The novel 12 channel octahedral transmit/receive array for parallel imaging of human head at 3 T.

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Motivation: Recent years witnessed a tremendous boost in parallel imaging techniques, which proved to be especially effective when applied to high-field MRI. In combination with state of the art detection algorithms like GRAPPA and SENSE parallel techniques drastically shorten scan times and reduce image artefacts in fMRI [1]. Further benefits in the fields of arterial and heart imaging as well as B_1 homogenisation at high fields could be achieved in the transmit-SENSE experiment [2] utilizing multiple independently controlled transmission antennas. These promising techniques require the development of new multi-channel coil arrays, applicable as RF transmitter as well as receiver.

Most of the widely used multi-channel head-coil arrays are based on structures of axial symmetry, in which the array elements are arranged on the surface of a cylinder [3,4]. Due to this architecture accelerated imaging can be only achieved in the transverse plain, since the sensitivity profile of the single elements along the cylindrical axis are not modulated. This fact constrains the flexibility of the imaging experiment, where often the slice direction has to be adjusted according to patient anatomy or other experimental requirements. In order to fully exploit the possibilities of state-of-the art parallel imaging, we present a novel 12-element octahedral coil array.

Methods and materials: The array consists of 12 Current Sheet Antennas (CSA) [5] symmetrically arranged on the edges of a right octahedron (see Fig.1). The subject inside the coil has an open view field facilitating functional MRI studies. Every array element has a quality factor of about 100 when loaded with a human head. The CSA elements are independently connected to the RF transmitters and the preamplifiers via TR switches and decoupled from each other with the help of capacitors implemented on the corners of the octahedron. Imaging experiments were performed on a MedSpec 30/100 scanner (Bruker, Ettlingen, Germany) operating at 3 T.

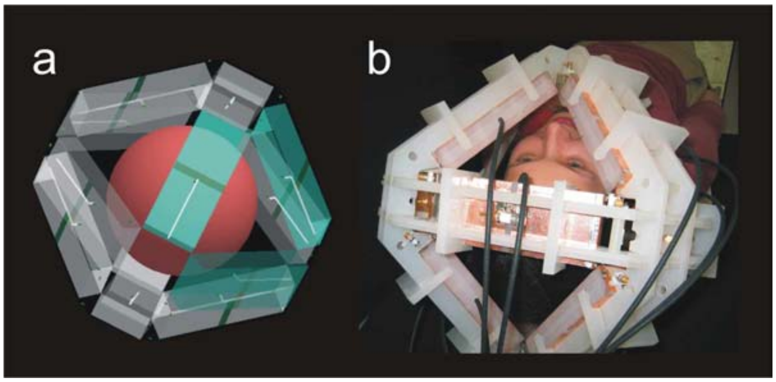

Fig. 1: Schematic (a) and photograph (b) of the 12-channel octahedral coil (resonance frequency 125.3 MHz).

Results: Homogeneous excitation (ΔB_1=10%) of the entire human head could be realised by driving the 12 elements with adjusted phases and amplitudes. Loaded with a human-head sized phantom and driven in homogenous mode, a sensitivity of 60 $\mu T/kW^{1/2}$ could be achieved. Decoupling of 17 dB between the elements allows for fast tuning of the octahedral array.

High-quality parallel SENSE measurements with coronal, sagittal, and axial slice orientation were successfully performed with acceleration factors ranging from 2 to 8 (see Fig.2). Low noise amplification factors (g-factors less then 2) were obtained for acceleration factors between 2 and 4 for every acceleration direction (see Fig.3). In the transmit-SENSE experiment performed with four independently controlled RF channels (each operating three array elements) we have demonstrated the possibility of selective excitation with an acceleration factor of 4.

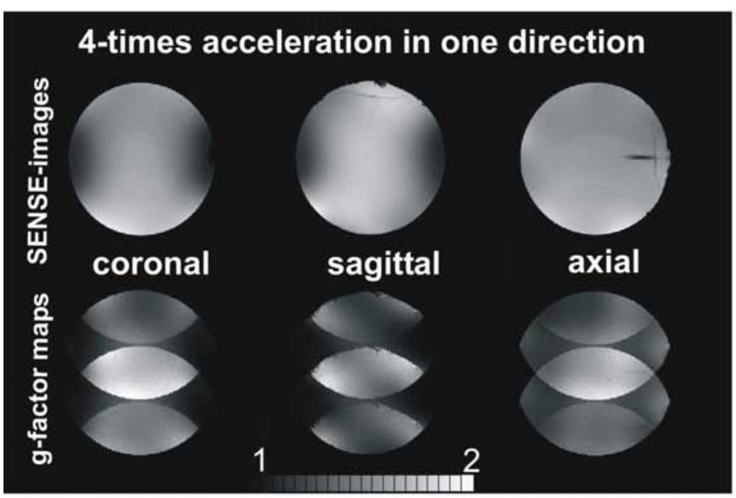

Fig. 2: Results of parallel imaging with the help octahedral array. Top: SENSE images of a human-head size agarose gel phantom in three slice directions; bottom: geometry factor maps for acceleration in three orthogonal spatial directions

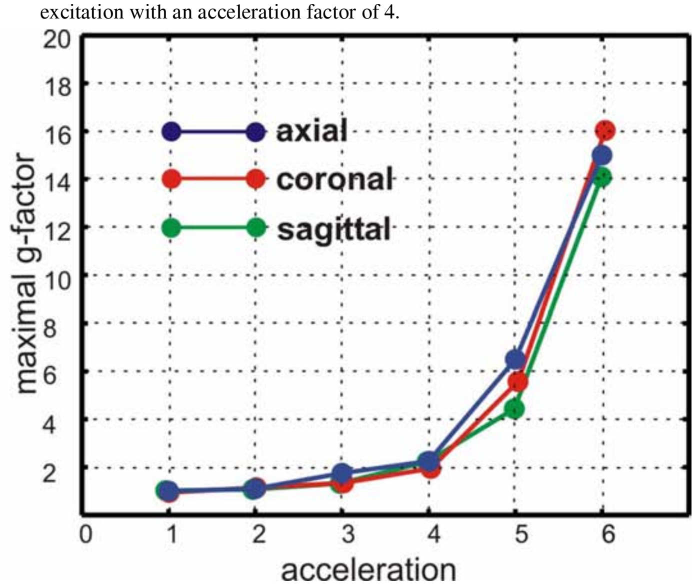

Fig. 3: Dependence of the maximal geometry factor on acceleration in parallel imaging experiments. The octahedral array shows equally high performance for all three acceleration directions.

Conclusion: A novel octahedral coil array was developed for parallel imaging and transmit-SENSE experiments of the human head with 12 independently controlled channels. Due to its high symmetry, the coil array provides equally high performance for accelerated parallel imaging in all three spatial direction. This gives the user flexibility in choosing the optimal slice direction for a particular experiment. Furthermore, selective excitation of anatomical structures in the transmit-SENSE experiment are feasible. The coil array can be operated on MRI scanners with less than 12 independent channels by combining array elements in groups of two, three or four elements.

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