A 60-Channel Ex-Vivo Brain-Slice Coil Array for 3T Imaging

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Target Audience: Clinicians and researcher pursing MR imaging of the ex-vivo human brain.

Purpose: Imaging brain samples ex-vivo is not well suited to RF array coils designed for living humans. This is especially true for imaging brain slices or slabs of tissue from a whole brain or hemisphere. In this case, the idea array places multiple small array elements immediately against the each flat face of the slab. To achieve this and allow high resolution anatomical and diffusion imaging of 1cm – 5cm thick slabs of brain tissue, we construct and validate an array of 60 small surface coils placed flat against each surface (30 circular loop elements per side). The mechanical aspect of the array resembles a "panini press" in that it can accept 1cm - 5cm thick slabs of tissue. The array was built for 3T to allow it to be used for diffusion imaging in our *Connectome* gradient scanner. The coil is validated through SNR and 1/G-factor map comparisons as well as MR-diffusion imaging and highly accelerated ex vivo brain-slices.

Fig. 1 - Constructed Array Coil

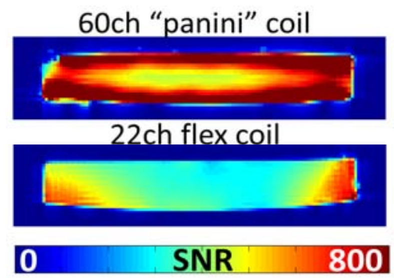

Fig. 2 - SNR map comparison between a 22ch Siemens Flex coil and the 60ch ex-vivo coil.

Materials and Methods: The coil is designed like a sandwich toaster (panini press) with a double-hinged opening. It is shown in the open and closed position in Fig.1. The coil former consists of an upper half with 30 elements and a lower half with 30 elements, connected through a moveable hinge. Out of the dimension-requirement of a sample brain-slice the populated area on each former has an oval size of 220x180mm and a thickness of minimum 1cm and up to 5cm (maximum for a standard adult brain-slice) - providing coverage of a whole axial brain slab cut - the arrangement of the coil-elements itself was derived. All parts, excluding the connection plug to the scanner (industrial part, Siemens) and the baseplate for the coil (wood) were printed in polycarbonate (ABS) plastic, using a rapid prototyping 3D printer (FORTUS 3D Production Systems by Stratasys, MN, USA). Adjacent circular coil elements were inductively decoupled from one another using critical overlap employing a hexagonal tiling pattern. Each loop has a diameter of 40mm - that means that the distance between the center of each element is $a_{center} = 0.75*d = 30mm$ – and is critically overlapped with its nearest neighbors. Next-nearest neighbor decoupling is realized by preamplifier decoupling, performed by transforming the low impedance of the preamplifier to an open circuit in the loop using a 50mm long coaxial cable and a series capacitor of 10 pF. **[2]** We divided each loop symmetrically into two inductances (semi circles) and connected them with discrete components (tuning circuit: variable capacitor; output circuit: capacitive voltage divider, series matching capacitor and active detuning trap). A pair of coils is attached to preamps and low noise converters (Siemens Healthcare, Erlangen, Germany) which also served to down-convert the detected signal to an intermediate frequency and frequency domain multiplex the two channels onto a single coaxial output. The signals are later de-multiplexed back into individual channels in the receiver. **[1]** Initial data was acquired on a 3T Siemens MAGNETOM Skyra '*Connectome*' MRI scanner (Siemens Healthcare, Erlangen, Germany) equipped with 64 receive channels and a gradient coil capable of 300 mT/m maximum gradient strength. **[3]** SNR and G-factor maps were derived from PD weighted phantom images (TR/TE/α=300ms/15ms/90°, SL=5mm, matrix (m)=128×128). The array coil performance was tested in 200 μm isotropic gradient echo flash scans (TR/TE/α=100ms/10ms/25°, BW=120Hz/pixel, matrix=256x256, TA=2h 23min).

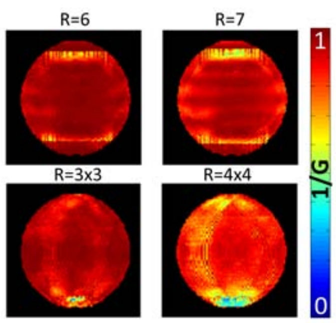

Fig. 3 - 1/G maps of transversal brain slice for 2D & 3D acceleration.

Results: The preamplifier decoupling reduced coupling between next-nearest and further neighbor-loops, to -20dB and a S_{12} decoupling between nearest-neighbors of around -15dB. The Q-ratio (Q_{unload}/Q_{load}) for a single element was 263/60=4.38 and the ratio for 6 surrounding elements was 167/62=2.69. Compared to the 22ch flex coil, the 60ch ex-vivo array has an overall 3.5-fold SNR improvement (Fig. 2). This resuls in high sensitivity and high resolution ex-vivo images (Fig. 4). G-maps show high acceleration capabilities without substantial noise amplification (Fig. 3).

Conclusion: The 60-channel array coil for ex-vivo brain imaging was constructed and tested. The array coil benefits ex-vivo imaging by providing increased sensitivity and seems well suited for ex-vivo brain studies where high SNR and high resolution are needed.

References: **[1]** Keil B, et al. MRM (2012), 70:1, 248-258. **[2]** Wiggins GC, et al. MRM (2009), 62:3, 754-762. **[3]** JA McNab, et al. Poster OHBM (2012)

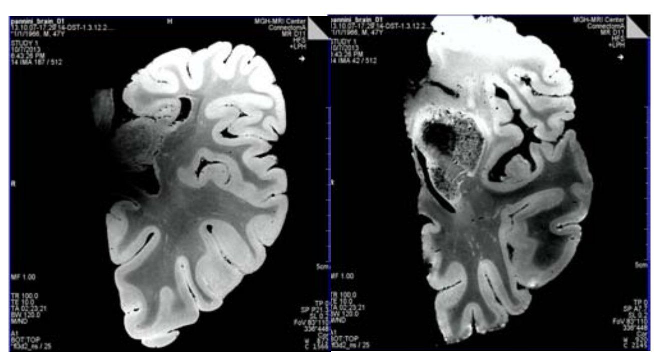

Fig. 4 – 60ch T1 weighted 0.2mm isotropic half brain slice, T_A=2h23min