Shielded Microstrip Head Array at 7T

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INTRODUCTION Microstrip transceiver arrays have been demonstrated to provide higher efficiency on signal excitation/reception and low mutual coupling and have become a popular RF solution to parallel MR imaging at ultrahigh fields in humans [1,2]. In most designs, the ground planes of microstrips are separated (Fig 1) to minimize their mutual coupling [1-5]. Practically, due to space limitations, the size of ground planes of the microstrip elements is usually not large enough to become a "true" ground, in which the condition of microstrip (an unbalanced transmission line) is not rigorously satisfied. Consequently, the transceiver array may suffer from cable resonance, lower Q factors and imaging quality degradations. This problem is more prominent in transceiver arrays with a large number of resonant elements. Symmetrical feeding [4] by inserting the tuning/matching circuit at the center of each microstrip can alleviate the cable-resonance problem, improving the coil's stability despite some difficulties in performing on-site tuning/matching. In this work we present an approach to improving the performance of microstrip transceiver arrays by introducing RF shieldings outside the microstrip array and the feeding coaxial cables. With this improvement, reduced interaction among cables, better resonance stability, better Q-factors and thus improved imaging quality are achieved.

METHODS The 16-ch transceiver head array is composed of alternatively placed 1st and 2nd harmonic microstrip elements such that the nearest neighbors can be intrinsically isolated [5]. For better adjustment, all tuning/matching circuits are arranged at one side of the strips. To compensate for the insufficient size of ground plane of each microstrip element in the head transceiver array, a cylindrical slotted RF shielding with a diameter of 26.7cm is added to the coil array. The cylindrical shielding has no physical connection with the coil array elements (Fig 1, right insert). The distance between the RF shielding and the ground plane of the coil elements is ~1.3cm. This RF shield is cut into eight pieces, within each piece there are one 1st and one 2nd harmonic elements. To minimize the RF interference between the resonant elements and feeding cables, the coaxial cable of each resonant element is shielded by a 10cm long copper tape which is directly connected to the coil shielding as illustrated in Fig 2. This coil array is then tested on bench and on a GE whole body 7T scanner. Human head gradient echo images are acquired from a healthy volunteer.

RESULTS The coil arrays are tuned and matched with presence of the human head. Q-factors (1st harmonic elements) of the shielded and non-shielded microstrip volume arrays measure 120 and 67, respectively, yielding a doubled Q-factor gain and a much reduced losses for the proposed design. The S11 plots from a network analyzer are shown in Fig 3. RF interference between resonant elements and feeding cables, and also among feeding cables are significantly reduced, resulting in a much improved stability of coil resonance. Compared with the unshielded 7T microstrip volume array custom-made in our lab, the proposed coil array dramatically diminishes frequency shift before and after moving into the magnet. It reduces the on-site tuning/matching effort. Isolations between strips are slightly degenerated after shielding, but still retain a S21 of -15dB or better when loaded with human head. Fig. 4 demonstrates the 7T human head GRE images acquired from each resonant element, the combined head image, and images reconstructed using GRAPPA with reduction factors of 2, 3, 4, 5, 6, 7, 8 and 9. Imaging parameters used are TE/TR 6.9ms/100ms, FOV 24cm*24cm, slice thickness 3mm, Matrix 256*256, NEX = 4.

CONCLUSIONS An improved microstrip transceiver volume array for human head imaging at ultrahigh field is designed and tested. The treatment of RF shielding on coil elements and feeding cables significantly improves the resonance stability and quality factors, and thus leading to an improved image quality and parallel imaging performance at 7T. The method proposed in this work is also suitable for designing other 7T coil arrays, such as knee arrays and spine arrays.

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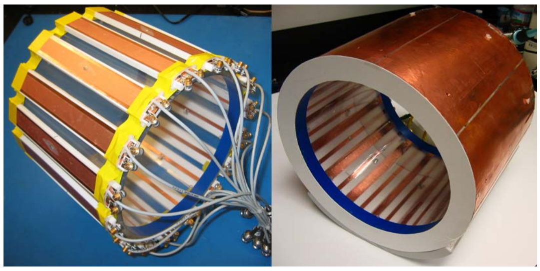

Fig 1. Photos of microstrip head array without shield (left) and with a shield (right)

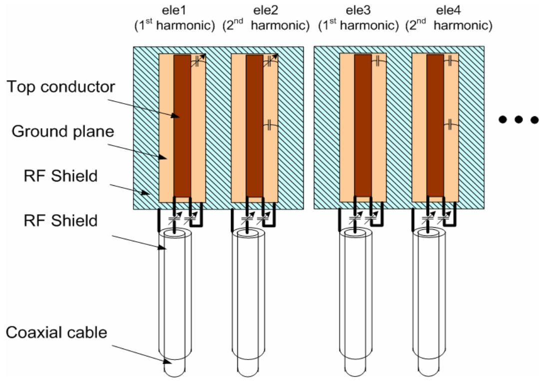

Fig 2. Scheme of the coil elements, RF shield and their connections.

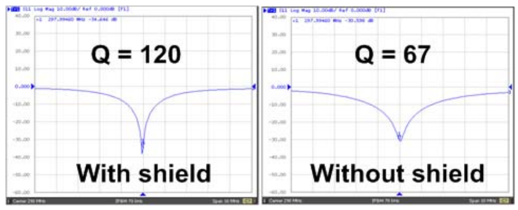

Fig 3. S11 parameter of the 1st harmonic element before and after shielding

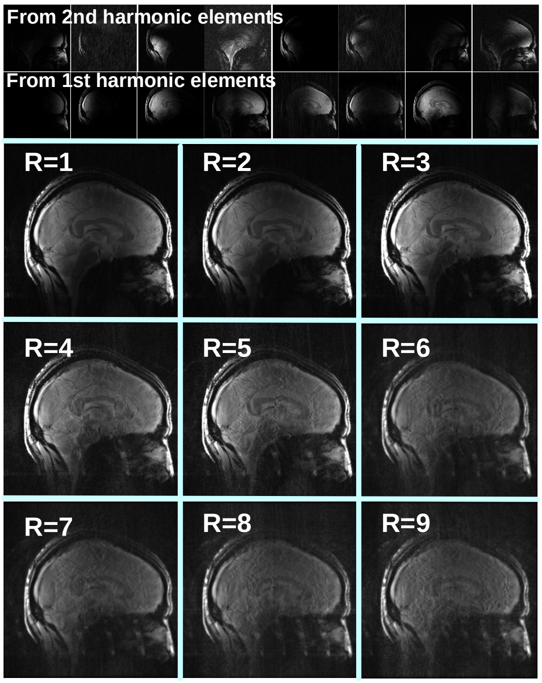

Fig 4. Sub-images from each coil element, their combination, and images reconstructed using GRAPPA with different reduction factors.