Dentatorubrothalamic tract

The dentatothalamic tract (or dentatorubrothalamic tract) is a tract which connects the dentate nucleus and the thalamus while sending collaterals to the red nucleus.

The term “dentatorubrothalamocortical” is sometimes used to emphasize termination in the cerebral cortex.

The dentatothalamic tract or dentatorubrothalamic tract (DRTT) originates from the dentate nucleus in the cerebellum and terminates in the contralateral ventral lateral nucleus (VL) of the thalamus after decussating to the contralateral red nucleus. Identification of the DRTT is difficult due to the fact that it is a long, multisynaptic, neural tract crossing to the opposite hemisphere.

The dentato-rubro-thalamic tract (DRTT) regulates motor control, connecting the cerebellum to the thalamus. This tract is modulated by deep brain stimulation in the surgical treatment of medically refractory tremor, especially in essential tremor, where high-frequency stimulation of the thalamus can improve symptoms. The DRTT is classically described as a decussating pathway, ascending to the contralateral thalamus. However, the existence of a nondecussating (i.e. ipsilateral) DRTT in humans was recently demonstrated, and these tracts are arranged in distinct regions of the superior cerebellar peduncle.

Petersen et al., hypothesized that the ipsilateral DRTT is connected to specific thalamic nuclei and therefore may have unique functional relevance. The goals of this study were to confirm the presence of the decussating and nondecussating DRTT pathways, identify thalamic termination zones of each tract, and compare whether structural connectivity findings agree with functional connectivity. Diffusion-weighted imaging was used to perform probabilistic tractography of the decussating and nondecussating DRTT in young healthy subjects from the Human Connectome Project (n = 91) scanned using multi-shell diffusion-weighted imaging (270 directions; TR/TE = 5500/89 ms; spatial resolution = 1.25 mm isotropic). To define thalamic anatomical landmarks, a segmentation procedure based on the Morel stereotactic atlas of the human thalamus was employed, and DRTT targeting was quantified based on the proportion of streamlines arriving at each nucleus. In parallel, functional connectivity analysis was performed using resting-state functional MRI (TR/TE = 720/33 ms; spatial resolution = 2 mm isotropic). It was found that the decussating and nondecussating DRTTs have significantly different thalamic endpoints, with the former preferentially targeting relatively anterior...
and lateral thalamic nuclei, and the latter connected to more posterior and medial nuclei (p < 0.001). Functional and structural connectivity measures were found to be significantly correlated (r = 0.45, p = 0.031). These findings provide new insight into pathways through which unilateral cerebellum can exert bilateral influence on movement and raise questions about the functional implications of ipsilateral cerebellar efferents.

Pineda-Pardo et al., published a cohort of 24 essential tremor patients before and 3 months after unilateral transcranial magnetic resonance guided focused ultrasound targeting at the posteroventral part of the VIM. Microstructural changes along the dentatorubrothalamic tract (DRTT) were quantified by means of probabilistic tractography, and later related to the clinical improvement of the patients at 3-months and at 1-year after the intervention. In addition the changes along two neighboring tracts, that is, the corticospinal tract and the medial lemniscus, were assessed, as well as the relation between these changes and the presence of side effects. Thalamic lesions produced local and distant alterations along the trajectory of the DRTT, and each correlated with clinical improvement. Regarding side effects, gait imbalance after thalamotomy was associated with greater impact on the DRTT, whereas the presence of paresthesias was significantly related to a higher overlap between the lesion and the medial lemniscus. This work represents the largest series describing the microstructural changes following transcranial MR-guided focused ultrasound thalamotomy in essential tremor. These results suggest that clinical benefits are specific for the impact on the cerebello-thalamo-cortical pathway, thus reaffirming the potential of tractography to aid thalamotomy targeting.

Diffusion tensor imaging was performed at 1.5-T using a synergy-L sensitivity encoding head coil. DRTTs were obtained by selection of fibers passing through three regions of interest (the dentate nucleus, the superior cerebellar peduncle, and the contralateral red nucleus) from 41 healthy volunteers. Probabilistic mapping was obtained from the highest probabilistic location at 2.3 mm above the anterior commissure-posterior commissure level.

DRTTs of all subjects, which originated from the dentate nucleus, ascended through the junction of the superior cerebellar peduncle and the contralateral red nucleus and then terminated at the VL nucleus of the thalamus. The highest probabilistic location for the DRTT at the thalamus was compatible with the location of the VL nucleus.

Kwon et al identified the DRTT in the human brain using probabilistic tractography. Our results could be useful in research on movement control.

The dentatorubrothalamic tract (DRTT) is the major efferent cerebellar pathway arising from the dentate nucleus (DN) and decussating to the contralateral red nucleus (RN) and thalamus. Surprisingly, hemispheric cerebellar output influences bilateral limb movements. In animals, uncrossed projections from the DN to the ipsilateral RN and thalamus may explain this phenomenon. The aim of a study was to clarify the anatomy of the dentatorubrothalamic connections in humans.

Meola et al applied advanced deterministic fiber tractography to a template of 488 subjects from the Human Connectome Project (Q1-Q3 release, WU-Minn HCP consortium) and validated the results with microsurgical dissection of cadaveric brains prepared according to Klingler's method.
The authors identified the “classic” decussating DRTT and a corresponding nondecussating path (the nondecussating DRTT, nd-DRTT). Within each of these 2 tracts some fibers stop at the level of the RN, forming the dentatorubro tract and the nondecussating dentatorubro tract. The left nd-DRTT encompasses 21.7% of the tracts and 24.9% of the volume of the left superior cerebellar peduncle, and the right nd-DRTT encompasses 20.2% of the tracts and 28.4% of the volume of the right superior cerebellar peduncle.

The connections of the DN with the RN and thalamus are bilateral, not ipsilateral only. This affords a potential anatomical substrate for bilateral limb motor effects originating in a single cerebellar hemisphere under physiological conditions, and for bilateral limb motor impairment in hemispheric cerebellar lesions such as ischemic stroke and hemorrhage, and after resection of hemispheric tumors and arteriovenous malformations. Furthermore, when a lesion is located on the course of the dentatorubrothalamic system, a careful preoperative tractographic analysis of the relationship of the DRTT, nd-DRTT, and the lesion should be performed in order to tailor the surgical approach properly and spare all bundles 4).

References


