Reduce power deposition using microstrip array with tilted elements at 7T

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Introduction: High and ultrahigh field MRI can greatly improve the signal to noise ratio (SNR). However, the power deposition is also increased with the static magnetic field [1]. On the other hand, Microstrip coils [2, 3] features low loss and high-frequency capability and has shown its advantage in ultrahigh field MRI. In this work, we show that microstrip transceiver volume array with tilted elements can decrease the power deposition at 7T. A microstrip array with rotatable elements is built and modeled using XFDTD (Remcom Inc.) and the E and B_1 fields are simulated for both 0^o rotation (regular array) and 25^o rotation (tilted array). To make fair comparison, the concept of E/B (ratio between the field strength of E and B) is also introduced to predict the power deposition of different coil structures.

Material and method: A receive array with tilted loop element was introduced for decoupling and g-map optimization [4]. In this work, a microstrip transceiver volume array with 8 tilted microstrip elements was built and the prototype is shown in Fig.1. Each element was a capacitive terminated microstrip resonator with half inch width and 16 cm length. Termination capacitors were DLC2R7 (Dalian Cap Co) with nominal capacitance of 2.7pF and a variable capacitor (NMAP25HV, Voltronics Co.) ranging from 1pF to 25pF. The strip conductor was built on the surface of a Teflon substrate with half inch thick and permittivity of 2.1. On the bottom of the substrate a piece of copper acted as ground. Total 8 elements were built on a supporting frame with 21 cm ID and 28 cm OD. Thus each element can be tilted to any angle for comparison. In the FDTD simulation, the cases of 0^o and 25^o rotation were simulated, which corresponded to regular microstrip array and tilted array. A standard human head was modeled in the center of the array.

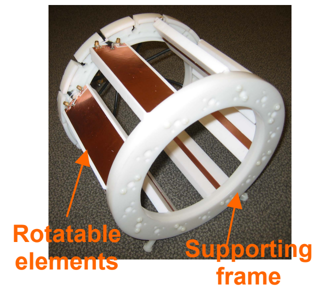

Fig. 1 Prototype of microstrip array with tilted element.

To analyze the power deposition of the two cases, the circularly polarized component B_1+ of magnetic field and electric field E within the head model were simulated using FDTD method, and the configurations of the regular and tilted arrays are shown in Fig.2. Here the concept of the ratio between E and B_1+ (E/B) was introduced to predict the possible power deposition. The E/B ratio means that when unit magnetic field is generated, how much electric field will be generated simultaneously. The power deposition is proportional to E^2, therefore can be estimated using E/B ratio. This is fair for comparison between different typed coils, because some coils can generate both high E and B field strength. If the power deposition is calculated with only the E field, the results will be unfair.

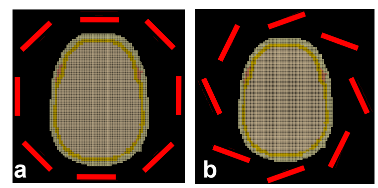

Fig. 2 FDTD model for the array with (a) 0^o rotation and (b) 25^o rotation.

Results: Bench test shows that the decoupling between tilted elements can be increased to -20dB. Fig.3 shows the E field, B_1+ field and their ratio E/B of three axial slices within human brain region for both regular array and tilted array. It is noticed that, although the E field is strengthened using the tilted array, its B_1+ field is also increased by 17% to 25%, especially at the center region of the human brain. This leads to the decrease in the E/B ratio from 9% to 20%, which is shown in the third row of Fig.3. These results demonstrate that by using the tilted element in microstrip array the power deposition is expected to be reduced due to the decreased E/B ratio. On the other hand, coil efficiency can also be increased.

Conclusion and discussion: In this work, the concept of E/B ratio has been introduced to predict the power deposition of different typed coil, and a microstrip volume array with tilted elements has been proposed to increase the coil efficiency and decrease the E/B ratio. Compared with regular microstrip array, the reduction in E/B ratio will lead to decrease of power deposition, which is very useful for ultrahigh field MRI. The decoupling between array elements can also be increased using tilted array, which will improve the parallel transmission and acquisition performance.

References: [1] Collins CM, et al, Magn Reson Med 2001; 45: 684-691. [2] Zhang X, et al, Magn Reson Med 2001; 46: 443-450. [3] Wu B, et al, J Magn Reson 2006; 182: 126-132. [4] Hardy CJ, et al, ISMRM 2005: p667.

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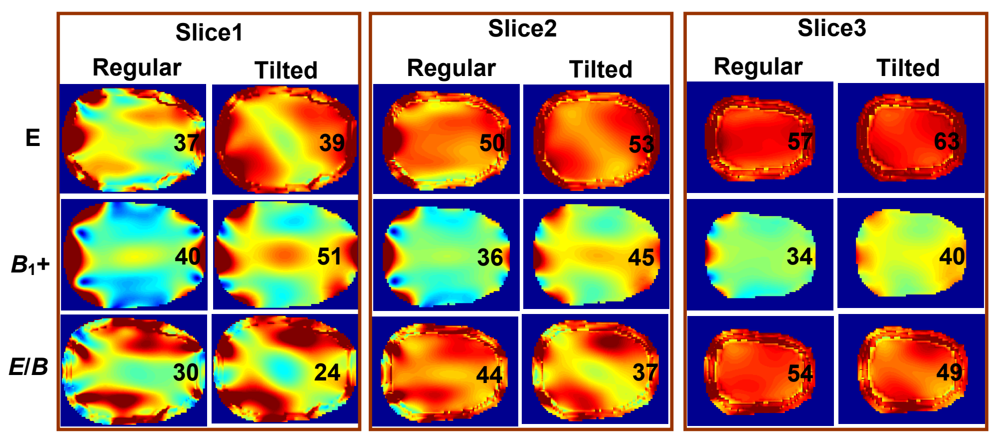

Fig. 3 Electric field E (first row), magnetic field B_1+ (second row), and E/B ratio (third row) images of three axial slices within human brain region. For each slice, the left column is regular array while the right column is the tilted array. The numbers on the images denote the relative amplitudes in the central of the brain. Using the tilted array, the B_1+ increase by 17% to 25%, while the E/B decrease by 9% to 20%.