Validation of diffusion weighted tractography in the dentaterubrothalamic tract

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Introduction:

Probabilistic tractography allows for reconstruction of white matter fibers in the brain using diffusion weighted magnetic resonance imaging (DWI) and is a tool for studying connectivity in the brain. For research and clinical application of tractography it is essential to know whether tract reconstruction correspond with their anatomical position. The gold standard for validation of tractography is the comparison with histological fiber staining in post mortem tissue. In this study probabilistic tractography is applied to reconstruct the dentaterubrothalamic tract (DRT) and validated with a myelin stain. Fig. 1. Probabilistic tractography (7T) of the dentaterubrothalamic tract (DRT) in ex vivo human brain.
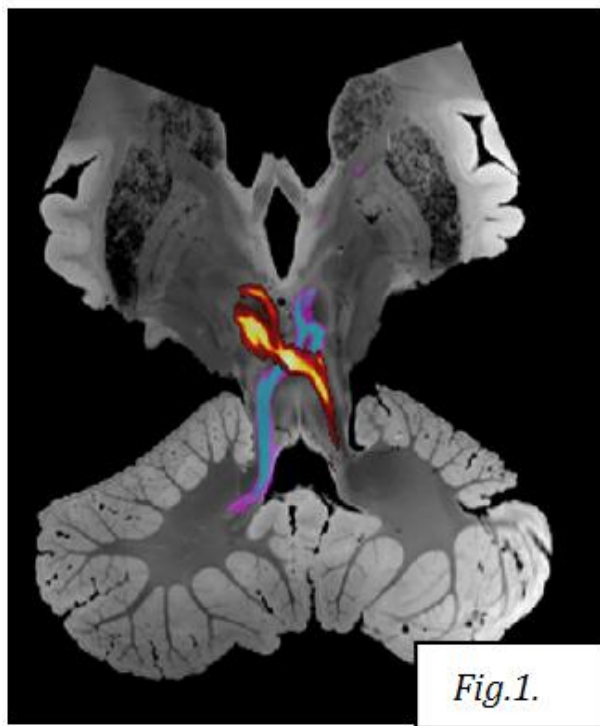
Fig.1.

Methods:

DWI data were acquired with a 7T MRI scanner from an ex vivo human brain specimen. Probabilistic tractography was performed with FSL. Subsequently, the cerebellum was prepared for histological processing and cut into sections which were stained for myelin. The sections were digitized for 3D reconstruction. Interslice alignment was performed to align neighboring slices with each other prior to 3D reconstruction resulting in the histological volume. The DRT was segmented in the histological volume which served as validation reference. Tractography and the validation reference were registered with each other for voxelwise comparison. ROC analysis, similarity index (SI) and miss fraction (MF) were computed for several tract probability thresholds for validation. Fig. 2. Histological coupe stained with the modified Heidenhain-Woelcke stain. The stain highlights myelinated nerve fibers, provides contrast between different gradations of myelination. Fig.3. Probabilistic tractography and MRI based tract segmentation (in red) overlaid on the MR structural.
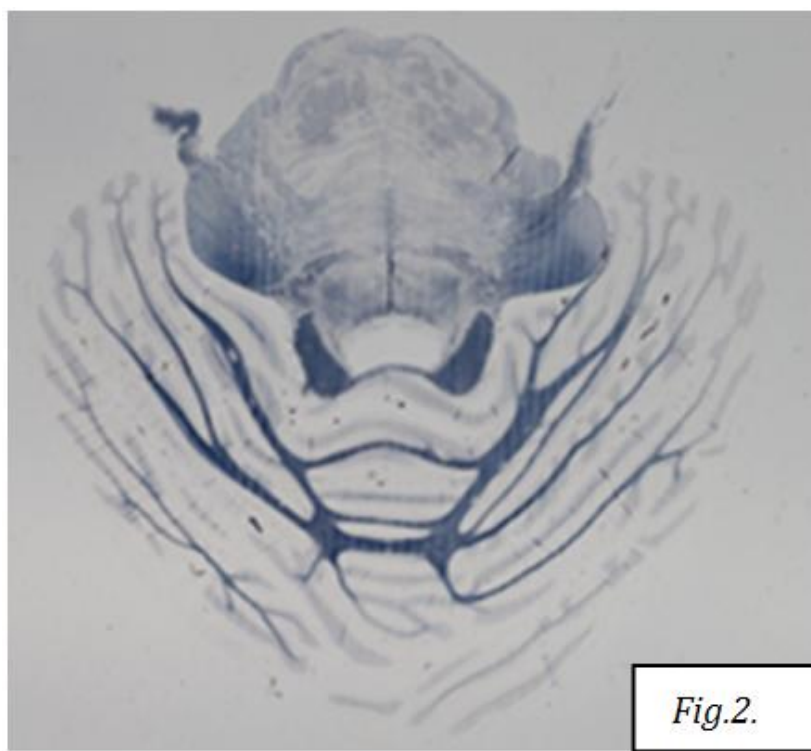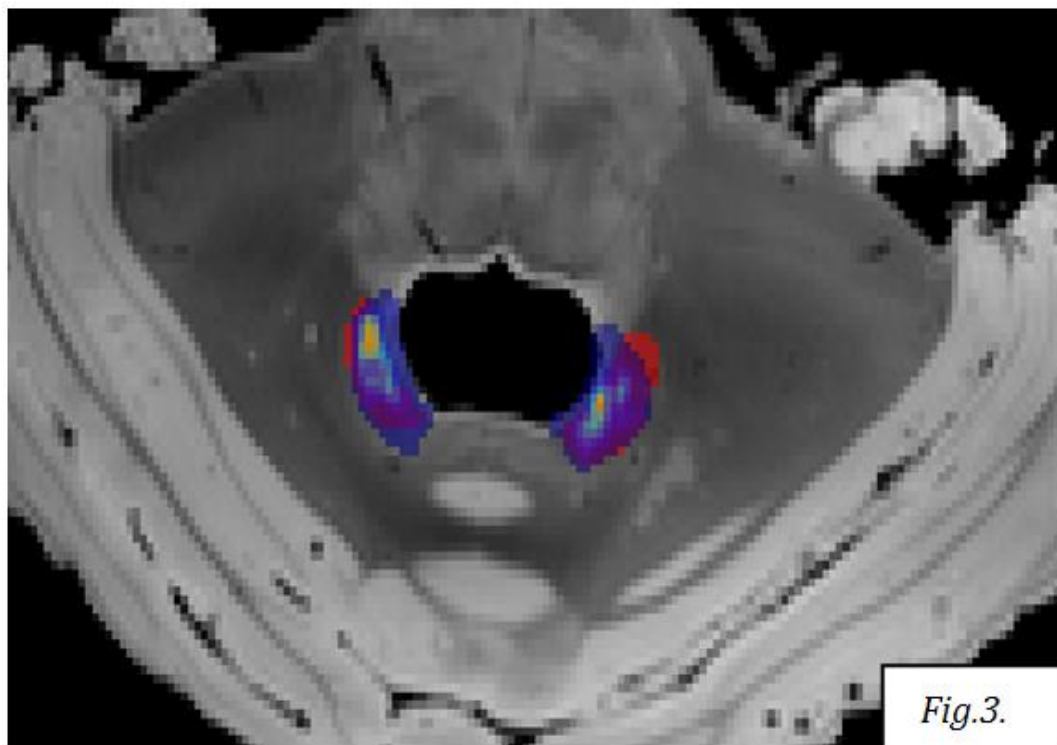
Fig.2.

Fig.3.

Results:

ROC analysis resulted in a sensitivity of 0.8348 with a specificity of 0.9963. Optimal SI of 0.63 and 0.78 with a MF of 0.37 and 0.17 were found for the whole tract and the superior cerebellar peduncle (SCP) region, respectively. In total, 85% of the reference tract was located within 1 mm range from the border of tractography. Fig. 4. ROC curves of the right tract. Performance histology based validation for the total tract and three regions within the tract.

ROC curves, right tract

Fig.4.
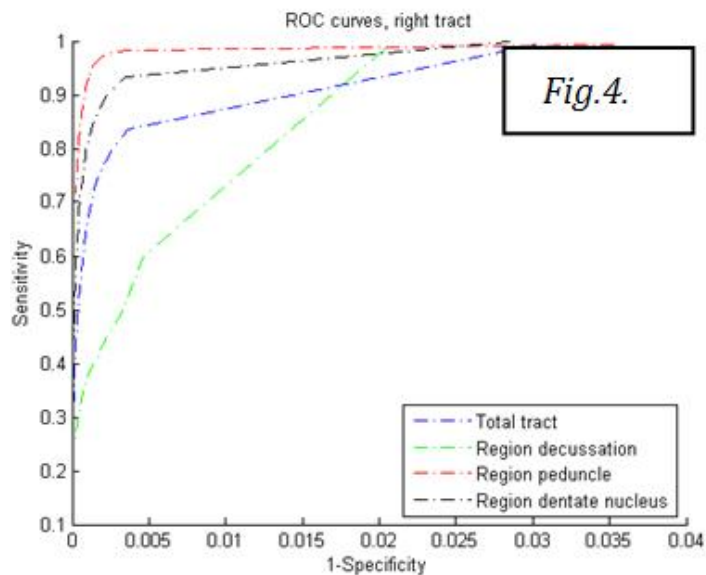
Conclusions:

The feasibility of histology-based validation of the diffusion weighted tractography in the DRT has been demonstrated in this study. A plausible 3D reconstruction of the DRT was achieved by histological sectioning as well as probabilistic tractography. SI reported here have been regarded as excellent in other segmentation studies. Spatial alignment between tractography and the histology based tract reaches an accuracy which is ready for comparison to in vivo studies of the DRT with probabilistic tractography.

Neuroanatomy:

White Matter Anatomy, Fiber Pathways and Connectivity

Abstract Information

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Please indicate which method was used in your research:

Structural MRI

Diffusion MRI

Postmortem anatomy

For human MRI, what field strength scanner do you use?

7T

What post processing software packages do you use?

FSL