for the anterior portion were bent around a 21 cm radius and were riveted together. Transmit blocking circuits and baluns were added to each coil. The posterior and anterior arrays are displayed in Fig. 3.

Figure 3. Posterior and anterior portions of 32-channel cardiac array.

A 52 x 41 x 30 cm^3 elliptical loading phantom (Fig. 4A) containing $CuSO_4$ was titrated with NaCl until it loaded the coils by the same amount as a typical human torso. Approximate SNR measurements were performed using a 3D SSFP pulse sequence. For each array element 10 identical data sets were acquired (slice thickness=4.0 mm, number of slice partitions=60, TE=1.9 ms, TR=3.8 ms, flip angle=70 degree, FOV=44x44 cm2). The center of the array was aligned with the S-I center position of the phantom. The signal was obtained from ROIs 1-4 as illustrated in Fig. 4B. The standard deviation of the signal in air was also derived from 2 large ROIs positioned posterior to the phantom. Breath-held ECG-gated 3D SSFP data sets were also acquired from the heart of a normal volunteer.

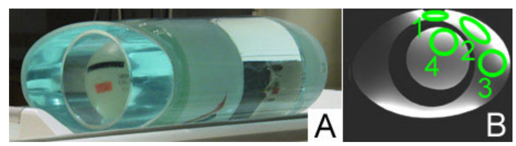

Figure 4. (A) Elliptical loading phantom. (B) ROIs for SNR measurements

Results: The average SNR for non-accelerated imaging was measured to be 1890, 1640, 535, and 356 for ROIs 1-4. These compare to 1280, 923, 209, and 311 respectively for the same ROIs acquired with a large 32-channel torso array [1]. Reformats of an 8-fold accelerated 3D axial cardiac data set (4-fold x 2-fold acceleration along the two phase encode directions) are shown in Fig. 5, through the short axis (A) and the origin of the right coronary artery (C), with corresponding measured *g*-factor maps in (B) and (D), respectively. The (minimum, mean, maximum) *g* factors were found to be (1.1, 1.7, 4.9) for (B) and (1.1, 1.7, 3.5) for (D). For coronal planes through the anterior, mid, and posterior heart (Fig. 2), *g* factors were (1.1, 1.9, 4.3), (1.1, 1.6, 3.2), and (1.1, 1.7, 4.0), respectively.

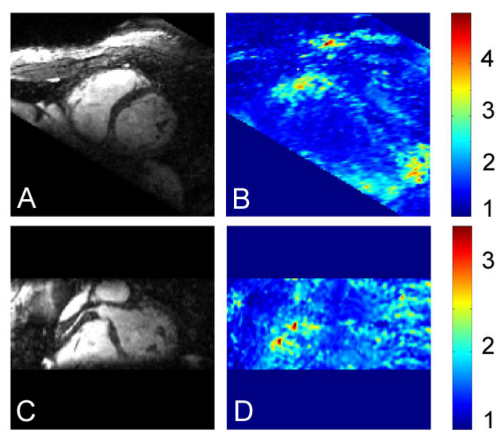

Figure 5. Reformatted images (A,C) and corresponding *g* maps (B,D) of x8 accelerated 3D cardiac data set acquired with array.

Discussion: More array elements were allocated to the anterior surface of the torso because of the anterior position of the heart in the chest cavity. The posterior array elements were made larger to allow roughly the same surface coverage and depth penetration with fewer elements. In principle, one might expect higher 2D accelerations to be possible near the front of the heart than the back, because it is closer to the anterior array, and because of the larger number of coils on that array. We found, however, that *g* factors were similar in the posterior, mid, and anterior regions of the heart. Overall, the performance of the array was found to meet the various demands of highly accelerated volumetric cardiac imaging.

References: **1.** Y Zhu, et al., Magn Reson Med 2004; 52:869-877.