An 8 Channel 23Na Heart Array for Application at 3 T

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Introduction

^{23}Na MR imaging has potential for assessing acute and chronic ischemic heart disease, due to increased sodium concentration after myocardial infarction. However, ^{23}Na imaging is challenging owing to the relatively low MR sensitivity of ^{23}Na. Increased field strength and phased-array reception schemes are our approach to this problem. It is essential for ^{23}Na imaging that the receive coil and receive chain are optimised for maximal SNR and to have high transmit field uniformity. Previous work on custom-made hardware has demonstrated increases in SNR and reproducibility from using phased array technology for X nuclear reception [1,2]. In this abstract we present for the first time an eight-channel ^{23}Na cardiac array for use on a standard clinical 3T scanner.

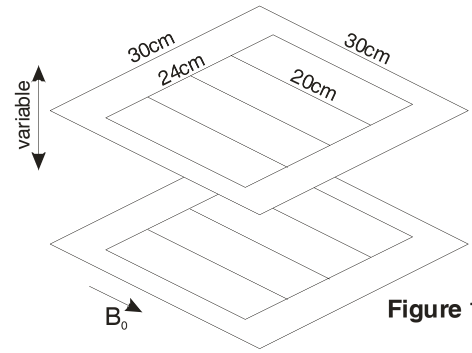
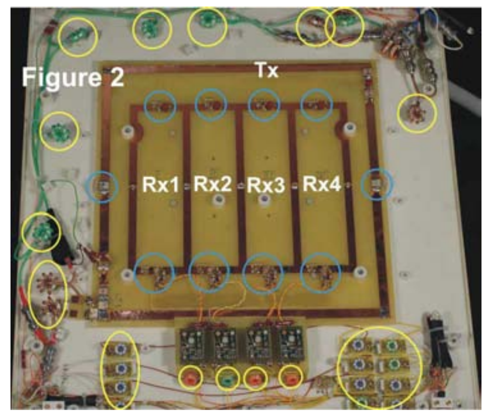


Figure 1

Methods

All experiments were performed on a Siemens TIM Trio equipped with multinuclear capabilities. The ^{23}Na coil array (Fig. 1) consists of two identical coil halves that each contain a transmit loop and 4 receive-only channels. The two halves have rigid housings and are used as an anterior and a posterior element. The square ^{23}Na transmit loops have a size of 30 x 30 cm^2 and are driven in a Helmholtz-like configuration. The tuning of the Tx elements was very robust against variations in their distance. The ^{23}Na receive-elements (6 x 20 cm) are located in the middle of the transmit loops. Rx elements are decoupled using a shared inductor design (Fig. 2). Each of them further contains a low noise preamplifier that provides preamplifier decoupling. All Rx elements are actively decoupled by a tuned ^{23}Na trap (blue circles, Fig. 2) whilst the Tx loops contain switched PIN diodes for detuning. Tuned and shielded cable traps (circled yellow) are used in order to avoid further coupling in the connecting cables. Furthermore, ^{1}H traps (circled blue) permit the use of the Tx/Rx ^{1}H body coil.



Non-triggered cardiac ^{1}H and ^{23}Na images on a volunteer were acquired with True FISP and gradient echo sequences.

Results

The Q factor of the Rx elements drops from 220 by a factor of 2.8 when loaded physiologically. The Q drop of the Tx elements is 5.5. The shared inductor method did allow decoupling of neighboring elements resulting in a decoupling better than -20 dB. The active decoupling of the Rx elements as well as of the Tx loops is better than -20 dB. The preamplifiers have a gain of 33.5 dB and a noise figure of 0.65 dB. Fig. 3 shows the short axes view of (a) a ^{1}H True FISP acquired with the ^{1}H body coil and (b) the corresponding ^{23}Na image.

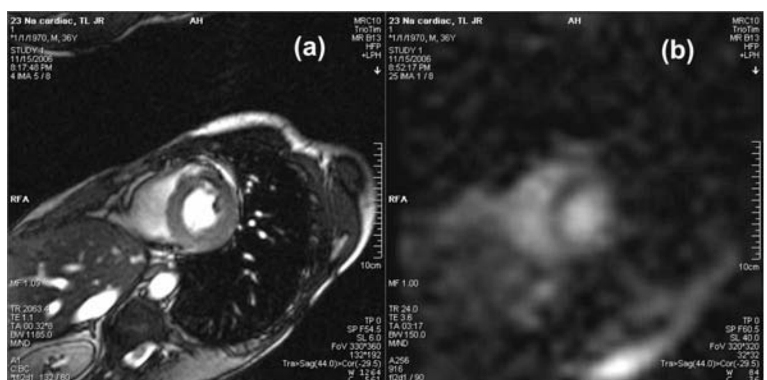


Figure 3: Short axes view of a volunteer, (a) ^{1}H True FISP acquired with body coil, (b) ^{23}Na gradient echo, 10x10x40mm^3, TR 24ms, TE 3.6ms, 32x32, t_{tot} 3:17min

Discussion

The Q drop of the elements proves sample noise dominance and, therefore, that it makes perfectly sense to use array technology for improving SNR in ^{23}Na imaging of the heart at 3 T. The techniques known from state-of-the-art ^{1}H arrays can be transformed to ^{23}Na arrays. Special care has to be taken on the wiring of the coil in order to attain good decoupling of the ^{23}Na Tx coil, the ^{23}Na Rx array and the ^{1}H body coil at both frequencies. High quality cardiac ^{23}Na images were acquired within 3 minutes on a clinical 3 T scanner. These first results are very promising to achieve ^{23}Na images in even shorter imaging times and higher resolutions.

References

[1] Ray Lee et al. MRM 43: 269-277 (2000), [2] Ray Lee et al. MRM 55:1132-1141 (2006)