

8 Channel Double Spiral Head Array Coil for Enhanced 3D Parallel MRI at 1.5T

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Introduction:

In the last two years receiver banks with up to 64 channels have been developed [1]. Up to now only standard planar arranged array coils have been used for these multi channel receivers. While these arrays have been provided impressive results [2], they are generally limited to surface applications. In order to use these receiver banks for massively parallel volume imaging, an appropriate array coil design is needed. Recent studies have suggested that a spiral like array configuration may be beneficial, since this set-up provides good spatial encoding in all directions[3], so that with a 3D parallel imaging technique such as CAIPRINHA [4], high reduction factors could be achieved. The goal of this work is to build a prototype 8 channel spiral phased array coil to investigate problems in construction and encoding performance in axial direction of this coil design.

Materials:

This prototype 8 channel spiral phased array receive coil was constructed as a volumetric head coil for a 1.5T Siemens Vision whole body system (Siemens, Erlangen). It consists of two cylindrical G10 formers with diameters of 26.5 cm and of 32 cm and a length of 22 cm (Figure 1). On the inner tube, a 4 element array with a twist of $+\pi$ was built using 10 mm wide copper tape. The adjacent elements were capacitively decoupled and each channel was driven through a low noise preamplifier to increase the isolation properties of each array element. Active decoupling circuits were included to detune the spiral array coil during transmission and high-impedance shield traps were used in the signal cables for patient safety. A similar 4 element spiral array was constructed on the outer G10 tube but with a twist of $-\pi$. This set-up should provide a good geometrical decoupling and therefore minimize the noise correlation between both 4 channel arrays after the tubes are placed into each other [5].

This prototype 8 channel spiral phased array head coil was tested regarding pulse power application and single channel isolation by phantom experiments in the 1.5T spectrometer. Afterwards an in vivo dataset of the human brain was acquired.



Figure 1: Prototype 8 channel $\pm\pi$ spiral headcoil array

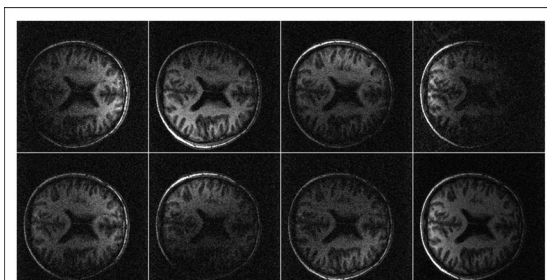


Figure 2: Uncombined in vivo images of all 8 single elements of the 8 channel $\pm\pi$ spiral headcoil

Results:

After constructing the 4 element spiral array coils on the two G10 tubes with a $+\pi$ and a $-\pi$ twist respectively the properties of each spiral array were separately determined on the workbench. For the array coil on the smaller former, the Q-factors were 330/90 indicating a reasonable performance of the array. In terms of isolation, adjacent coils could be decoupled without preamplifiers by -20 dBs, while opposite coils were isolated -17 dBs. Adding the -20 dBs isolation provided by the low-noise preamplifiers the 4 channels of the $+\pi$ spiral array coil are well decoupled. The properties of the 4 channel $-\pi$ spiral array on the larger cylinder showed almost identical values. Putting the two spiral arrays into each other, the intrinsic isolation due to geometrical decoupling averaged -18 dBs, again without the preamplifiers.

In vivo experiments confirmed the good isolation of all 8 channels of the $\pm\pi$ spiral array head coil prototype (Figure 2). Furthermore in an in vivo 3D parallel imaging dataset, no reduction in image quality due to the reduced phase encoding in axial direction was noticeable and so that a 3D reduction factor of R=4 could be achieved without any issues (Figure 3).

Conclusions:

Two 4 element spiral array coils were constructed separately with a opposite twist. All array elements possess a reasonable mean Q and good isolation properties. However, the primary advantage of this spiral array coil design is that due to the $\pm\pi$ twisted arrangement of the array elements an intrinsic geometrical decoupling of both cylinders down to -18 dBs can be achieved. Constructing two essentially identical 4 channel spiral surface arrays with a twist of $\pm\pi$, inserting them into each other to obtain an 8 channel spiral surface array is in our opinion easier than building an 8 channel i.e. birdcage-like surface coil array on one surface.

The good channel isolation of this prototype 8 channel $\pm\pi$ spiral head coil array was confirmed by in vivo measurements. It could also be shown that a spiral like array coil design indeed provides high encoding performance not only in transverse but also in axial direction, as shown by a 3D parallel imaging dataset. As a result of these properties, a $\pm\pi$ spiral surface coil array design is a promising set-up for volumetric massively parallel imaging applications.

Acknowledgments:

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References:

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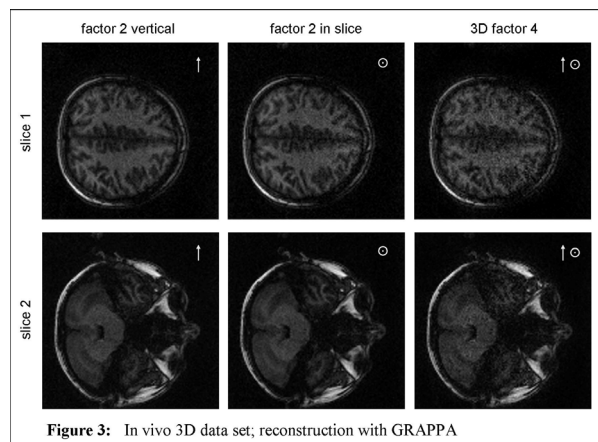


Figure 3: In vivo 3D data set, reconstruction with GRAPPA