A 16-channel double-row microstrip array for human head parallel imaging at ultrahigh fields

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INTRODUCTION Transceiver arrays using microstrip technology have been advocated for ultrahigh field MRI due to the improved resonance stability, reduced radiation losses and simple structure [1-4]. However, the image coverage is limited because of the length constrains of regular microstrip resonators at ultrahigh fields and the reduced B_1 field near the ends of the resonators [2, 4]. This problem could be addressed by using the multiple-row designs which could provide enough longitudinal coverage by using regular or even shorter elements. With independent transmit elements from different rows, the multiple-row microstrip transceiver array offers the feasibility of RF shimming and parallel transmission along z-direction. The multiple-row design could also improve the parallel imaging performance due to the enlarged number of independent receive elements.

MATERIALS AND METHODS The 16-channel double-row human head array herein consists of eight 2-channel blocks. Each 2-ch block consists of two microstrip elements (9×4.5×1.5 cm^3) and a decoupling element (21×1×1.5 cm^3) [5]. The ground was made from adhesive-backed copper foil with a width of 4.5 cm and the strip conductors were made from 10 mm-wide copper tapes. A resonator with two capacitors terminated at both ends and one variable capacitor terminated at the center was applied as the decoupling element. The distance between the two elements was 1 cm and the total length of the double-row array is 19 cm. All coil elements were mounted on an acrylic former with an outer diameter of 25 cm. Fig. 1A shows the constructed coil array and Fig. 1B presents the element numbering. All coil elements were matched to 50 Ω and tuned to the Larmor frequency at 7T (297.2 MHz). Shielded cable traps were employed to avoid possible "cable resonance". For comparison, we also built a regular single-row 8-channel microstrip array which has the same parameters as the double-row array (19×4.5×1.5 cm^3).

S-parameter matrix of the 16-ch array loaded with a human head was measured with an Agilent 5071C network analyzer. GRE images on a healthy human head using the 16-ch double-row array and the regular 8-ch single-row array were obtained. The parameters of the GRE sequence are: FA=25 degree, TR/TE=100/10 ms, FOV=210×210 mm^2, matrix= 256×256, thickness=5 mm, NEX=1. Accelerated GRE images and g-factor results with reduced factor (R) of 2, 3 and 4 were also acquired to show the parallel imaging capability of the 16-ch double-row array. The accelerated images were reconstructed with GRAPPA method. MRI experiments were performed on a 7T whole-body scanner (Siemens, Erlangen, Germany).

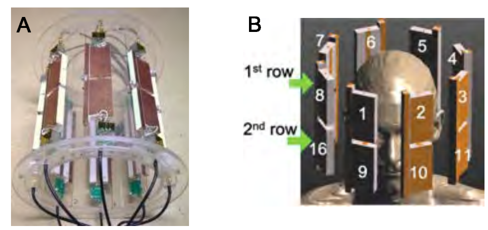

Figure 1 (A) Photograph of the 16-channel double-row transceiver microstrip array. (B) Coil elements numbering and layout vs. the human head model.

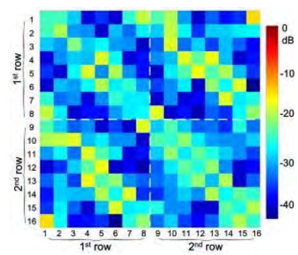

Figure 2 S-parameter matrix of the 16-ch double-row microstrip transceiver array loaded with a healthy human head. The coil numbering was corresponded to that from Fig. 1B.

RESULTS Fig. 2 demonstrates the S-parameter matrix of the 16-ch double-row microstrip transceiver array loaded with a healthy human head. Each element was well matched to 50 Ω, with S_{11} better than -24 dB. The isolation among any two elements was better than -18 dB, indicating excellent decoupling performance. Fig. 3 shows the sagittal GRE images obtained using the 16-ch double-row array and the regular 8-ch single-row array. The two arrays have the same length and the sequence parameters for MR imaging are exactly the same. The double-row array, compared with the regular array, promises a larger imaging coverage and expands the imaging area to the lower portion of the human brain, as shown in the red boxes of Fig. 3.

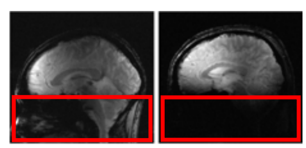

Figure 3 Sagittal GRE images obtained using 16-ch dual-row array (left) and 8-ch single-row array (right).

Fig. 4 shows sagittal images using the 16-ch array with R=1 (no acceleration), 2, 3 and 4. The image quality has no obviously degradation even when the reduced factor achieves 4. To further investigate the improvement of parallel imaging performance of the double-row design, g-factor maps in the sagittal plane using the 16-ch array were measured, calculated (Musaik, Speag, Switzerland) and compared with those from a regular 8-ch array. Average g-factors with R varying from 2 to 5 were marked in white color in Fig. 5. Based on these results, the proposed dual-row design, compared with regular single-row array, could significantly improve the g-factors and thus parallel imaging performance in the AP direction, even that both arrays have the same number of coil elements in this direction. Considering that there are two elements arranged in z-direction, the double-row design should also be capable of performing acceleration longitudinally, which is not possible for a single-row design.

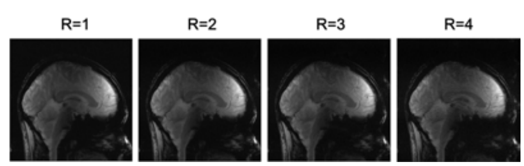

Figure 4 Reconstructed images of the 16-ch double-row array using GRAPPA with R from 1 to 4, ACS lines =18.

DISCUSSIONS AND CONCLUSION The feasibility of the double-row microstrip array has been validated through bench tests and *in vivo* MR imaging experiments. Compared to the signal-row microstrip array, the double-row array provides enhanced imaging coverage along z-direction, being able to image the whole brain including the cerebrum, cerebellum, and brainstem. The double-row array has also shown better parallel imaging performance over the regular single-row array. By using the proposed double-row technique, the average g-factor of sagittal human head images is improved from 1.41 to 1.06 at the acceleration rate of 4. In addition, the multi-channel multiple-row design provides the capability of performing RF shimming and parallel transmission along z-direction besides the x- and y- directions. This is advantageous in providing more homogenous transmit field in the human head. By changing the terminated capacitance of coil elements from different rows, distribution of transmit fields and receive sensitivity fields could be changed [5]. Although in this work the microstrip array with only two rows was tested, the number of rows could extend to three or even more.

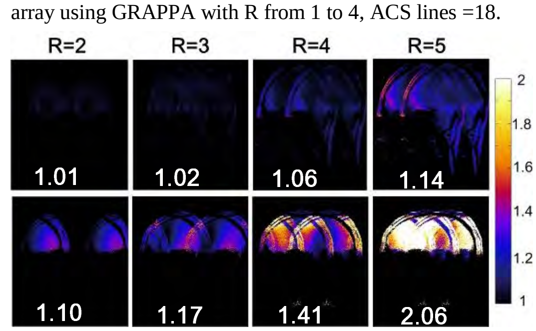

Figure 5 G-factor maps of the 16-channel (top row) and 8-channel (bottom row) arrays with R=2, 3, 4 and 5.

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