Improved longitudinal coverage for human brain at 7T: A 16 Element Transceiver Array

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Introduction: At 7T, interactions between the human brain and RF result in substantial inhomogeneity and poor efficiency when single drive large volume coils are used for transmission. Although short (9cm length) transceiver arrays can dramatically improve both axial homogeneity (<10% SD in B_1^+) and efficiency (17 uT/kW) using RF shimming methods, homogeneity and coverage in the longitudinal direction is limited. Increasing the overall length of the transceiver array to 15cm provides only modest improvements in longitudinal coverage at the cost of significant decreases in sensitivity and transmit efficiency. To overcome this limitation we have developed an inductively decoupled 16-coil transceiver array, with the individual surface coils arranged in two rows along the z-axis of 8 coils each (2x8 array). The array provides dramatically improved longitudinal coverage and SNR while retaining high efficiency.

Methods: All data were acquired using a 7T MR system with 8 independent transmit channels. To demonstrate the improved coverage achievable from two rows of coils as opposed to a single coil of the same overall length, data was acquired with two test coils, a 2x2 array, using four coils of 7cm x 7cm with a 1cm gap and a 1x2 array using two 15cm (z-axis) x 7cm coils (schematic Fig. 1a,b). The 2x8 split elliptical transceiver array (Fig.1c) consisted of two rows of 8 coils each (7cm - length). The array (Fig.1c) measured 19.5 cm in width and 22 cm in height with the total length of 15cm. To better conform to the contours of the head, the top row was tilted by 19°. All the adjacent coils were inductively decoupled to -14 dB or better when loaded. The 2x8 array was compared to a previously reported inductively decoupled 1x8 transceiver array of 9cm (z-axis) x 7.5cm coils (Fig 1d).

Fig 1

Results: Displayed in Fig. 2 are sagittal B_1^+ maps from the occiput acquired using the two test coils from a volunteer. The 2x2 array (Fig 2a) improves coverage of the brain and provides deeper excitation at equivalent power in comparison to the 1x2 coil (Fig 2b). Displayed in Fig 3 are sagittal B_1^+ maps acquired using the 1x8 array (Fig 3a), and the 2x8 array using only the top row (Fig 3b), bottom row (Fig 3c.) or 4 coils simultaneously from each row (Fig 3d). When both rows are driven simultaneously, both homogeneity and coverage of the brain are dramatically improved.

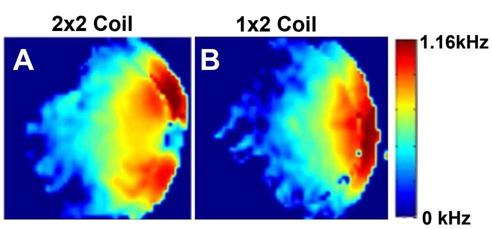

Fig 2

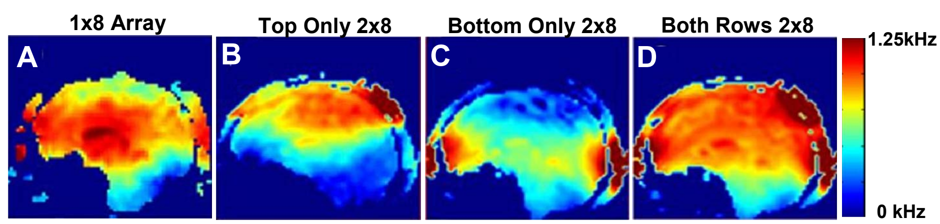

Fig 3

To compare transmit efficiency and SNR, we acquired images with the same pulse angle from each row of the 2x8 array and compared that to the 1x8 array. To provide a fair comparison, the position of the 1x8 array was shifted so as to be centered over the same brain locations as the individual rows of the 2x8 array. The SNR of the upper row of the 2x8 array was 15% greater than 1x8 array, while the lower row had equal (<1% difference) SNR as the 1x8 array. The upper and lower rows of the 2x8 coil achieved 1 kHz of B_1, at 1.27 and 2.20 kW respectively, similar to the 1.19 and 2.07kW required by the 1x8 coil. In axial slices, the standard deviation of the B_1^+ for the upper and lower rows was 4.1 and 13.0% for the 2x8 coil and 6.4 and 11.7% for the 1x8 coil from the same brain locations.

Conclusions: The test coils demonstrate that simple increases in the length of an individual coil in a transceiver array are less effective than using multiple rows of smaller coils. In the 2x8 array longitudinal coverage, homogeneity and SNR in the human brain are improved by the use of a multiple rows of transceiver arrays. Further, although the 2x8 coil can provide homogeneous excitation of the majority of the brain, overall power deposition for slice selective imaging can be reduced by only applying power to rows or coils which overlap the targeted slice. Addition of a third row over the cerebellum (3x8 array) should provide homogeneous coverage of the entire brain.