A 128 Channel Receive-Only Cardiac Coil for 3T

M. Schmitt[1], A. Potthast[2], D. E. Sosnovik[3], G. C. Wiggins[1], C. Triantafyllou[1,4], and L. L. Wald[1]

[1]Department of Radiology, MGH, Charlestown, MA, United States, [2]Siemens Medical Solutions, Malvern, PA, United States, [3]Department of Cardiology, MGH, Charlestown, MA, United States, [4]Department of Brain and Cognitive Science, MIT, Cambridge, MA, United States

Introduction: The application of MRI for coronary angiography is hampered by either long scanning times or insufficient spatial resolution. The use of array coils with an increasing number of coil elements, together with parallel imaging methods, has the potential to significantly reduce this problem. Preliminary results have demonstrated the increasing benefit of imaging with a high number of coil elements for both sensitivity and possible acceleration factors in parallel imaging (1, 2, 3). In this work, we test the utility of expanding this approach to determine the added benefits of parallel imaging technology if the coil designer is essentially unconstrained by the number of RF channels. We have therefore developed a 128-channel, close-fitting receive array specifically for cardiac MR imaging at 3T.

Methods: The coil (Fig. 1.) consists of a fiberglass shell molded to the thorax (~85 kg male) with a “clam-shell” geometry. The posterior portion houses 68 circular coil elements, each with a mean diameter of 75mm, while the anterior portion houses 60 elements. The coils were arranged in a continuous overlapped array of hexagonal symmetry to minimize next neighbor coupling (3). The preamplifier (Siemens Medical Solutions, Erlangen Germany) of each coil element is positioned approximately 3 cm above the corresponding element to improve compactness. Each element has active PIN diode trap detuning during transmit. Preamplifier decoupling is achieved by transforming the preamplifier input impedance to a low impedance across the trap circuit by a 4.5cm semi-rigid coaxial cable. The output coaxial cables have a diameter of 1.2mm and groups of 16 to 18 cables enter the large copper box-traps, which operate like a bazooka-balun.

Initial testing was done on a Siemens Tim TRIO 3T whole body scanner extended to accommodate 128 independent receive channels. This allowed the signal of each individual coil element to be matched with a single RF receive channel. The coil was evaluated in phantom and *in vivo* measurements. An oil phantom was constructed with the matching torso shape to allow visualization of the coil profiles without the large B1 inhomogeneities present in large water phantoms. A sensitivity map of each element was evaluated from a 2D GRE protocol (TR/TE/α=50ms/3.77ms/20°, FoV=500 X 500 mm, matrix: 256 x 256, BW=260 Hz/Pixel, slice thickness=250mm) to provide a projection image across the AP dimension.

Cardiac MR images were acquired in the 3 healthy volunteers using a 2D, PD-weighted, ECG triggered GRE protocol (TR/TE/α =200 ms/4.03ms/20°, FoV=480 mm, 10 mm slice thickness, Matrix size: 256 x 256, BW=300 Hz/Pixel). Each image was acquired in a single 15-20 second breath hold. SNR and G-factor maps were evaluated on a pixel by pixel basis from these images. Noise correlation was calculated from an image with no RF excitation. SNR was evaluated in myocardial ROIs using both a Sum-of-Squares (SoS) reconstruction and with an optimum reconstruction method, which accounts for the noise correlation of the coil.(1, 3) All results were compared to that obtained with the Siemens Body Matrix and Spine Matrix coils using 24 elements under identical imaging conditions. 2D cine images (TR/TE/α=43.9 ms/2.4 ms/12°, BW=450 Hz/Pixel, Res=2.3mm x 1.9mm x 6mm) were acquired with R values up to 8 in order to evaluate the potential of the coil for highly accelerated parallel imaging

Results: The noise correlation measures showed coupling between the elements ranging from 0.02% to 86% with an average of 5.5%. The optimum SNR in different regions of the myocardium in the 4-chamber images showed a SNR gain from 2% to 89% (c.f. Fig. 2). The maximum G-factor within the region of the heart in the short axis images for an acceleration factor of R=5 in R-L-direction was 3.3 to 4.1 times lower for the 128 channel coil in all three volunteers showing a significant improvement in parallel imaging performance with this coil (Fig 3). This result was also confirmed by the initial experience with highly accelerated gradient echo cine imaging in one of the volunteers, which showed good image quality with R values up to 6 (Fig 4).

Conclusion: A prototype 128 channel cardiac coil has been successfully developed for cardiac imaging at 3T and shows significant potential for highly accelerated cardiac MR imaging. Our results are in accordance with the theoretical prediction (4, 5) that the SNR near the coil elements should increase significantly with the number of RF channels with modest gains in the center. This should facilitate improved resolution of the smaller more distal segments of the coronary arteries. The G-factor benefits of this coil are also very promising and raise the possibility of performing highly accelerated parallel imaging in a single breath hold while maintaining adequate SNR. Future work will thus concentrate on exploiting applications utilizing high acceleration factors R to either reduce the scanning time or increase image resolution.

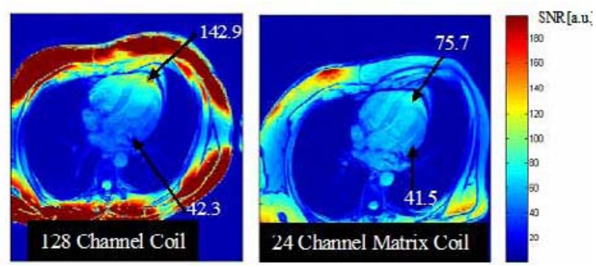
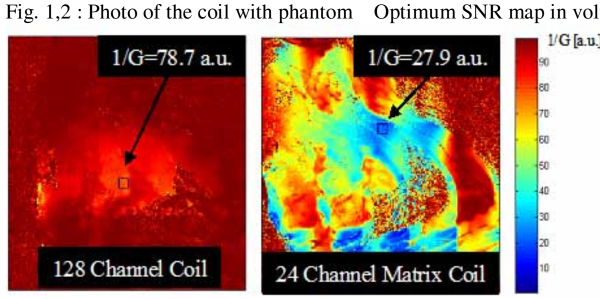


Fig. 1,2 : Photo of the coil with phantom   Optimum SNR map in volunteer #1: 4-chamber view



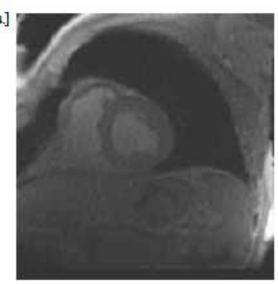


Fig. 3:1/G map for the short axis images in volunteer #2   Fig. 4: 2D Cine FLASH: Accel. = 6

References:

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