A 30 channel receive-only 7T array for ex vivo brain hemisphere imaging

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Introduction: While post mortem serial sectioning of the brain offers exquisite spatial resolution and histological detail, tearing and distortions between cryotome sections renders volumetric analysis of large volumes (such as a brain hemisphere) impractical. MRI of *ex vivo* samples provides 3D encoding at resolutions capable of resolving laminar and myeloarchitectonic features as small as a few hundred neurons [1]. To achieve the highest spatial resolutions (<100 µm isotropic), *ex vivo* imaging of brain hemispheres typically requires many hours of averaging, yet even higher resolution is desirable. Typically, however, a standard clinical *in vivo* RF coil such as a head array or knee coil is pressed into service. Large arrays of small surface coils are ideal for *ex vivo* imaging since they can be placed very near the sample, but a specifically designed array geometry and sealable sample container is needed.

In this work we have designed and constructed an optimized 7T 30-channel receive-only array with a brain hemisphere container conformed to the shape of an average *ex vivo* human brain hemisphere. The hemisphere holders fit left or right hemispheres and are mass-produced using a 3D printer. The sensitivity of the array was compared with other available coils with high resolution imaging.

Methods: The coil array (Fig 1) was tested on a 7T scanner (Siemens Medical Solutions, Erlangen Germany) with 32 receive channels and utilizing a 36 cm diameter head gradient coil. The air/water tight brain container is half of an oblate spheroid (28 cm × 32.5 cm) with a flat top. The brain hemisphere is placed with its flat interhemispheric fissure against the flat top. The brain container fits into a fiberglass former of slightly larger dimensions. The bottom half uses 16 overlapped circular loop elements and the flat top half uses 14 with a gap between the two halves. The elements used 5 mm trace widths and diameters of approximately 78 mm (20 elements) and 62 mm (10 elements) and four or five distributed capacitors. A simple lattice balun with a PIN diode detuned each element during transmit [2]. Preamp decoupling was achieved using lumped element phase shifters. Cable traps were placed between the element and preamp. Tuning, matching, and decoupling of neighboring elements was optimized on the bench with the sample in the paraformaldehyde solution. Imaging samples in different preservatives required variable matching circuits. Thus variable capacitors were used to tune and match the coil to different loading properties of the samples. A detunable volume coil (band-pass birdcage, diameter 28 cm, length 20 cm) was used for excitation.

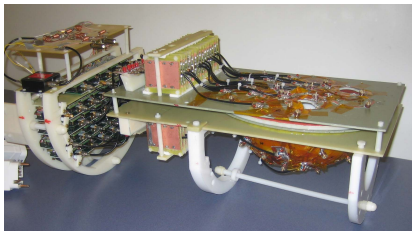

Fig 1: 30-ch *ex vivo* receive array 7T.

Array noise covariance was estimated from thermal noise data acquired without excitation, and SNR maps were computed for the Sum-of-Squares and Optimal SNR combinations (utilizing the channel noise covariance) following the methods of Kellman & McVeigh [3]. A high-resolution scan from the 7T 30-channel array (150 µm isotropic resolution, 6-hour acquisition, TR/TE/flip=41ms/19ms/15°, 934×522×1024 matrix, BW=30Hz/px) was compared to a matched T2*-weighted scan with the 3T 12-channel head array.

Results: S12 coupling between neighboring elements, measured with all other coils preamp decoupled, ranged from -10.9 to -24 dB. All individual elements had S11 < -15 dB. Figure 2 compares the SNR maps and the noise correlation coefficient matrix with the other available 7T coils. The average SNR (Table 1) of the 30-channel array is significantly higher than all the other coils and also shows good whole-brain coverage. Figure 3 shows a comparison to a matched scan with the 3T 12-channel head array.

Conclusions: The array coil benefits *ex vivo* imaging by providing increased SNR in a housing to facilitate high throughput imaging. An extension of this design will seek to place the elements closer to the sample on the top half to increase body noise dominance.

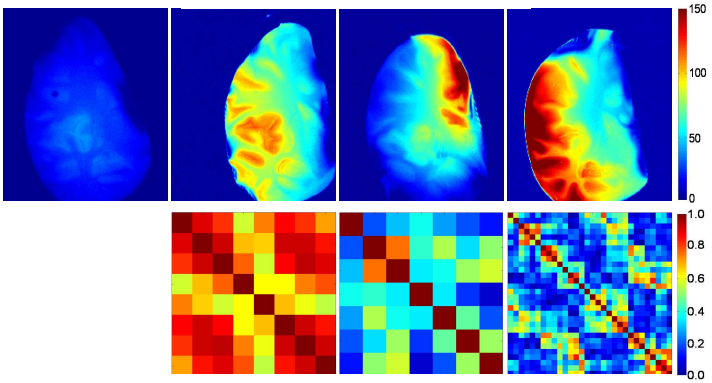

Fig 2 SNR maps (top row); noise correlation coefficient matrix (bottom row).

Coil	Ave. SNR
30 Ch	70
7 Ch Ento-rhinal	44
8 Ch *In vivo*	23
Bird-cage	10

Table 1 Average SNR.

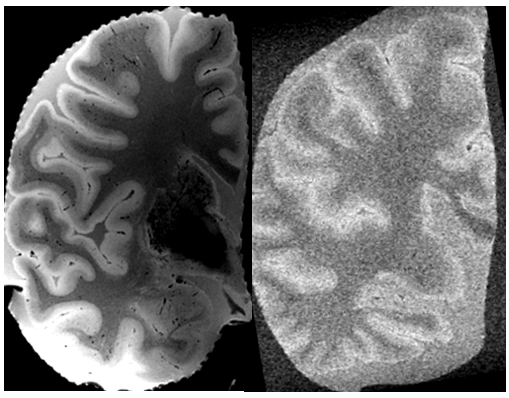

Fig 3 Comparison to conventional *ex vivo* scanning (3T standard head array).

References: [1] Augustinack *et al.* (2005) Ann Neurol, 57(4):489-94. [2] Ledden *et al.* (2007) Proc ISMRM, 242. [3] Kellman *et al.* (2005) MRM, 54(6):1439-47.

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