Morel stereotactic atlas of the human thalamus

In 1997, Morel, Magnin, and Jeanmonod presented a microscopic stereotactic atlas of the human thalamus. Parcellations of thalamic nuclei did not only use cyto- and myeloarchitectonic criteria, but were additionally corroborated by staining for calcium-binding proteins, which bears functional significance. The atlas complies with the Anglosaxon nomenclature elaborated by Jones and the data were sampled in three orthogonal planes in the AC-PC reference space [1)].

Niemann et al., report on the generation of three-dimensional digital models of the thalamus based on the three sets of sections (sagittal, horizontal, and frontal). Spatial differences between the three anatomical specimens were evaluated using the centers of gravity of 13 selected nuclei as landmarks. Subsequent linear regression analysis yielded equations, which were used to normalize the frontal and horizontal digital models to the sagittal one. The outcome is an internally consistent Canonical Model of Morel's atlas, which minimizes the linear component of the variability between the three sectioned anatomical specimens. In addition, Niemann et al., demonstrate the feasibility of the atlas-to-MRI registration in conjunction with on-line visualization of the trajectory in the digital model [2)].

Case series

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40 patients with PD in whom bilateral DBS electrodes had been implanted in the Subthalamic nucleus (STN). Based on the Morel stereotactic atlas of the human thalamus, Garcia-Garcia et al., created an adaptable 3D atlas that takes into account individual anatomical variability and divides the STN into functional territories. The locations of the electrodes and active contacts were obtained from an accurate volumetric assessment of the artifact using preoperative and postoperative MR images. Active contacts were positioned in the 3D atlas using stereotactic coordinates and a new volumetric method based on an ellipsoid representation created from all voxels that belong to a set of contacts. The antiparkinsonian benefit of the stimulation was evaluated by the reduction in the Unified Parkinson Disease Rating Scale Part III (UPDRS-III) score and in the levodopa equivalent daily dose (LEDD) at 6 months. A homogeneous group classification for contact position and the respective clinical improvement was applied using a hierarchical clustering method.

Subthalamic deep brain stimulation induced a significant reduction of 58.0% ± 16.5% in the UPDRS-III score ($p < 0.001$) and 64.9% ± 21.0% in the LEDD ($p < 0.001$). The greatest reductions in the total and contralateral UPDRS-III scores (64% and 76%, respectively) and in the LEDD (73%) were obtained when the active contacts were placed approximately 12 mm lateral to the midline, with no influence of the position being observed in the anteroposterior and dorsoventral axes. In contrast, contacts located about 10 mm from the midline only reduced the global and contralateral UPDRS-III scores by 47% and 41%, respectively, and the LEDD by 33%. Using the ellipsoid method of location, active contacts with the highest benefit were positioned in the rostral and most lateral portion of the STN and at the interface between this subthalamic region, the zona incerta, and the thalamic fasciculus. Contacts placed in the most medial regions of the motor STN area provided the lowest clinical efficacy.

The authors report an accurate new methodology to assess the position of electrodes and contacts used for chronic subthalamic stimulation. Using this approach, the highest antiparkinsonian benefit is achieved when active contacts are located within the rostral and the most lateral parts of the motor region of the STN and at the interface of this region and adjacent areas (zona incerta and thalamic fasciculus) [3].

1)

Morel A, Magnin M, Jeanmonod D. Multiarchitectonic and stereotactic atlas of the human thalamus. J Comp Neurol. 1997 Nov 3;387(4):588-630. Erratum in: J Comp Neurol 1998 Feb 22;391(4):545. PubMed PMID: 9373015.

2)

Niemann K, Mennicken VR, Jeanmonod D, Morel A. The Morel stereotactic atlas of the human thalamus: atlas-to-MR registration of internally consistent canonical model. Neuroimage. 2000 Dec;12(6):601-16. PubMed PMID: 11112393.

3)

Garcia-Garcia D, Guridi J, Toledo JB, Alegre M, Obeso JA, Rodríguez-Oroz MC. Stimulation sites in the subthalamic nucleus and clinical improvement in Parkinson's disease: a new approach for active contact localization. J Neurosurg. 2016 Nov;125(5):1068-1079. PubMed PMID: 26848922.