

Three-dimensional reconstruction of the lentiform nucleus from serial sections in man*

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*This study was presented as an oral communication at the National Congress of Anatomy, Histology and Embryology with International Participation at Pleven, Bulgaria, on September 18, 1999.

[Received 27 February 2002; Revised 5 June 2002; Accepted 5 June 2002]

Three-dimensional (3-D) reconstruction of the lentiform nucleus was performed by using serial macroscopic anatomic sections, taken from a human cadaver. When the rendered form of this wire-frame reconstruction was examined, it was found that both the putamen and globus pallidus had upper and lower poles. The distances between the upper and lower poles were 2.23 cm in the putamen and 1.45 cm in the globus pallidus. The lower poles of the putamen and globus pallidus were about the same level but the upper pole of the putamen was 0.78 cm higher than in the globus pallidus. The vertical dimension of the lentiform nucleus was 22.9 mm. This is the first study reporting the three-dimensional reconstruction and the dimensions of the lentiform nucleus of the human brain. We believe that this study will be of help in future studies concerning the lentiform nucleus and its relations.

key words: lentiform nucleus, three-dimensional (3-D) reconstruction, human brain

INTRODUCTION

The lentiform nucleus is a group of nuclei accepted as a part of the basal nuclei. It has the shape of a biconvex lens, with its medial surface having a more pronounced curvature [6]. The connections and functional significance of the lentiform nucleus in the human brain are widely studied [1–3] but the three-dimensional reconstruction of the lentiform nucleus has not been reported previously. Therefore we aimed to obtain a computer-aided three-dimensional appearance and the dimensions of the lentiform nucleus by using serial sections taken from the brain of a human cadaver.

MATERIAL AND METHODS

The three-dimensional (3-D) reconstruction of the lentiform nucleus was performed on the left cerebral hemisphere of a 50-year-old formalin-fixed male cadaver. This cerebral hemisphere was kept at -20° C for 48 hours. Serial horizontal sections (Fig. 1) of the cerebral hemisphere were obtained with 600 μ m increments on a cryotome (Reicheirt). The landmarks were put into the trimming system apparatus in the X-axis and in the Y-axis, in order to prevent the rotation and shift of the serial sections.

After each trimming procedure, the obtained sections were photographed with close-up lenses. These

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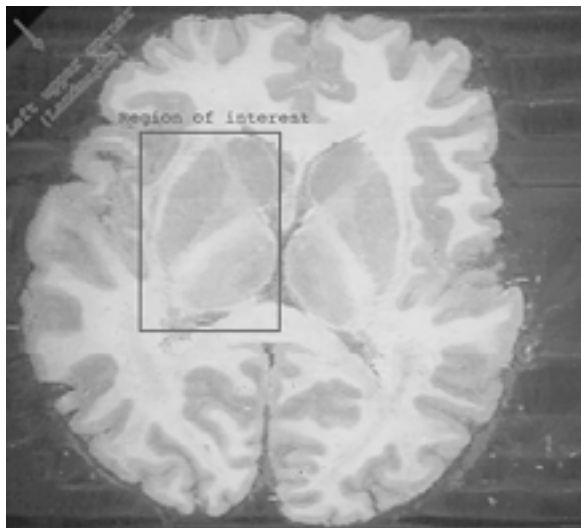


Figure 1. Transverse section of the reconstructed brain.

photographs were scanned by an UMAX Astra 1200S scanner and they were transferred into an Apple Power Macintosh 4400/200 computer. The contours of the lentiform nucleus were traced by a manual method (Adobe Photoshop 3.0 for Macintosh) and the obtained traces were transformed into a 3-D reconstruction program (Adobe Dimension 2.0 for Macintosh). The thickness of each serial section ($100\ \mu\text{m}$) and the distance between two consecutive serial sections ($500\ \mu\text{m}$) were taken into consideration during the 3-D reconstruction process. At first, the wire-frame reconstruction (Fig. 2) and then the rendered form of this wire-frame reconstruction from different view angles (Figs. 3–5) was obtained. The obtained images were transformed into hard-copies by a Xerox Docu Color 40 (Fiery 525) printer.

The contours of the major related structures were added to the 3-D reconstruction once for every ten lentiform nucleus serial sections in order to facilitate the understanding of the relations of the lentiform nucleus (Figs. 2–5).

The statistical analysis was performed by using an Apple Macintosh Colour Classic computer with InStat for Mac and StatView II software.

RESULTS

The serial sections of the lentiform nucleus were $100\ \mu\text{m}$ in thickness. The distance between two consecutive serial sections used in the 3-D reconstruction of the lentiform nucleus was $500\ \mu\text{m}$. With this method, 39 serial sections were obtained and, therefore, the vertical dimension of the lentiform nucleus was $22.9\ \text{mm}$ [$(39 \times (100 + 500)) - 500\ \mu\text{m}$].

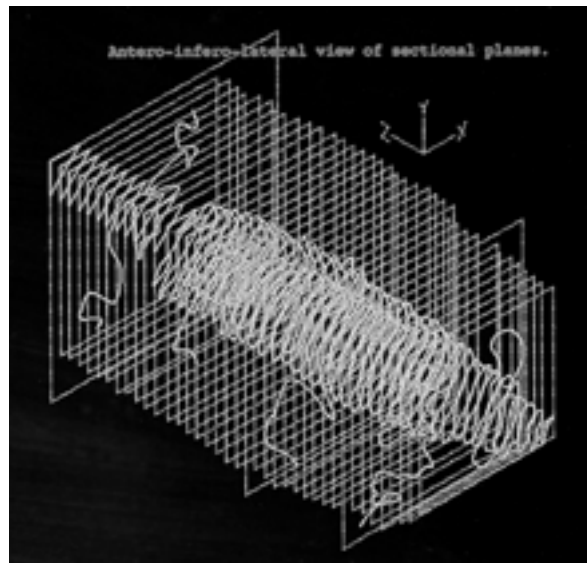


Figure 2. The wire-frame image of the human left hemispheric lentiform nucleus and the anatomic axes.

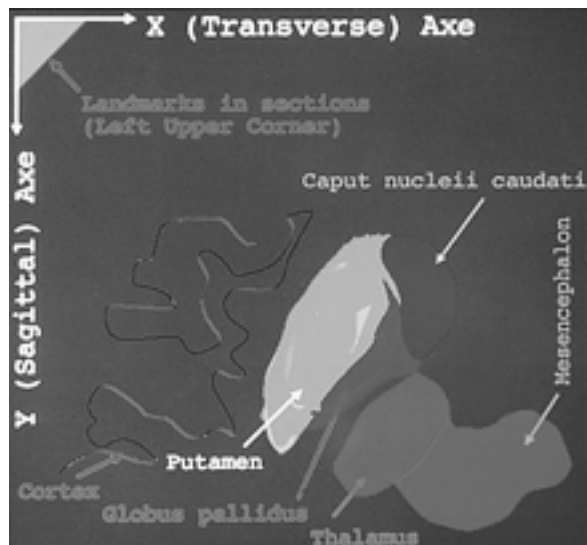


Figure 3. The rendered image of the human left hemispheric lentiform nucleus from above.

Wire-frame reconstruction of the lentiform nucleus did not give any idea about the 3-D shape of these nuclei. On the other hand, when rendered form reconstruction was built, the lentiform nucleus was observed as an oval structure. It was possible to give different colours to the putamen and globus pallidus and examine their 3-D positions. At the rendered forms, one section from the surrounding structures, thalamus, mesencephalon, caudate nucleus and cerebral cortex, were included in order to examine their relationship with the lentiform nuclei. It was possi-

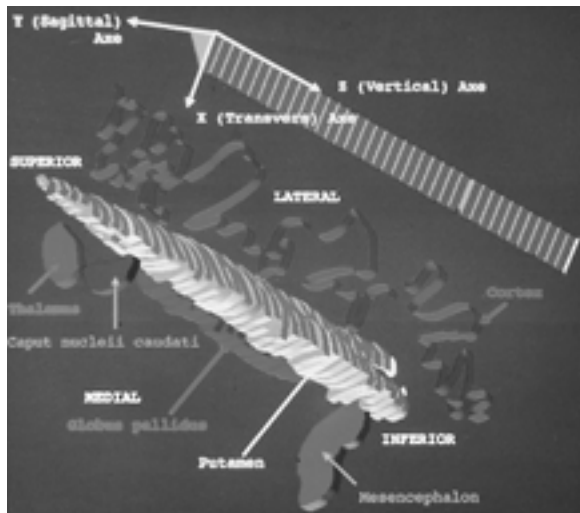


Figure 4. The rendered image of the human left hemispheric lentiform nucleus from anterior, superior and medial aspect.

ble to turn the whole structure in any direction, which can be very useful for educational purposes and for understanding the spatial relationship of the defined structures.

In addition to the classically defined lens shapes, both the lentiform nucleus and globus pallidus had upper and lower poles. The distances between the upper and lower poles were 2.23 cm in the putamen and 1.45 cm in the globus pallidus. The lower poles of the putamen and globus pallidus were about the same level but the upper pole of the putamen was 0.78 cm higher than in the globus pallidus.

This is the first study reporting a 3-D reconstruction of the lentiform nucleus of the brain taken from a human cadaver. Cheap and easily available programs were used during the reconstruction procedure.

DISCUSSION

The lentiform nucleus, composed of the globus pallidus and putamen, has important connections with parts of the central nervous system. It sends and receives information from cortical areas [3] and also sends information through the substantia nigra pars reticulata [2]. These connections are very important in the control of movement and motor control disorders, like Parkinson's disease.

The 3-dimensional anatomy of the globus pallidus has gained special clinical importance since pallidotomy received wide acceptance as an effective treatment method in Parkinson's disease. During the application of pallidotomy, the positioning of the

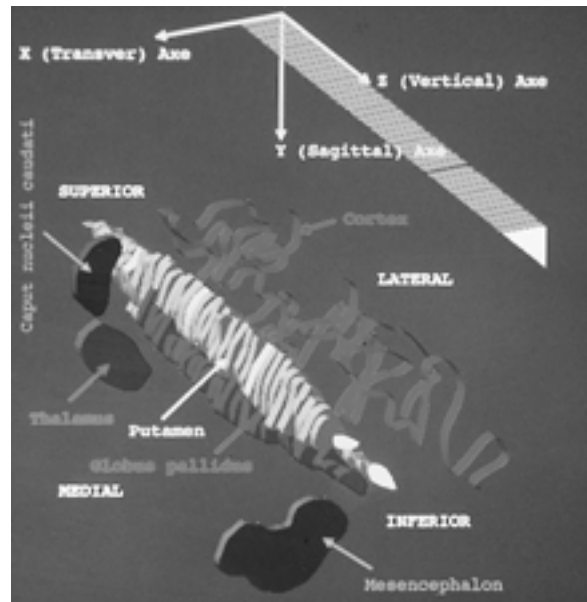


Figure 5. The rendered image of the human left hemispheric lentiform nucleus from anterior, inferior and medial aspect.

lesion at an optimal site is considered essential for achieving clinical improvement [4]. Neurophysiological maps of the globus pallidus are being developed to help define the optimal lesion site precisely [5].

As mentioned previously, there are only a few data related to the lentiform nucleus of the human brain in the literature. Additionally, the computer-aided 3-D reconstruction of the lentiform nucleus and the measurements regarding the dimensions of this structure have not been reported previously. In this study we define a cheap and easy method for 3-D reconstruction from any serial sections or images and demonstrate its application on a real human cadaver. This application gives considerable unreported information about the dimensions and 3-D relationship of the globus pallidus and putamen in man. Therefore, we believe that this study will be of great help in future studies related to the lentiform nucleus.

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