Twenty-Four Channel Receive-Only Array for Brain Imaging at 7T

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Introduction: The availability of increasing numbers of receivers on 7T MRI scanners leads to the question of how to optimally make use of the additional channels. In the axial plane, radially gapped elements provide an relatively efficient use of elements in terms of sensitivity and SENSE G factors (1,2). However, for large element numbers, purely radial element placement creates long thin elements with the undesirable features of relatively low coupling to the subject, high inductive coupling to neighboring coil elements, and significant electric field interactions at high frequencies. For this work, we describe a 24 channel receive-only array using radially gapped columns of overlapping elements parallel to B0 for human brain imaging at 7T.

Methods: The receive-array consisted of twenty-four coil elements placed on a curved splittable whole brain former (1). On the bottom half, sixteen elements were placed in a 2D arrangement with four radially gapped columns each consisting of four overlapped coils parallel to B0 (e.g. z axis of magnet bore). On the top half, eight elements were also placed in four radially gapped columns though each column consisted of only two overlapped elements parallel to B0. The fewer element number on the top half allowed the face and particularly the visual fields to remain unobstructed (figure 1). Each element was designed for approximately 30% gap relative to element width. To keep a consistent gap width over the curved former, the inferior coils were slightly shorter and wider than the superior coil elements though total area of all elements was held roughly constant.

Each receive-coil element was tuned 298MHz with multiple distributed capacitors and matched to 50 ohm cable with a bridge balun. A PIN diode across the bridge balun detuned each element during transmit. One or more secondary passive traps were placed on each receive coil in addition to the active trap. In each column, cables from the inferior coils were routed in a bundle over the superior coils. Depending upon cable length, three or four common mode cable traps were implemented in the 45-60cm of cable which connected each receive coil to a high impedance 298MHz preamplifier.

A previously described 30cm ID shielded volume transmitter was used to provide the transmit B1 field (3). Comparison was made to both this volume coil in transmit/receive mode and a 7T eight channel radially gapped receive array coil of similar dimensions to the present one (3). Imaging tests were performed on a General Electric 7T MRI scanner located at National Institutes of Health in Bethesda MD, USA. Data for the twenty-four element array was obtained from successive images using the scanner provided sixteen channels with unused coils being preamp isolated during receive. Human imaging was done under institution review board approval.

Results and Discussion: Bench measurements showed that the loaded to unloaded ratio of the individual elements was approximately 3:1 when placed on the former which provided a head to coil distance of approximately one cm. The PIN diode detuning was found to provide >35dB isolation of the receive coils which increased to >50dB with activation of the passive traps.

Compared to the shielded quadrature volume coil (figure 2), central brain SNR was improved roughly two-fold and peak cortical SNR improved 7-10 fold. Comparison with an eight channel radially gapped array showed the twenty-four channel array had minimally increased central brain SNR (by approximately 5%) but significant 40-50% improvements in cortical brain SNR. Individual array coil images showed good isolation between coil elements as well as some effects of high frequency wave phenomenon in the human head (figure 3). Sense G factors are shown in figure 4 and were quite low for both rate 2 (av=1.03) and rate 3 (av=1.28).

Conclusion: This study demonstrates the feasibility a 24 channel array for brain imaging at 7T with radially gapped columns of overlapped elements along the B0 axis. Sensitivity was dramatically improved over a quadrature volume coil operated in transmit/receive mode and more modest yet significant sensitivity improvements were seen over an eight channel radially gapped coil. In addition to providing high sensitivity, axial plane G factors were low and this coil geometry allows for SENSE acquisition with non-axial phase encoding.

References:

1) de Zwart, el al, MRM (2004) 51(1):22-6.
2) Weiger, et al, MRM (2001) 45(3) 495-504.
3) Ledden, et al, Proc ISMRM 2005, p. 322.

Fig 1. Overall Coil Element Geometry

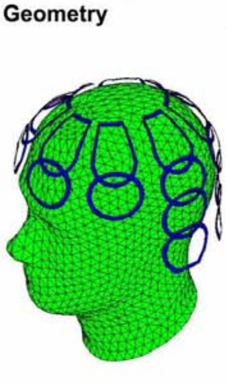

Fig 2. SNR WEIGHTED IMAGES: INTENSITY PORPORTIONAL TO SNR A) Shielded Birdcage B) 24 Ch Array

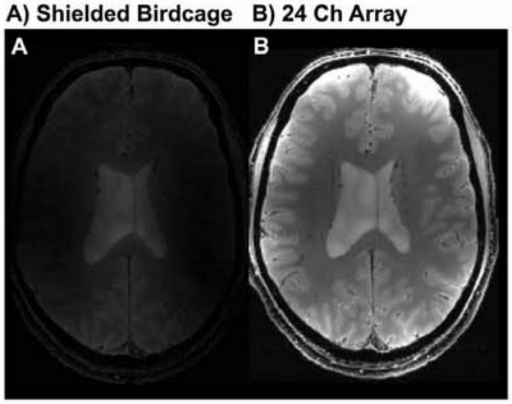

Fig 3. Individual Coil Images: A-D superior to inferior coil rows axially imaged over row B. NOTE: bottom two rows had no anterior coils

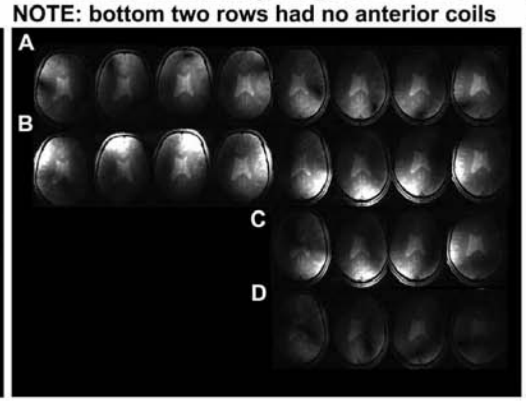

Fig 4.G Maps A) Rate X2, B) Rate X3