A 1.5T 32-Channel Cardiac Array Coil for Coronary and Whole Heart MRI

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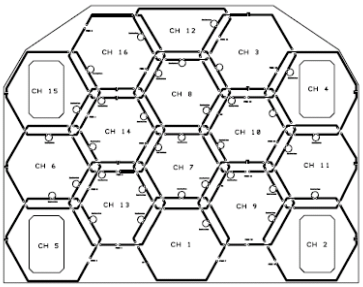
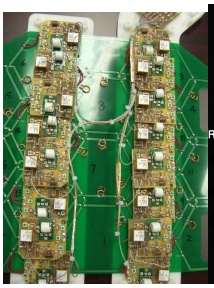
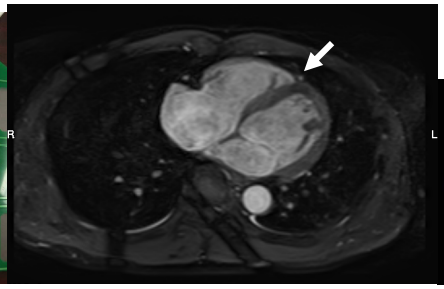
Introduction MRI provides unparalleled soft-tissue contrast, and the temporal resolution has been much improved because of the rapid advancement of high channel receiver count MRI system hardware and sophisticated parallel imaging techniques. These state-of-the-art parallel imaging technologies enable effective real-time MR cardiac applications. In this work, the authors constructed and tested a 1.5T 32-channel cardiac array, which is capable of higher acceleration factors to advance coronary and whole heart MRI.

Methods The detector array, designed for the Toshiba 1.5T Vantage Atlas 32-Channel MRI system (Tochigi, Japan), consists of anterior and posterior halves, each with 16 receive coils (Fig. 1). In particular, with parallel imaging in mind, the array is designed to provide acceleration factors in any directions, which is required for an oblique phase-encoding direction often selected in the cardiac imaging. The overall dimension of the array is 40cm in S-I and 45cm in L-R. For this 32-channel configuration, particular attention was paid to maintain an effective loop size of approximately 11cm by 11cm to achieve the required sensitivity depth (i.e., SNR) and to furthermore avoid the coil loss/resistance becoming dominant as opposed to a desired case of sample-noise dominant condition. While there have been reports on other cardiac coil designs [1], [2], [3], in our design, neighboring coils were appropriately overlapped to minimize the mutual inductance coupling to optimize the resultant SNR. The intrinsic isolation measured was at least -11dB or lower. The coil-to-coil coupling was further reduced by the use of our non-magnetic micro-size preamplifier (approximately $1cm^3$, gain=27dB, NF<0.5dB, input impedance<3Ω) integrated directly to each loop (Figs. 2 & 3). Each coil was tuned and matched at 63.86MHz. Furthermore, to minimize the unwanted coupling due to many cables required to realize this high channel count detector, multilayer PCB with transmission lines was used to minimize the cabling and reduce the overall weight of the array. This design approach also improves coil consistency from a unit to a unit, assuring the high quality manufacturing. To provide the patient comfort, the anterior half is made of soft and flexible foam materials while the electronics and components are protected by rigid plastic cases. The posterior half is housed in a rigid case covered with soft pads (Fig. 4).







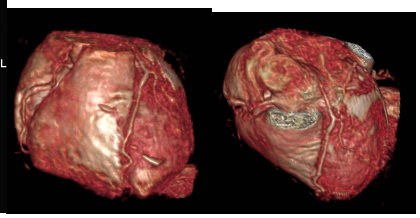


Fig. 1 16-coil element layout for the anterior half. Fig. 2 Anterior array circuit. Fig. 5 3D whole heart coronary imaging using ECG-gating (SSFP, TR/TE 4.3/2.2, R=4x1.5, Time=67s). Fig. 6 (a) and (b): 3D whole heart MRCA (SSFP, TR/TE 4.3/2.2, R=4x1.5, Time=67s). [From left to right in sequence]

Results Coronary and whole heart MRI applications were tested. Fig.5 shows 3D whole heart coronary imaging using ECG-gating. The image was obtained with a 2D acceleration factor of 4x1.5 in 67 seconds. Fig.6 (a) and (b) presents 3D whole heart MRCA with an acceleration factor of 4x1.5 obtained in 67 seconds.

Conclusions The 32-channel cardiac array was built and tested on the 1.5T Toshiba Vantage Atlas MRI system. This array enables advanced coronary MRI applications within much shorter acquisition times.

References [1] Lanz T, et al., "A 32-channel cardiac array optimized for parallel imaging," ISMRM Proceedings 2578 (2006). [2] Spencer D, et al., "Design of a 32-channel cardiac array for parallel imaging," ISMRM Proceedings 911 (2005). [3] Stehning C, Boernert P., "Advances in coronary MRI – from vessel wall to whole heart imaging," JJMRM 88, V. 26 (2006).

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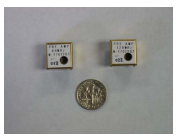

Fig. 3 Micro-size non-magnetic preamplifier.

Fig. 4 Mechanical package of the cardiac array.