Multi-purpose Flexible Transceiver Array at 7T

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Introduction: Flexible array allows for adjustments of coil geometry to best fit the size of subjects, thus, enabling better RF transmission efficiency as well as signal-to-noise ratio (SNR). A daunting challenge in designing such flexible coil arrays, particularly, transceiver arrays, is to achieve and retain sufficient decoupling among the resonant elements under all the geometry/size proposed. In this work, a multiple purpose flexible transceiver array was designed for ultra-high field MRI using a mixing technique of primary and 2nd harmonic microstrips. Besides the coil geometry, the number of coil elements in the proposed design is also selectable for different applications. To demonstrate its feasibility, MR imaging experiments using the flexible transceiver array were performed on a 7T scanner for human wrist, knee, head and liver.

Methods: The major technique challenge when allowing for such multi-purpose flexible array is to find a geometry-independent decoupling solution for coil elements. Due to the requirements of flexibility, the commonly used decoupling schemes, for example coil overlapping, decoupling networks [1-5] are not easily applied. In this work, the primary and second harmonics of microstrip transmission lines are utilized to build the coil elements. By alternatively placing the 1st and 2nd harmonic elements, the nearest neighbors are intrinsically isolated without using any interconnecting LC network circuitry [6]. Figure 1a shows the components of such array. Up to 16 coil elements, including eight 1st harmonic elements and eight 2nd harmonic elements are selectable. The dimension of strip elements (20cm long and 7mm thick) is determined to keep the balance between decoupling and B1 penetration. Coil elements can be densely attached onto a soft canvas in parallel through back-cohesive velcros. This design made it easy to finely adjust the element position for decoupling and also easy to attach/detach those elements for different applications. An additional slotted RF shield sheet was placed behind the ground plane of coil elements to increase the stability. To protect the human body, a 0.5mm thick Teflon sheet was inserted between the array elements and subjects. Fig1b shows the array after fully loaded with 16 elements. The gap between nearest neighbors can be smaller than 1cm and good isolation is still achieved. This multi-purpose array is flexible enough to be bent into semi-volume and volumes with various dimensions. Four applications for human wrist (8-ch), knee (8-ch), head (16-ch) and liver (8-ch) were tested on bench and on a 7T scanner. Fig2 indicates the dimensions and coil element arrangements for those applications. Isolations between coil elements were measured after loading.

Results: After loading with different subjects, the resonance peaks of coil elements are all distinct without splitting. S21 measurements (-dB) between all the elements were shown in fig.3b. Onsite tuning and matching were easily done with variable capacitors ranged from 1 to 19pF even when loading and coil shapes were changed. GE 7T whole body scanner was used for imaging. This scanner is equipped with two transmit channels, thus sub-images from channels were obtained in turns through multi-times acquisitions and then combined off-line. The wrist images were acquired with a specimen. The parameters used were GRE 30^{o} flip, TR/TE 150/6.6ms, 256*256, FOV 13*13cm, Slice Thickness 4mm, NEX 4. Parameters for human knee images were GRE 30degree, TR/TE 150/6.9, 256*256, FOV 21*21, Slice Thickness 3mm. For human head we used GRE 30degree TE/TR 6.9ms/100ms, FOV 24*24, slice thickness 3mm, matrix 256*256, NEX = 4. For in vivo liver images we used GRE 30degree, TR/TE= 150/3.6, 128*256, FOV 35*35, Slice Thickness 5mm, within one breath-hold. Individual channels were combined with sum-of-square method and were shown in figure 3c. To demonstrate its parallel imaging performance, 3x- GRAPPA images were calculated for wrist, knee and head (figure 3d). Eight channel images for the human liver were also shown to present the good isolation between elements.

Conclusions: A multiple purpose flexible transceiver array at 7T has been demonstrated. The nearly coil-size-independent isolation among elements allows it to be applied in humans for various subjects with different size. Besides the imaging examples demonstrated here, this array is also being successfully used for the ankle and may be applicable to other possible applications.

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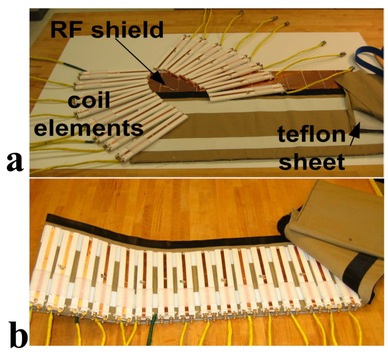

Fig 1. Components of the multi-purpose array before (a) and after (b) arranging with 16 coil elements.

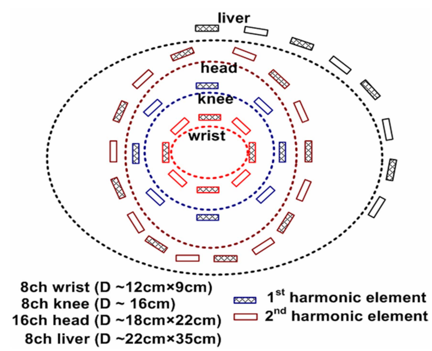

Fig 2. Size and coil elements arrangements for the wrist, the knee, the head and the liver.

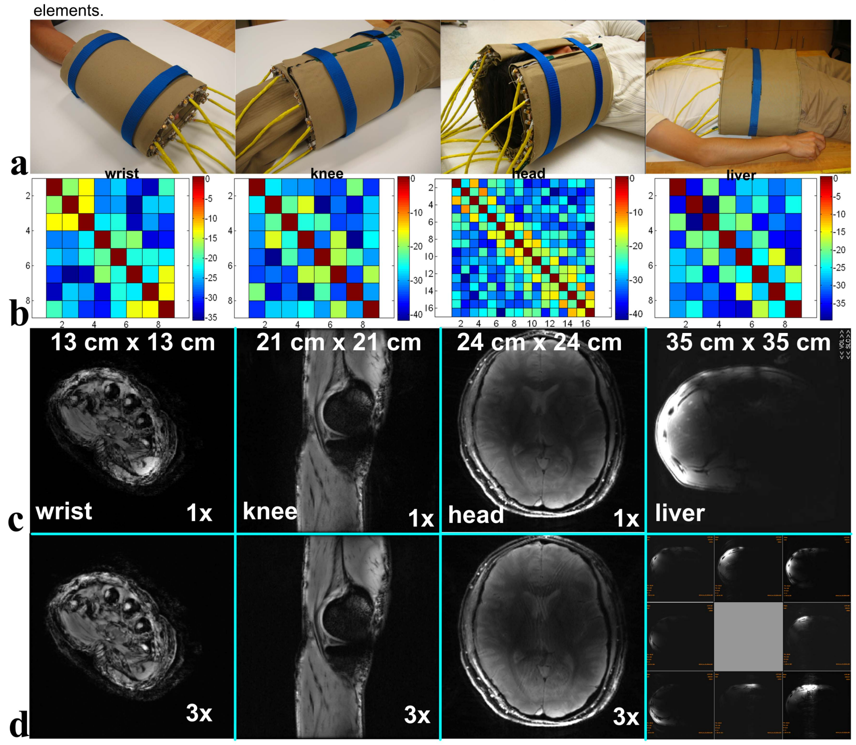

Fig 3. a: photos for 8-ch wrist array, 8-ch knee array, 16-ch head array and 8-ch liver array. b: decoupling (S21) between all coil elements after loading. c: Combined images with SoS method. d: 3x GRAPPA images for wrist, knee, head to show its parallel imaging performance and sub-images for liver to demonstrate the isolation between coil elements.