20-to-8 Channel Tx Array with 32-channel Adjustable Receive-Only Insert for 7T Head Imaging

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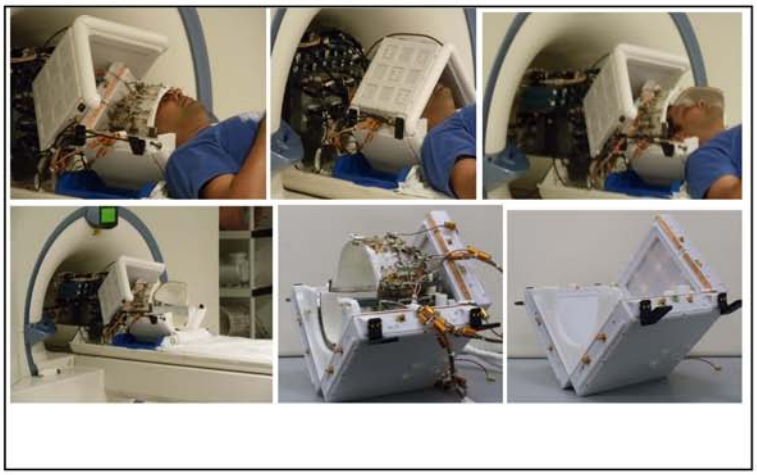

Introduction: The use of multi-channel arrays at 7T is currently common for alleviating RF inhomogeneities and addressing RF safety concerns. In this work, we integrate 32-channel Rx-only insert with 20-to-8 channel Tx array in order to achieve safe and robust 3D homogenous excitation across different subjects.

Methods: **Design of the 20-to-8 Tx array:** The modular 20-to-8 channel head Tx array was constructed from a selection of five, highly-coupled coil panels designed and manufactured using a 3D printer to an open box. Fig. 1 shows the integration of the Tx head array and Rx-only insert array. Each panel has 4 independent TX channels. The baseline configuration was taken as a coil composed entirely of 2x2 transmission line element panels. All coupling measurements for a human head load were consistent and were in excellent agreement of the FDTD simulations; the coupling between channels on a side is virtually unchanged with different subjects and different sides. While the array can operate in 20-channels it was combined based on numerical simulations to operate in 8-channels (where the 16 of the channels were combined into 4 groups of 4-channels that produce quadrature like excitation.) **Design of the 32 channel receive coil insert:** Modular receive arrays have been successfully designed and tested [1]. The 32 channel receive coil insert (Fig. 1) consists of four separate segments allowing for adjustment to each subjects head size. The top two segments each have seven coil elements and extend from the top of the head to just above the eyes. The bottom two segments each have nine coil elements and extend from the top of the head to just past the base of the skull. Each of the 32 coil elements has one active and two passive decoupling circuits. There are also two common mode suppression circuits associated with each element one at the feeding point and one after the elements cable exits the transmit coil. The elements on each of the segments are decoupled from their nearest neighbors (S12= -12db) and diagonal neighbor (S12= -15db) by critical coupling overlap. The decoupling of all other combinations of elements on each segment and between segments is handled with preamplifier decoupling. The physical size of 28 of the element is 10cm x 10cm with the remaining four elements at the crown of the head being slightly larger to offset the increased signal caused by their convergence. **Electromagnetic Simulations:** Highly intensive FDTD modeling was performed to analyze the performance of Tx array with and without the receive insert. Locally developed package was developed to optimize the phase and amplitude of 8 channels (originated from 20 channels.) **Pulse Sequence:** SWI images (TR = 1030ms, TE = 15ms, FOV = 230mm, bandwidth per pixel = 30Hz, Slice thickness=3mm and in-plane resolution 200 μm.) were acquired 7T human MRI scanner equipped with 8-channel Tx array capability.

Fig. 2: The 20-to-8 channel Tx array combined with 32-channel adjustable (for different head sizes) helmet insert.

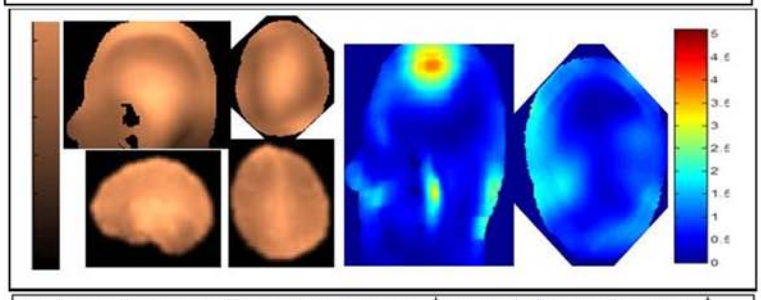

Fig.2: Left Top: FDTD simulations of B_1^+ field. Bottom: In-vivo B_1^+ field map. Right: Corresponding SAR.

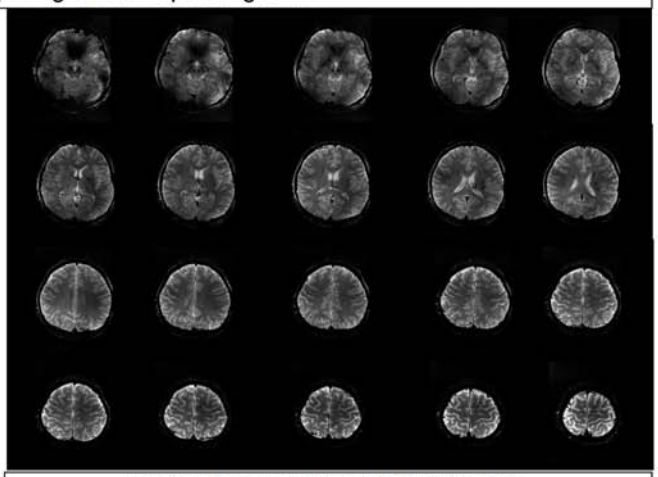

Fig.3. High resolution 7T SWI images

Results: While constraining global average SAR to be under 3.2 watts per Kg, and 10 watts per Kg per 10-gm for local SAR, the B_1 shimming tool was consistently capable of producing transmit field homogeneity on the order of 2 to 2.5 (maximum over minimum) over the top 16-cm of the entire human head. The most efficient case achieved a 90 flip angle using 1ms square pulse and 2.25 watts per kg average SAR. Fig. 2 displays sample of the transmit field measured using field mapping and calculated using FDTD, and SAR calculated using FDTD. The results show a scenario that was obtained with the 8-channel B_1 shimming optimization. SWI images acquired with the integrated 32-channel Rx-only insert with 20-to-8 channel Tx array are shown in Fig. 3

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References: De Zanche, N., et. al. NMR Biomed, p.644-654, 2008.