Microsurgical anatomy of the subthalamic nucleus: correlating fiber dissection results with 3-T magnetic resonance imaging with the aid of neuronavigation

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Introduction

Understanding of the three-dimensional (3D) anatomy of the subthalamic region remains challenging due to the variable shape, oblique orientation, and relatively small size of the nucleus. We aimed to reveal the 3D anatomy of the STN and related structures using fiber dissection technique, 3D reconstruction of high resolution MRI, and tractography.

Methods

20 hemispheres and 3 heads have been disscted in accordance with the Klingler method.The dissections were performed in a stepwise manner from lateral to medial, medial to lateral, superior to inferior, and inferior to superior to reveal the 3D anatomy of the STN. 3 T MRI with 1 mm slices was taken of head specimens for MR navigation before starting the cranial dissections. In addition, three brains were cut into 5 mm coronal, axial and sagittal slices to show the sectional anatomy.

Results

The hypothalamus is located anteromedial to the STN and lies just posteroinferior to the anterior commissure (Figure 1). The internal course of the oculomotor nerve and its nucleus are also related to the subthalamic area. The nerve arises from its nucleus lateral to the cerebral aqueduct at the level of the superior colliculi. The fibers from the third nerve nuclei, located in the pre-aquaductal grey matter region, run anteriorly lateral to the red nucleus and medial to the STN (Figure 2). The medial forebrain bundle is exposed by removing the STN medially and moving in an anteroinferior direction. The MFB connects the lateral hypothalamus and the septal area with the ventral tegmental area (Figure 3). The MFB lies at the level of and lateral to the red nucleus, lateral to the mamillothalamic tract, medial to the substantia nigra and slightly anterior and inferomedial to the STN (Figure 4).

Figure 1

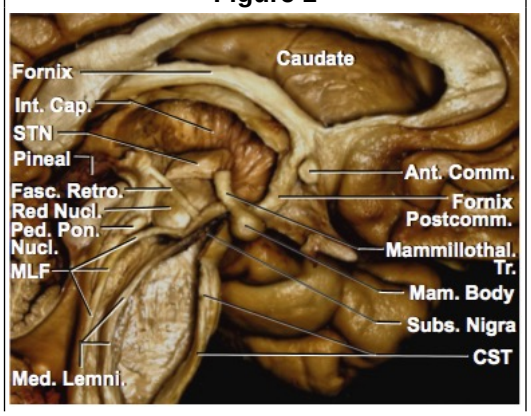
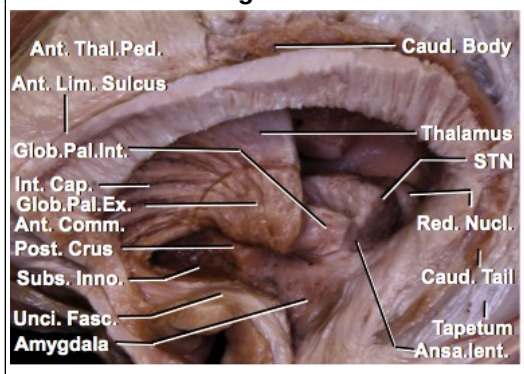
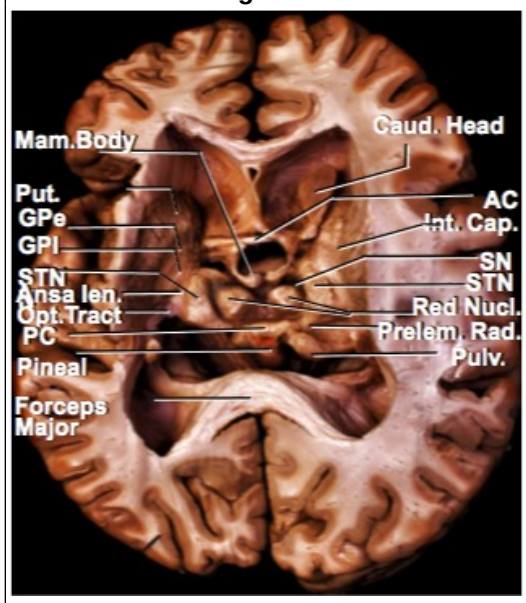


Figure 2



Fiber Dissection: lateral to medial. Removing posterior part of the thalamus exposes subthalamic nucleus laterally, red nucleus inferomedially and substantia nigra inferiorly.

Figure 3

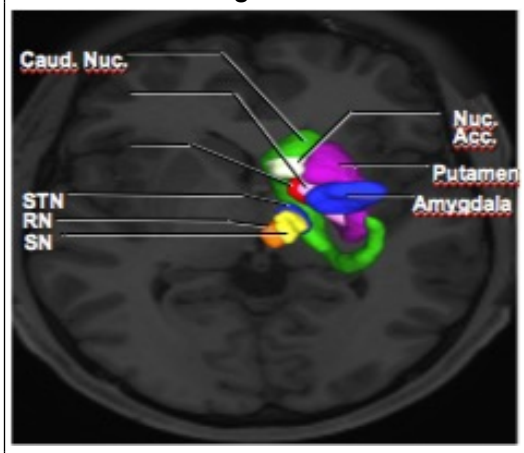


Fiber Dissection: Superior to Inferior.

Conclusions

Understanding the complex 3-D anatomy of the STN and peri-subthalamic area may provide a better perspective for STN targeting.

Figure 4.



The inferior view of 3D MR reconstruction of the STN, RN, SN,ZI, GPi,GPe, amygdala, caudate nucleus and putamen.