In vivo fiber tracking in the rabbit brain on a clinical 3T MRI system

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Introduction:

The white matter structure of the developing rabbit brain has been studied recently in great detail *in vitro* by using high-resolution diffusion tensor imaging and tractography [1] with an animal MR scanner. Both the simple structure of the lissencephalic rabbit brain and the reproducibility of *ex vivo* fiber tracking make the rabbit model a powerful tool for neuroscience investigations. Up to now *in vivo* fiber tracking of small animals has been shown only for the rat model using an insert gradient coil on a clinical whole body MR system [2]. Thus, the purpose of this study was to investigate the feasibility of performing diffusion tensor imaging and fiber tractograph with sub-millimeter resolution and a short scan protocol on a clinical 3T MR system without the need for a special insert gradient system.

Materials and Methods

The MR scans were performed on a clinical 3 T MRI system (Tim Trio, Siemens Medical Solutions, Erlangen, Germany) and a small 8-channel multipurpose coil consisting of two elements each containing four small coil loops (CPC, Noras, Höchberg, Germany). The rabbit was anesthetized by using a mixture of Ketamine (10 mg/kg per hour) and Xylazine (1 mg/kg per hour). The head of the animal was fixed using an adapted, custom-made framework. The two elements of the coil were placed above and beneath the rabbit's brain, respectively. The anatomical scan was performed by using a single slab 3D T2-weighted TSE sequence with slab selective, variable excitation pulse sequence (SPACE sequence) in sagittal orientation with an isotropic resolution of 0.4 mm³ (FoV: 110 mm; matrix: 256; slices: 224, TR: 2500 ms; TE: 340 ms). The diffusion tensor scan was performed with a standard EPI sequence and a direction scheme comprising 70 directions each with a *b*-value of 900 s/mm² and six b_0-images. Sixty slices with coronal orientation and a thickness of 1.2 mm (FoV: 154 mm; matrix: 128) were acquired with a GRAPPA acceleration factor of 4 resulting in an echo time of 92 ms. With in-plane interpolation by using zero-filling and repeating the measurement by shifting the slice stack by half the slice thickness in slice direction yielded isotropic resolution of 0.6 mm³ for the diffusion tensor data set. The total acquisition time for the interleaved blocks was 20 min. Tensor reconstruction and fiber tracking were performed using the Diffusion Toolkit [3] and the tracts were evaluated and visualized using Trackvis [3].

Results

For visualization the major fiber tracts several ROIs, including the genu (*yellow*) and splenium (*blue*) of the corpus callosum, the anterior part of the internal capsule (*red*), the brain stem (*light blue*) and the olfactory tracts (*pink)* were drawn in the anatomic volume. The fibers which passed these selected ROIs are shown in different views in Fig. 1.

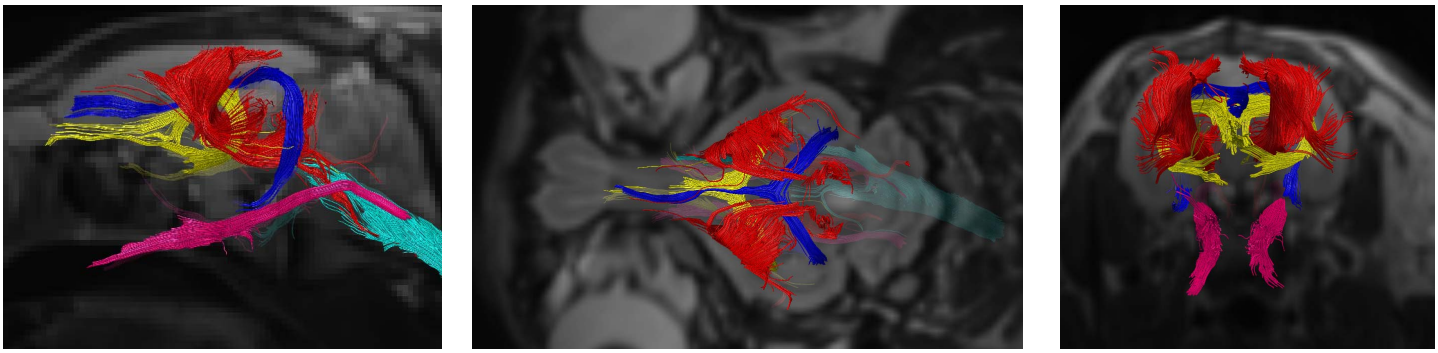

Fig. 1 From *left* to *right*: Sagittal, transverse and coronal view of the fiber tracts revealed from the selected ROIs overlaid on single T_2-weighted slices reconstructed from the 3D T_2-weighted TSE data slab for better anatomic orientation.

Discussion

This study shows the feasibility of *in vivo* fiber tracking of white matter tissue in a rabbit brain by using standard equipment in combination with a clinical MR system. Based on these first promising results we feel encouraged to investigate further white matter diseases or brain development by using this animal model with the proposed setup. Furthermore, despite the fact that the white matter structure of the rabbit brain is relatively simple, it nevertheless comprises challenging objects for fiber tracking like kissing, crossing or branching fibers, which make the model a suited testbed for validation of new tracking algorithms.

References

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