

Diffusion Tensor Imaging of Basal Ganglia Output Fibers

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Introduction:

Deep Brain Stimulation (DBS) is an effective treatment for the symptoms of Parkinson's disease (PD) and other movement disorders. DBS involves the surgical implantation of electrodes that stimulate brain nerve cells to signal. DBS of these cell bodies results in relief of Parkinson's symptoms. Although DBS of cellbodies in the subthalamic nucleus is commonly used to treat the symptoms associated with Parkinson's disease, several groups have reported clinical benefit of high frequency stimulation (HFS) in areas adjacent to the STN (prelemniscal radiation, posterior zona incerta) which are largely acellular regions containing pallidofugal and cerebellothalamic tracts where HFS stimulation would potentially have the greatest effects on network function (2-4). A potential DBS target involves the pallidofugal fibers including the Ansa Lenticularis (AL) and Lenticular Fasciculus (LF) which are basal ganglia output fibre tracts that connect the globus pallidus (GPi) internus with the lateral thalamus (TH). The objective of the current study was to test if noninvasive Diffusion Tensor Magnetic Resonance Imaging (DTI) is a feasible tool to visualize the AL and LF.

Materials & Methods: Images were acquired on a clinical Siemens TRIO 3T MR scanner. Studies were performed on 15 healthy adults between the ages of 18-40. Subjects gave informed consent and were free of MRI exclusion criteria. DTI data were acquired using a SE-EPI sequence and a quadrature head coil. Imaging parameters: Imaging Plane, Axial; Phase Encoding Direction, Right-Left; TE, 84msec; Slice thickness, 2.0mm; Interslice gap, 0mm; Field of view, 270x175mm; Acquisition Matrix, 128 x 128; Number of averaging, 5. b value of 1000 s/mm², 12 gradient directions.

The MRICron package (<http://www.sph.sc.edu/comd/rorden/mricron/>) and its subprogram dcm2niigui.ini was used to extract the diffusion gradient matrix and b values from image header. MedInria software (<http://www-sop.inria.fr/asclepios/software/MedINRIA/>) was used for tractography. Seed points for the tractography were placed in the GPi. The program uses a pixel-by-pixel analysis along the main vectors. 3D ROIs for the whole GP and for the TH were drawn within the MedInria environment.

Results: Figure 1 displays a lateral-external view of the GPi and TH and some of the main fiber tracts passing between them. Fibers were also generated from the internal GPi only (Figure 2) using MedInria software. The results obtained with our fiber tracking methods suggest several parallels with the observations reported by Parent and Parent (2004): (a) two fiber tracts emerge from the GPi, (b) one tract emerges from a more ventral aspect of the GPi, potentially the AL (tract II) (see arrow in Figure 2), (c) the other tract emerges from a more dorsal aspect of the GPi, potentially the LF (tract I) (see arrow in Figure 2), (d) fibers from tract I cross through the internal capsule where they meet with fibers from tract II (see circle in Fig.2) and (e) tract I and II join to move towards the thalamus (Fig.2).

Conclusion: Overall we observed that the reconstructed fibers connecting the GP and Th are originating from the internal part of the GP which is consistent with primate and human anatomical reports. The fibers connecting the GPi with the Th suggest the existence of two branches/tracts, one originating in the dorsal aspect of the GPi and the second in the ventral aspect of the GPi. These two tracts may be indicative for the localization of the Lenticular Fasciculus (LF) and the Ansa Lenticularis (AL), respectively. The long term goal will be to use this information to help guide DBS therapies.

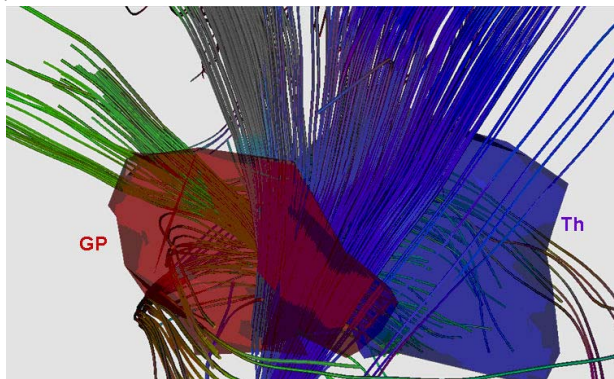


Fig.1: The latero-external view of the GPi (red) and Th (blue) and some of the main fiber tracts passing between them. There are no visible connections between the external part of GPi and Th. One can see the corticospinal tract (blue fibers -superior/inferior) running through the internal capsule.

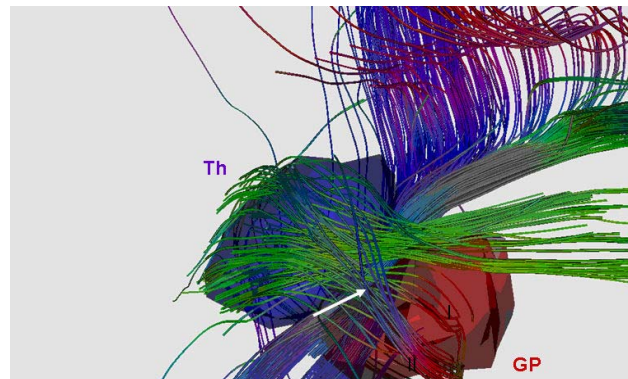


Fig.2: The latero-internal view of the GPi and Th. The fibers initiate only within the internal part of GP. The communication fibers between the GPi and TH seem to organize in two tracts, their location suggest the presence of the lenticular fasciculus (I), emerging from higher part of GP internus and ansa lenticularis (II), emerging from lower part of GP internus. Tracts I and II join (white arrow) to move towards the thalamus.

References:

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