Localization of the Ventro-Intermediate Thalamic Nucleus using Local Diffusion Properties

Presented During: Poster Session
Tuesday, June 28, 2016: 12:45 PM - 02:45 PM

Stand-By Time

Tuesday, June 28, 2016: 12:45 PM - 2:45 PM

Poster Number:

2185

Submission Type:

Abstract Submission

On Display:

Monday, June 27 & Tuesday, June 28

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Introduction:

The ventro-intermediate nucleus (Vim), as a part of the motor group of thalamic nuclei, is a commonly used target in functional neurosurgical procedures, such as Gamma Knife Surgery, for the treatment of drug-resistant tremor. Since there is no direct visualization of the Vim on current routine Magnetic Resonance Imaging (MRI), the targeting method is indirect, typically employing stereotactic coordinates or the quadrilatere of Guiot[2]. Several authors made an attempt to automatically outline the thalamic subparts by exploring the diffusion-weighted images (DWI)[1,3,6], but none of them is providing validated or accurate delineation of the nuclei.
Recently, our group proposed a fully automated and robust method that partitions the thalamus in 7 anatomical groups of nuclei based on the local diffusion information from the spherical harmonics (SH) representation of the orientation distribution functions (ODFs)[4]. Among the 7, we delineate the Ventral-Lateral-Ventral (VLV) group, which encloses all motor-related nuclei including the Vim. However, the method was evaluated for a healthy population and withal, the precise automatic localization of the Vim still remains an unfulfilled task.
In this study, we extend our previous work[4] to 11 patients with essential tremor (ET) and we present an approach for constraining the Vim location established on further ODF-based analysis inside the VLV group. As assessment, we compared our results with the post-operative images, at 6 months after Gamma Knife thalamotomy (GKT) of the left Vim.

Methods:

Data were acquired from 11 ET patients (mean age: 79 y.o.) before and 6 months after GKT, where the target was the defined with the quadrilatere of Guiot. For 3 patients the pre-operative MPRAGE was acquired with 1.5T Aera Siemens (1mm3), DWI pre-operative with 3T TimTrio Siemens (72 directions, b=1000s/mm2, 2.2mm3) and the post-operative MPRAGE with 3T Skyra Siemens (1mm3). For the remaining 8, the images were acquired with 3T Skyra Siemens: MPRAGE pre-operative with voxel of 1mm3, DWI pre-operative: 64 directions, b=1000s/mm2, voxel 2.2mm3 and MPRAGE post-operative with voxel of 0.9mm3.
To delineate the 7 thalamic nuclei groups we followed the procedures described in [4]. The segmentation was performed applying k-means algorithm with 2 equally contributing features: the spatial position and the ODF coefficients in the SH basis computed with FSL Qboot.
The cluster corresponding to the VLV nuclei group was further partitioned in 3 sub-clusters, in each case respectively. For this aim, we first constructed a k-nn graph with 10 nearest neighbors within each VLV. We used only the ODF distances to represent the graph edges. Then, we applied NCut algorithm[5]. We subdivide the VLV in 3 sub-clusters since it is the maximum number of clusters that gave a consistent segmentation pattern along the subjects.
The outcome was qualitatively compared with the GKT target appearing as contrast enhancement (CE) on the post-operative images.

Results:

The robust segmentation pattern previously observed in the healthy population was found again in all 11 patients. Moreover, the CE was always enclosed inside VLV (figure1).

A reproducible pattern of the VLV subdivision was also observed. Additionally, in 8 cases one exclusive sub-cluster entirely covered the CE, while in the remaining 3 cases, the CE was found on the interface, but still overlapping with the same cluster (figure1).

Conclusions:

Our previously proposed method for thalamic nuclei parcellation remains robust even in clinical cases of elderly subjects with tremor that are likely to engender more motion artifacts. Moreover, the CE on the post-operative images appears always inside VLV, which is an extended validation of the framework.
Additionally, the VLV sub-partition allowed us, for the first time in the literature, to automatically outline a narrower spatial localization of the Vim that should be further investigated to accurately delineate the actual borders of the treatment target.

Disorders of the Nervous System:

Parkinson's Disease and Movement Disorders [2]

Modeling and Analysis Methods:

Segmentation and Parcellation [1]

Poster Session:

Poster Session - Tuesday

Keywords:

Movement Disorder
Segmentation
Thalamus

[1|2]Indicates the priority used for review

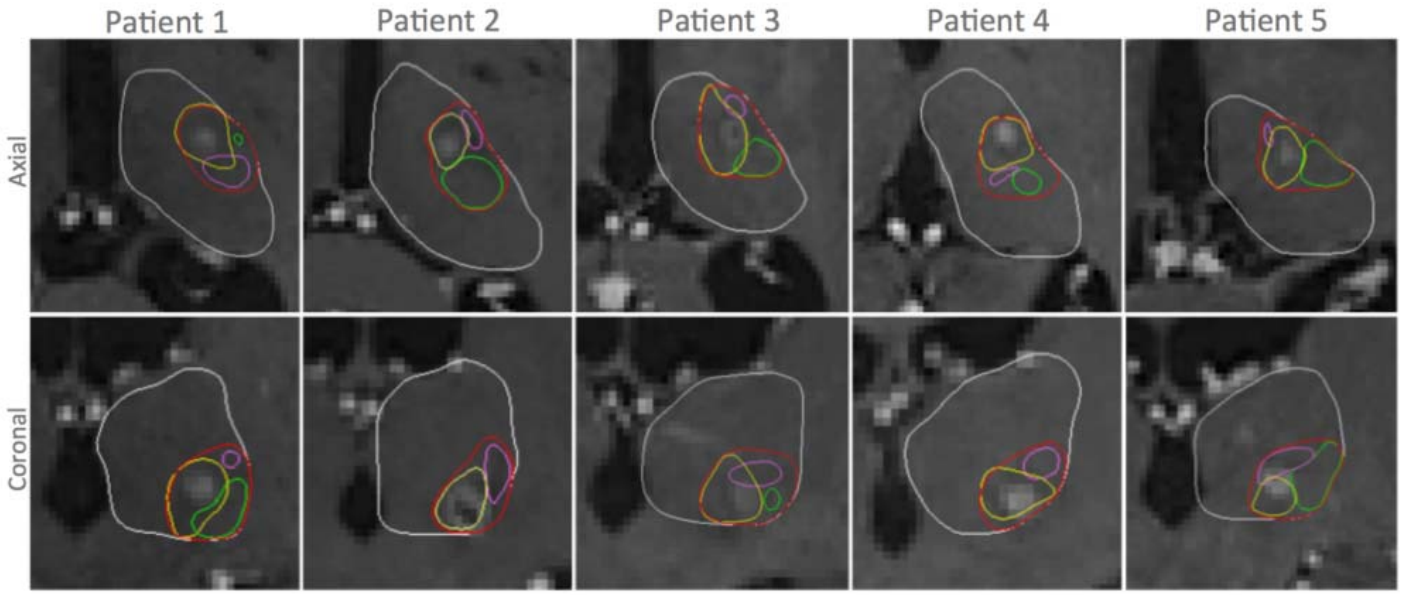

Figure1: Overview of the results shown in 5 different cases in axial and coronal view
The white and the red contours represent the thalamus and the automatically segmented Ventral-Lateral-Ventral (VLV) nuclei group, respectively. The further VLV sub-partitions, obtained with NCut, are given in pink, yellow and green. One can observe that the contrast enhancement (CE) corresponding to the GKT targeted area (e.g. the Vim) is always inside VLV, and furthermore, inside the yellow sub-cluster. Patient 5 is an example (one of the 3 observed among all 11 cases) where CE appears on the the sub-partitions interface but, at the same time, has an important overlap with the yellow sub-cluster.

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1.5T
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FSL
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Provide references in author date format

1. Behrens et al., Non-invasive mapping of connections between human thalamus and cortex using diffusion imaging. Nat Neurosci, 2003. 6(7): p. 750-7
2. Guiot et al., Stereotaxic surgery of tremors. Neurochirurgie, 1976. 22(6): p. 532-5
3. Kumar et al., Direct diffusion-based parcellation of the human thalamus. Brain Struct Funct, 2015. 220(3): p. 1619-35
4. Najdenovska et al., Novel Robust Segmentation of the Thalamic Nuclei Proceedings of the International Society for Magnetic Resonance in Medicine, 2015
5. Shi et al., Normalized cuts and image segmentation. 1997 Ieee Computer Society Conference on Computer Vision and Pattern Recognition, Proceedings, 1997: p. 731-737
6. Wiegell et al., Automatic segmentation of thalamic nuclei from diffusion tensor magnetic resonance imaging. Neuroimage, 2003. 19 (2 Pt 1): p. 391-401