High Resolution in vivo DTI of the mouse brain: Comparison of a Cryogenic coil with a Room Temperature Coil

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Introduction:
High resolution diffusion tensor imaging (DTI) of mice brain suffers from low signal to noise ratio (SNR) due to the required small voxel sizes (< 0.2 mm). Recently, cryogenically cooled resonators were introduced to increase the effective SNR [1]. Currently the benefit of these coils for DTI of the mice brain is undetermined. The aim of this study was a comparison of the SNR in DTI images acquired with a cryogenic coil and a room temperature (RT) surface coil and a comparison performed by qualitative assessment of the calculated fractional anisotropy (FA)-maps at different spatial resolutions.

Materials and Methods:
Animals: Three male *C5 black/6J* mice were used for this study. The animals were anesthetized with isoflurane (2.0%) and placed in a prone position on a plate holder with an adjustable nose cone. The rectal temperature was held constant at 36°±0.5° C by a water heated cradle.
In vivo imaging: Two commercially available coil systems were compared on a 9.4 T Biospec 94/20 USR (Bruker, Germany) small animal system equipped with 740 mT/m gradients. Diffusion tensor images were acquired using a spin echo-echo planar imaging (SE-EPI) sequence at three different isotropic in plane resolutions (87.5 µm, 140 µm, 93.75 µm) with a cryogenic surface coil (transceiver, quadrature) and a dual resonator system composed of a transmit-only volume resonator and a receive-only surface coil at room temperature (Bruker, Germany). Imaging parameters were set to: TE/TR=23.8/4000 ms, matrix=128x96, bandwidth=300000 Hz, 16 slices with slice thickness=0.5 mm, NEX=1, partial Fourier=2/3, Stejskal-Tanner diffusion scheme (Δ=10 ms, δ=2 ms), 30 diffusion directions with b=1000 s/mm^2 and 5 unweighted b=0 s/mm^2 images resulting in an acquisition time of TA=140 s. Additionally high resolution DTI-images were acquired using the cryogenic coil only with identical imaging parameters except for: EPI-segments=4, TE=19.6 ms, FOV=12.5x8.5 mm, matrix=192x128 and TA=9 min. Fractional anisotropy (FA) maps were calculated from the DTI-images. Two of the five unweighted images (b=0 s/mm^2) were subtracted according to the difference method [2] in order to calculate the SNR.

Results:
Figure 1 shows the FA-maps using the cryogenic coil and the RT surface coil with different resolutions. The FA-map using the cryogenic coil and a resolution of 93 µm clearly delientes the white matter bundles of the murine brain from the surrounding tissue, e.g. the corpus callosum. In comparison the noise on the FA-map acquired with the RT surface coil impedes delineation between white and grey matter. At the lower resolutions, the differences between the two coils are less pronounced. Table 1 shows the SNRs of the cryogenic coil and the surface coil for different resolutions measured from the unweighted images and the slice position shown in figure 1. The SNR of the cryogenic coil is about threefold higher compared to the SNR of the RT surface coil.
A high resolution FA-map of the same mouse brain calculated from the DTI-images acquired with the segmented EPI and the cryogenic coil is presented in Figure 2. The SNR was 16.

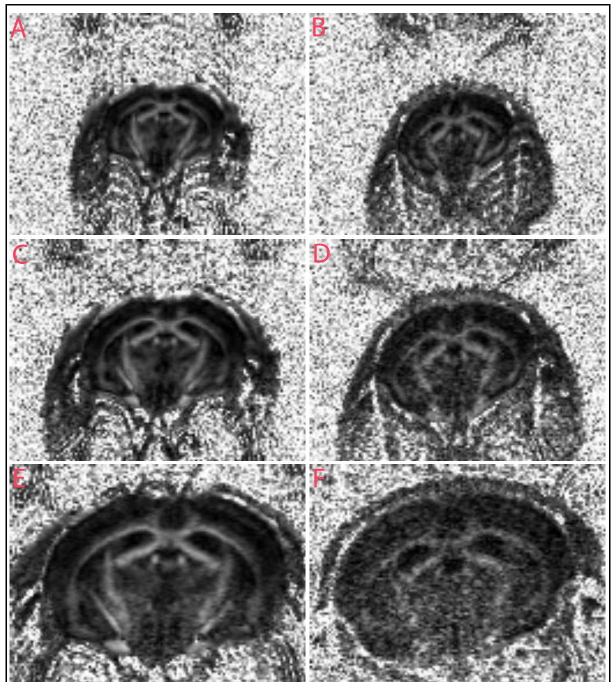

Fig. 1: Comparison of FA-maps using the cryogenic coil (A,C,E) and the RT surface coil (B,D,F) at different resolutions. As the resolution increases (from top to bottom) the image quality of the FA-maps differs significantly between the two coils.

Resolution	Cryogenic coil	RT coil
187.5 µm	81.7±7.2	25.0±4.5
140 µm	54.2±2.6	15.7±2.2
93.75 µm	25.73±0.5	8.13±1.2

Tab. 1: SNR of the cryogenic coil and the surface coil for different resolutions. The SNR with the cryogenic coil is more than three times higher than with the RT surface coil.

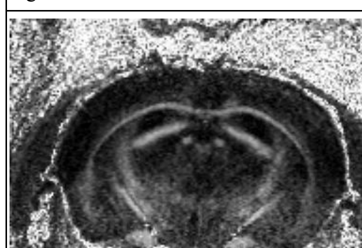

Fig. 2: FA-map calculated from DTI images acquired with the segmented EPI and the cryogenic coil yielding a resolution of 65 µm.

Discussion:
In this study we demonstrated that FA-maps of the murine brain can be obtained within 140 s with an isotropic in plane resolution of 93 µm using a cryogenic coil at 9.4 T, whereas the lower SNR using the RT-coil hampered a reliable depiction of well known fibre trajectories. This gain in SNR enabled the computation of *in vivo* FA-maps with unseen resolution [3,4], which could provide novel insight on fibre architecture in rodent models. Also, the gain in SNR could be used to perform kurtosis or q-ball imaging in an acceptable scan time, which should be investigated in future studies.

References:
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