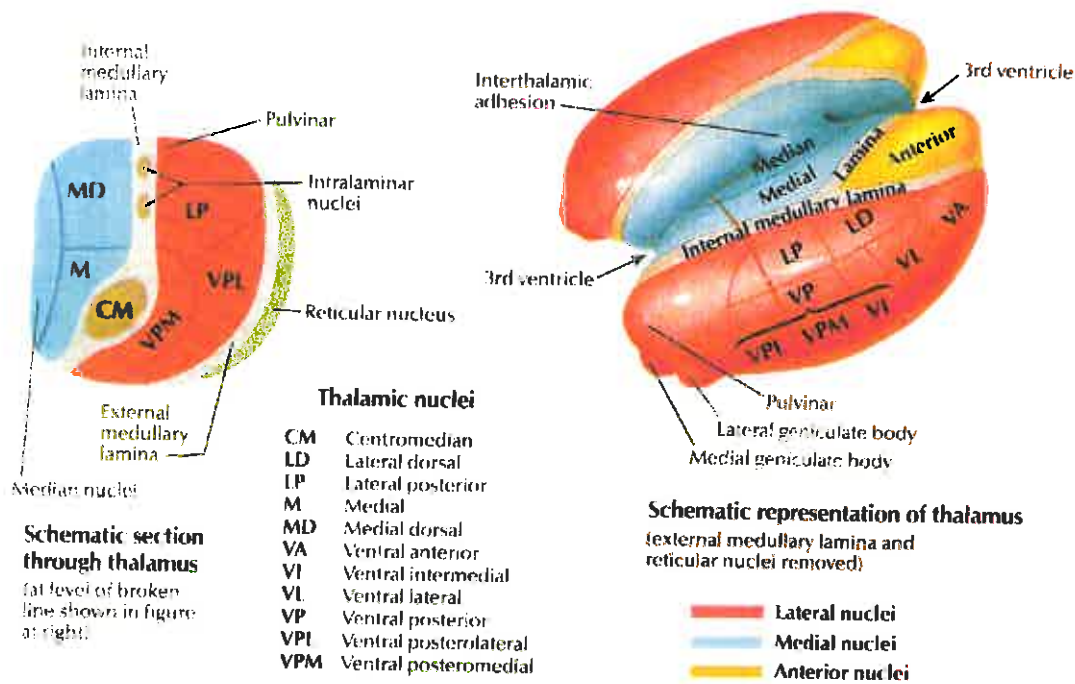


Mediodorsal Nucleus Tracing Guidelines

Introduction:

True to its name, the mediodorsal nucleus of the thalamus lies on the medial aspect of the thalamus' dorsal surface. Separated from the lateral and anterior nuclei by the internal medullary lamina, the MD or mediodorsal nucleus encompasses the majority of the medial portion of the thalamus.



This schematic taken from Netter's *Atlas of Human Anatomy* demonstrates the 3-D relationships of the thalamic nuclei bilaterally. Note the division of the anterior, medial and lateral thalamic nuclear groups as created by the "Y-shaped" internal medullary lamina (Netter 105).

In his discussion on the histology and sectioning of the thalamus, Young provides an excellent description of the mediodorsal nucleus:

The MD begins just caudal and ventral to the AV and ends at the level of the rostral pulvinar. Its medial border is near the lateral wall of the third ventricle except where it merges into the massa intermedia. It is bounded laterally by the fasciculus mammillo-thalamicus anteriorly and by the internal medullary lamina and the centromedian nucleus posteriorly. The large cells of the centrolateral nucleus clearly delineate the lateral boundary of the MD for most of its rostral-caudal extent. The lateral ventricle, fornix, anterior nuclei, and the lateral dorsal nucleus lie on its superior surface and are clearly recognizable. Most posteriorly, the inferior limit merges with the nucleus parafascicularis and centromedian nuclei (Young 946).

These diagrams, taken from John H. Martin's *Neuroanatomy: Text and Atlas*, illustrate how the coronal shape of the mediodorsal nucleus evolves as one moves posteriorly through the thalamus (Martin 389).

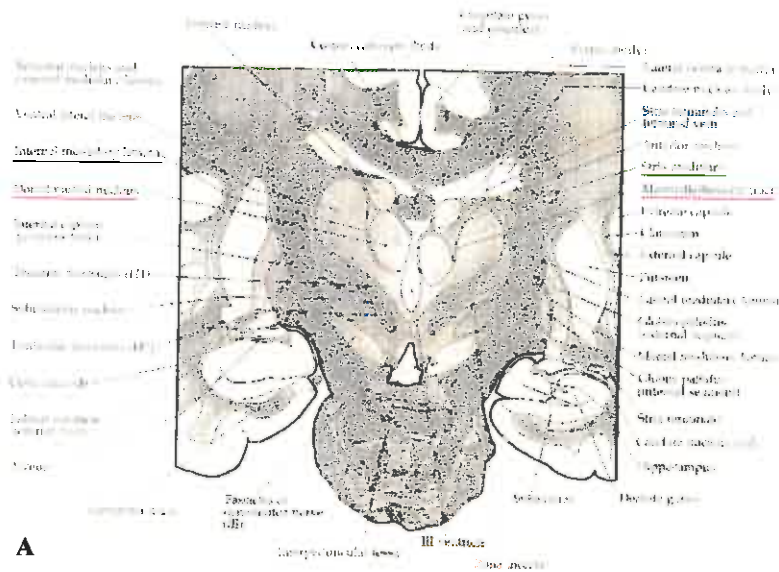


Diagram A

Diagram A depicts an anterior frontal section displaying both the left and right anterior thalamic nuclei. Note the left and right asymmetry of both the anterior and the mediodorsal nuclei.

Diagram B illustrates a more posterior frontal section. In this view, one of the anterior nuclei is replaced by the lateral dorsal nucleus while the other anterior nucleus remains.

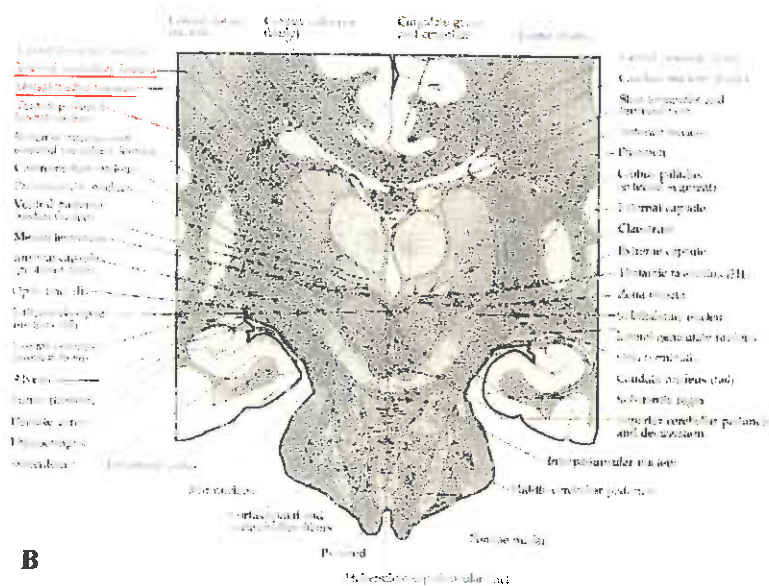


Diagram B

an oblique
transverse
section

These diagrams, taken from Carpenter's *Core Text of Neuroanatomy*, provide a unilateral view of the thalamus as a 3-D structure (Carpenter 262).

Diagram C provides an oblique dorsolateral view of the thalamus and its major subdivisions, again demonstrating the separation of the MD from neighboring structures by the internal medullary lamina.

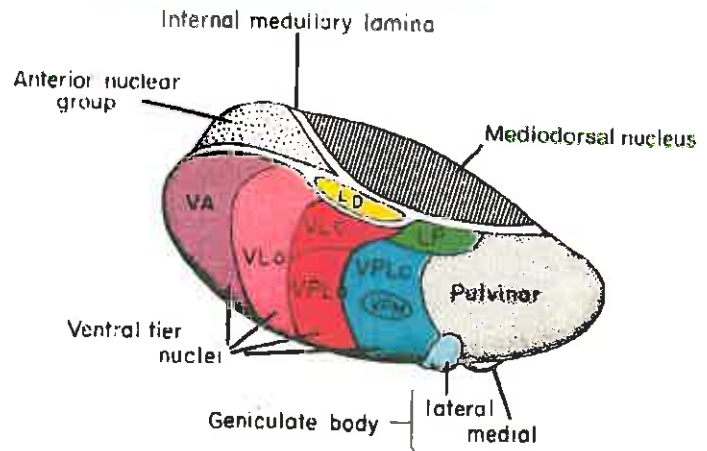


Diagram C

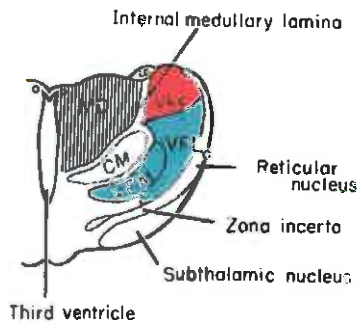


Diagram D

Diagram D is an example of an oblique section showing the spatial relationships between the mediodorsal nucleus, the centromedian nucleus and the ventral lateral nuclei as created by the internal medullary lamina.

In his *Core Text of Neuroanatomy*, Carpenter comments on the medial and lateral boundaries of the mediodorsal nucleus as seen on oblique section:

The mediodorsal nucleus (MD), or dorsomedial nucleus, occupies most of the area between the internal medullary lamina and the periventricular grey (Carpenter 258).

In his ??????, ?????????????????? discusses the difficulty of delineating the posterior boundary of the mediodorsal nucleus:

The n. medialis is well delimited by the midline and the cells of the internal medullary lamina (n. intralamellaris) except posteriorly where it joins with the pulvinar. Here the n. intralamellaris breaks up into small islands of cells between which the cells of n. medialis go over into the pulvinar without a sharp boundary on either cresyl violet or myelin stains (????? 68).

In his text, *The Thalamus*, Jones describes the relative location of the mediodorsal nucleus and its boundaries as seen on histological sectioning:

The mediodorsal nucleus is usually large and occupies up to two-thirds of the length of the thalamus. Its anterior pole is usually difficult to define for it blends with the parataenial, and other adjacent nuclei. The posterior pole is also often unclear as it is traversed by the habenulopeduncular tract and encroached upon by irregular islands of cells belonging to the parafascicular and central lateral nuclei. Medially there is usually a cellular condensation where the two mediodorsal nuclei meet in the midline, though it seems to me to consist mainly of posterior parts of the rhomboid nucleus. Ventrally and laterally, the nucleus abuts upon the internal medullary lamina containing the central medial, paracentral, and central lateral nuclei but the line of junction between them usually becomes less clear posteriorly. Here, large cells of the central lateral nucleus and/or parafascicular nucleus tend to invade the ventrolateral aspect of the mediodorsal nucleus (Jones 649).

Boundaries:

- i. The anterior boundary of the MD was arbitrarily established using the presence of the bilateral mamillary bodies as a landmark (Figures 2-3). Tracing begins two slices posterior to the most posterior view of the bilateral mamillary bodies (Figures 4-6). At this level, the crus cerebri is often easily identifiable and can serve as a useful reference structure.
- ii. The medial border of the MD is established by the wall of the third ventricle, the CSF of the third ventricle or the massa intermedia (interthalamic adhesion) where present (Figures 4-21). The stria medullaris, as it extends along the dorsomedial margin of the thalamus, also serves as a medial border (Figures 7-21).
- iii. The MD is bounded laterally by the white matter of the mammillothalamic tract as it courses from the mamillary bodies to the anterior nuclei and the internal medullary lamina in more posterior slices (Figures 4-18). With their emergence posteriorly, the centromedian nuclei provide the inferolateral boundaries of the MD (Figures 19-21). At this level, the central lateral and the parafascicular nuclei serve as inferior borders on the ventrolateral surface of the MD.
- iv. Surrounded by a capsule of myelinated fibers, the anterior nuclei establish the MD's superior border in the anterior most slices (Figures 4-15). As one moves in a posterior fashion, the anterior nuclei are replaced by the lateral dorsal nucleus in the coronal plane. At this level the lateral dorsal nucleus serves as the superior boundary for the MD (Figures 16-21).
- v. In the anterior slices, care was taken not to include the hypothalamus inferiorly (Figures 4-9). Posterior to the level of the hypothalamus, the white matter of the

mammillothalamic tract and the zona incerta (a small, relatively clear area dorsal and rostral to the subthalamic nucleus) serve as the inferior border of the MD (Figures 10-18). Note the clear separation of the MD from the nucleus rubor as provided by the zona incerta (Figures 13-18). In the most posterior slices the centromedian and the habenular nuclei served as the inferolateral and inferomedial borders, respectively.

vi. The posterior boundary of the MD was arbitrarily determined using the posterior commissure as a landmark. The most anterior slice containing the posterior commissure's complete "bridge" of white matter is located (Figures 22-23). Tracing terminates two slices anterior to this landmark (Figures 19-21).

Figures:

The figures that follow are grouped into threes. The first figure represents a frontal section taken from Duvernoy's *The Human Brain Surface, Three-Dimensional Sectional Anatomy and MRI*. The second and third figures represent a similar slice as seen on the T1 image—one figure representing the examples of anatomical landmarks and the other figure illustrating the boundaries of the mediodorsal nucleus as it was traced in the coronal plane. Sets including only two figures represent slices on which the mediodorsal nucleus was not traced. It should be noted that a grey-scale palette was applied to the resampled T1 image in an effort to increase contrast between grey matter and to aid in the visualization of the MD.

Figure 1 depicts the thalamus at the level of the ventral anterior thalamic nucleus (va) as seen on frontal section in Duvernoy's *The Human Brain Surface, Three-Dimensional Sectional Anatomy and MRI*. Note the relative size and location of the hypothalamus (h), the amygdala (a) and the mamillary bodies prior to the emergence of the mediodorsal nucleus (Duvernoy 117).

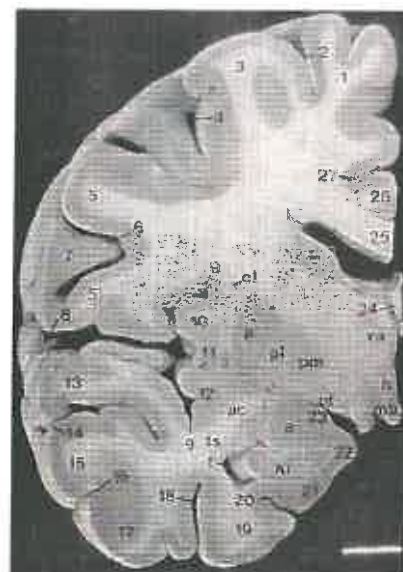


Figure 1

Figure 2 is an example of the area slightly caudal to the ventral anterior thalamic nucleus as illustrated in the Duvernoy atlas. Note the retreat of the hypothalamus as one moves in a posterior fashion (Duvernoy 119).

The size and relative location of the caudate (c), the fornix (25) and the corpus callosum (26) assist in orienting one within the brain.

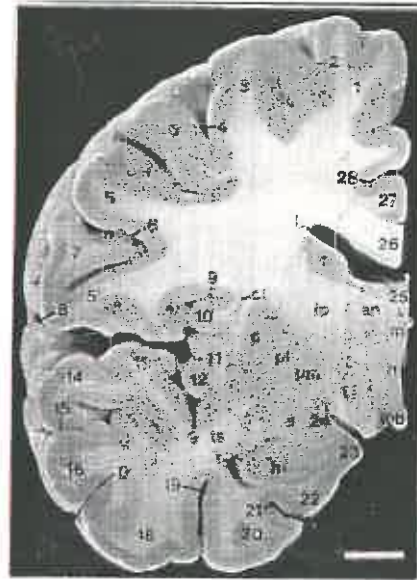


Figure 2



Figure 3

Figure 3 represents a similar coronal section as seen on the T1 image. The emergence of the mamillary bodies serves as an important landmark as tracing begins two slices posterior to their bilateral visualization.

Figure 4, taken from the Duvernoy atlas, represents a frontal section depicting the emergence of the mediodorsal nucleus (m) as surrounded by the anterior nucleus (an), the ventral lateral thalamic nucleus (vl) and the hypothalamus (h) on its superior, lateral and inferior borders respectively (Duvernoy 121).

Figures 5 & 6 represent a similar coronal section as seen using the T1 image. Note the use of the internal medullary lamina as the lateral border of the mediodorsal nucleus.

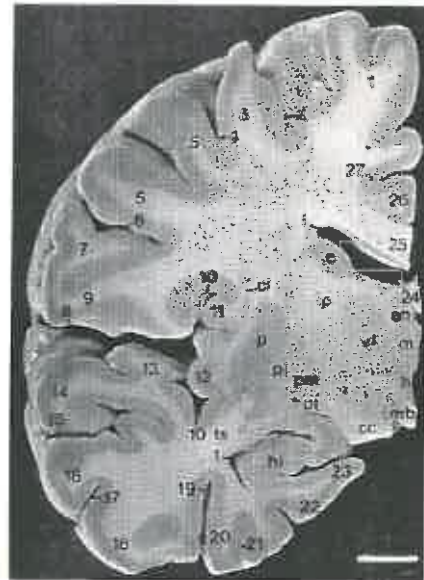


Figure 4

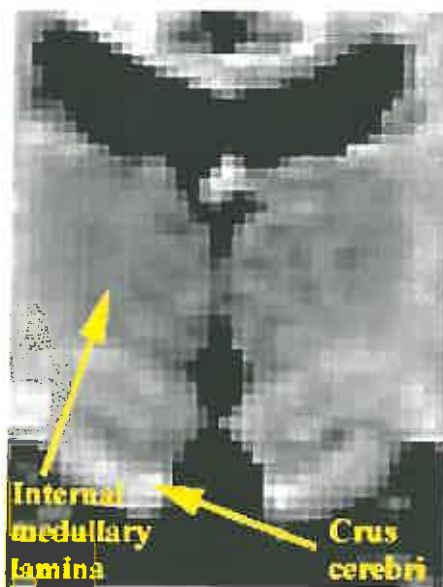


Figure 5



Figure 6

Figure 7 illustrates a frontal section from Duvernoy's *The Human Brain Surface, Three-Dimensional Sectional Anatomy and MRI* that demonstrates the progression of the mediodorsal nucleus (m) as one moves in a posterior fashion (Duvernoy 121). Note the disappearance of the hypothalamus and the apparent dilation of the ventral lateral thalamic nucleus (vl).

Figures 8 & 9 represent a similar coronal section as seen using the T1 image. Note the presence of the stria medullaris as it serves as the dorsomedial border.

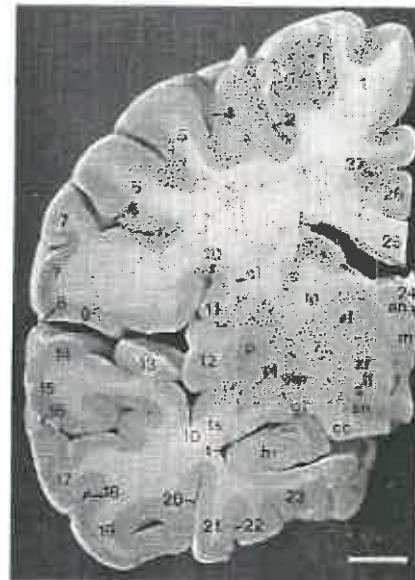


Figure 7

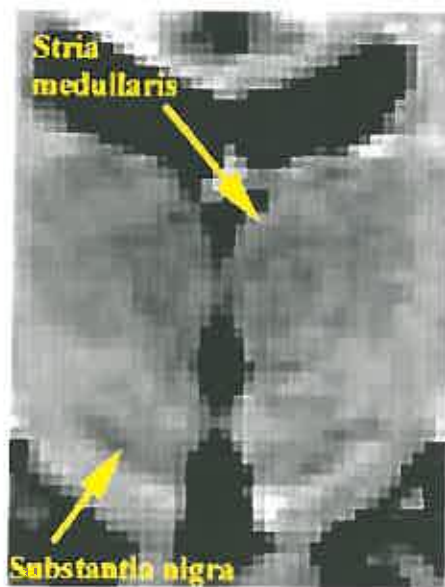


Figure 8



Figure 9

Figure 10 is a frontal section taken from the Duvernoy atlas. Note the presence of the mammillothalamic tract (mt) as it meanders in an inferior fashion separating the mediodorsal nucleus (m) from the ventral lateral thalamic nucleus (vl) and joins with the zona incerta (zi) below (Duvernoy 125).

Figures 11 & 12 represent a similar coronal section as seen on the T1 image. Careful inspection reveals the presence of white matter surrounding the entire mediodorsal nucleus, even on its medial border. Note the presence of the subthalamic nucleus (s) and the substantia nigra (sn).

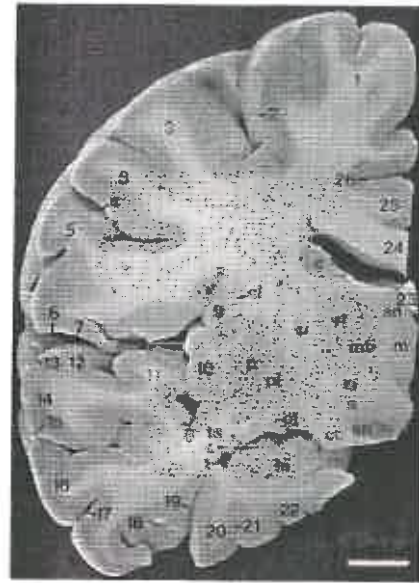


Figure 10

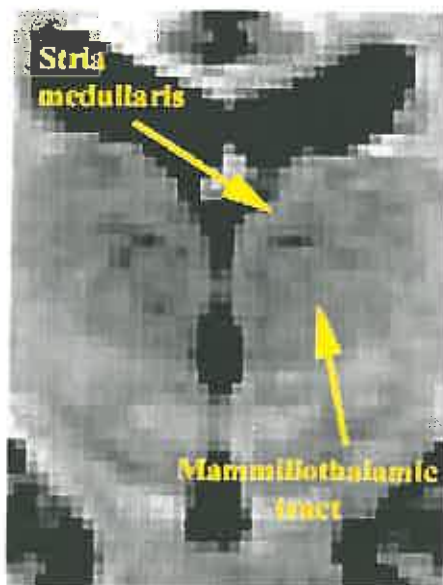


Figure 11



Figure 12

Figure 13 demonstrates the coronal retreat of the anterior thalamic nucleus (an) as depicted by Duvernoy's *The Human Brain Surface, Three-Dimensional Sectional Anatomy and MRI*. Note the dilation of the mediodorsal nucleus as depicted on frontal section (Duvernoy 127).

Figures 14 & 15 illustrate a similar coronal section as seen on the T1 image. White matter is depicted by variations in grey along the medial and lateral borders of the mediodorsal nucleus as seen with the internal medullary lamina. Note the appearance of the red nucleus on coronal section.

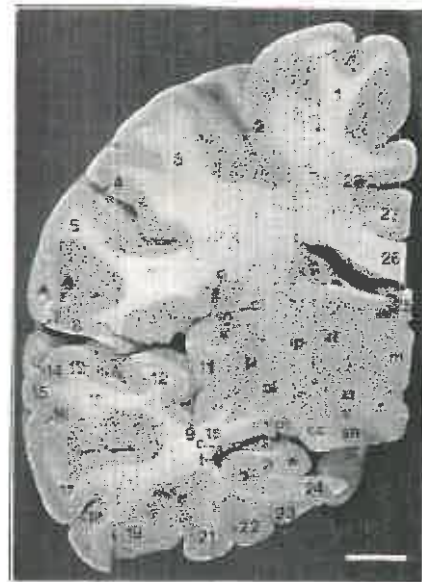


Figure 13

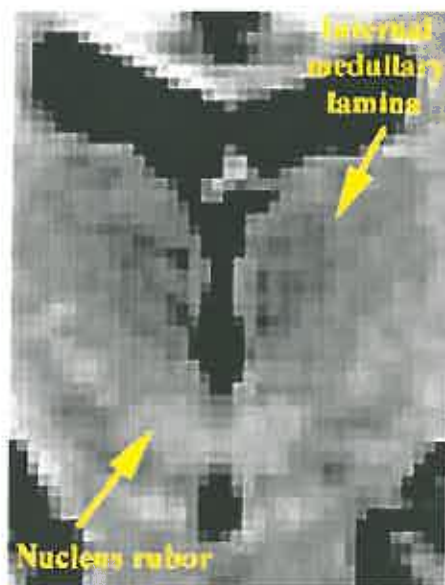


Figure 14



Figure 15

Figure 16, taken from the Duvernoy atlas, depicts the emergence of the lateral dorsal thalamic nucleus (ld) as seen on frontal section. Note the absence of the anterior thalamic (an) nucleus at this level (Duvernoy 129).

Figures 17 & 18 display a similar coronal section, illustrating the use of the stria medullaris and the internal medullary lamina as the medial and lateral boundaries respectively.

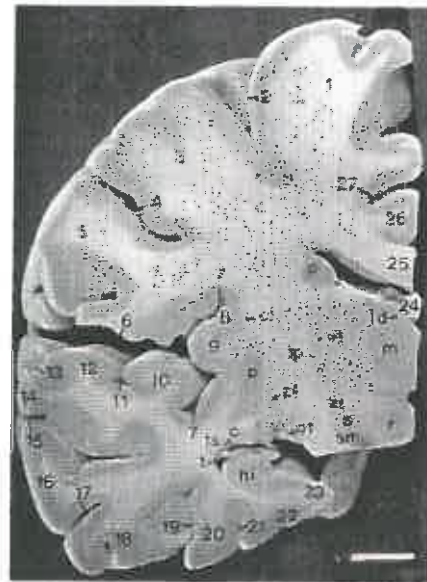


Figure 16

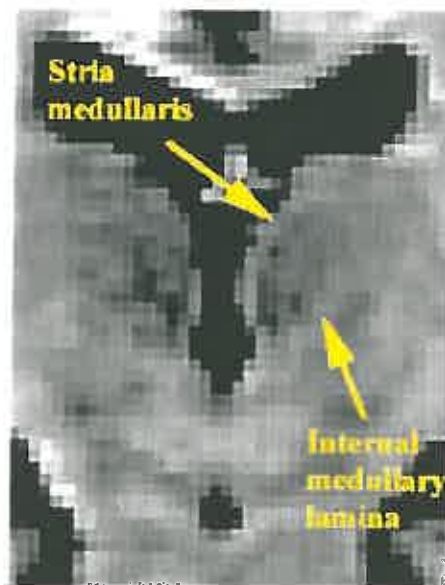


Figure 17



Figure 18

Figure 19 is an example of the caudal portion of the mediodorsal nucleus on frontal section as illustrated in the Duvernoy atlas. Note the persistence of the lateral dorsal thalamic nucleus (ld) and the emergence of the lateral posterior (lp), centromedian (cm) and the habenular (ha) nuclei (Duvernoy 141).

Figures 20 & 21 depict a similar coronal section as seen on the T1 image. Note the intensity of the habenular nucleus (ha).



Figure 19

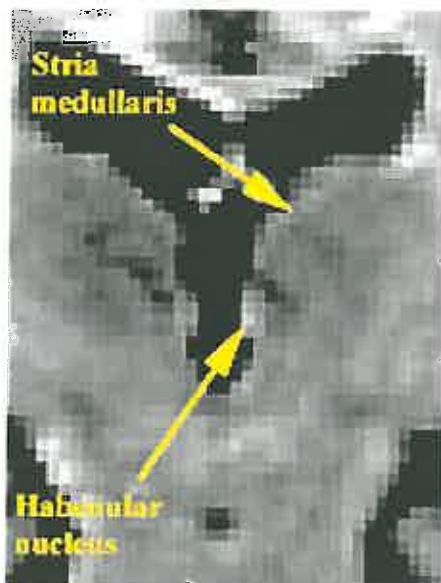


Figure 20

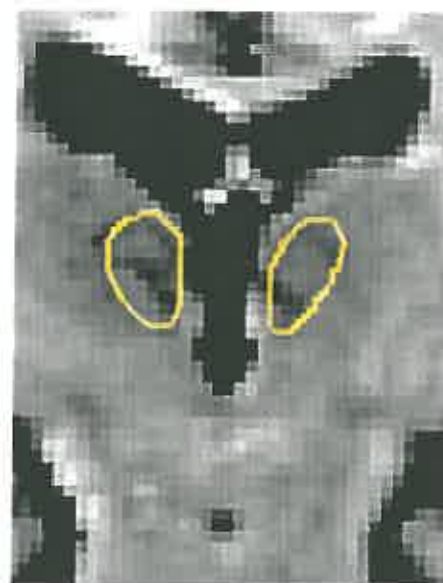


Figure 21

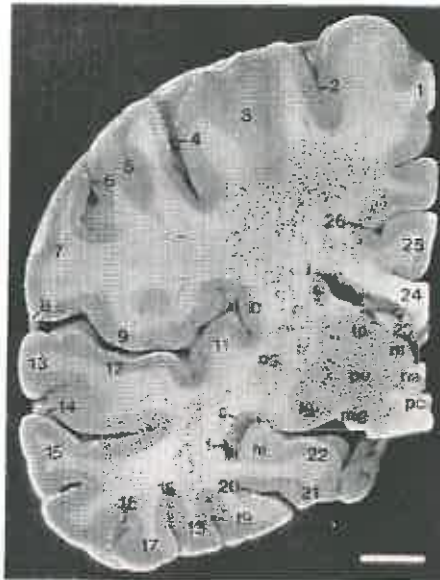


Figure 22

Figure 22, a frontal section taken from Duvernoy's *The Human Brain Surface, Three-Dimensional Sectional Anatomy and MRI*, illustrates the relative location of the lateral posterior thalamic nucleus (lp), the pulvinar nucleus (pu) and the habenular nucleus (ha) as they enclose the mediodorsal nucleus (m).

Figure 23 is a similar coronal section as seen on the T1 image. Notice how the posterior commissure forms a white linear structure as it bridges the gaps between the hemispheres. Tracing terminates two slices anterior to the emergence of this structure.

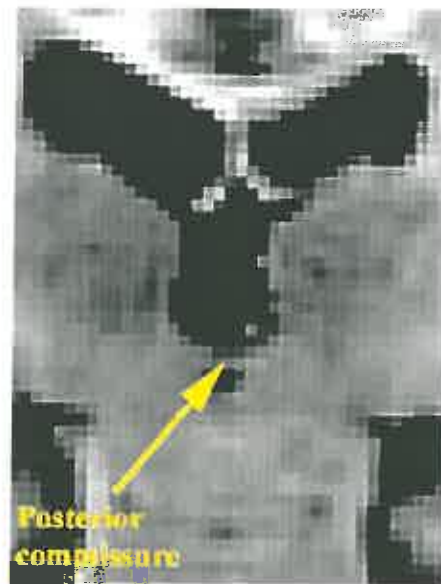


Figure 23

Figure 24 illustrates the capability of BRAINS2 to telegraph coronal traces into the axial plane. These telegraphed crosses prove useful in visualizing the spatial relationships between thalamic nuclei. Note the presence of the internal medullary lamina, serving as the lateral border of the mediodorsal nucleus.

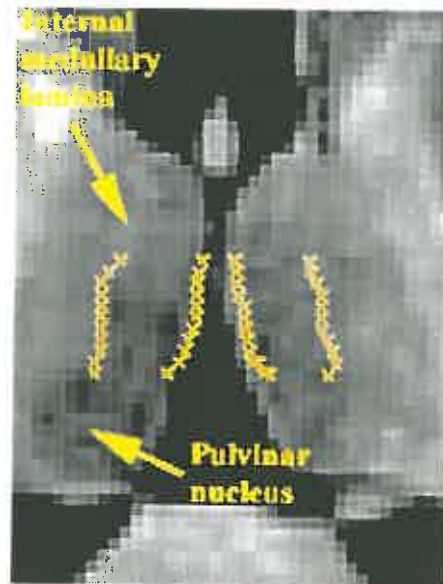


Figure 24

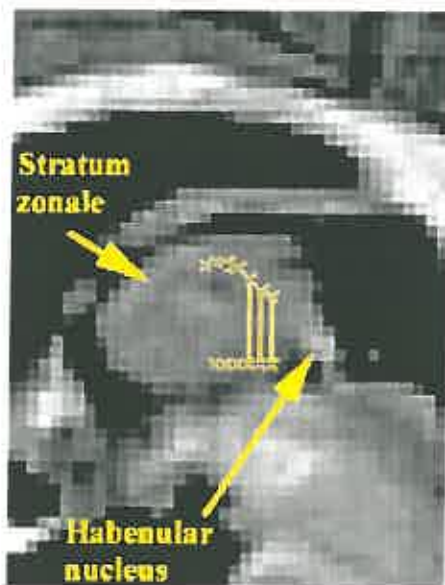


Figure 25

Figure 25 makes use of the telegraph crosses, allowing for the visualization of the mediodorsal nucleus in the sagittal plane. Note the presence of the thin layer of fibers covering the superior surface of the thalamus (stratum zonale) and the habenular nucleus in relation to the telegraphed crosses.

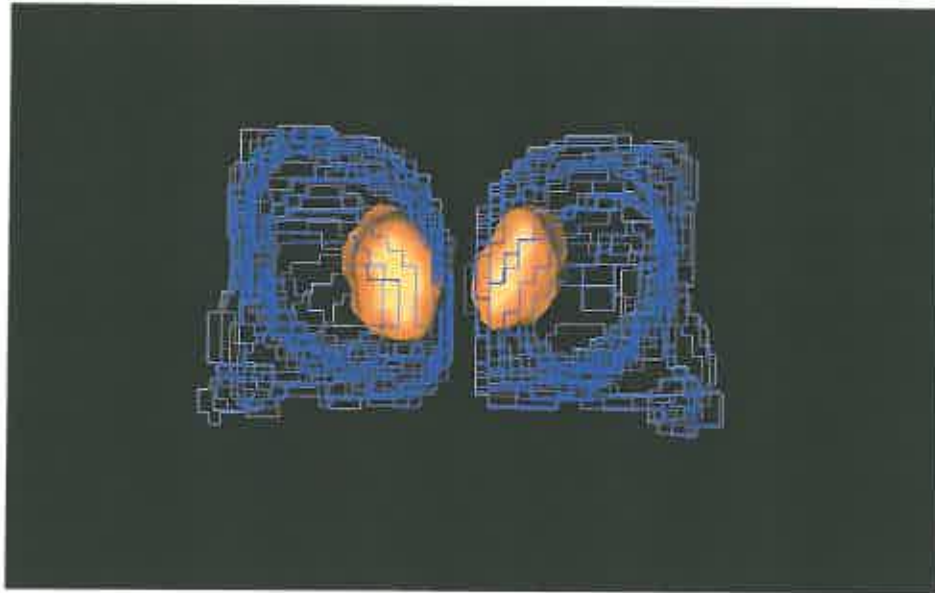


Figure 26

Figures 26 & 27 demonstrate the ability of BRAINS2 to display a surface within a wire-frame using the surface viewer. Note the placement of the mediodorsal nucleus as represented by the tan surface within the blue wire-frame of the gross thalamus.

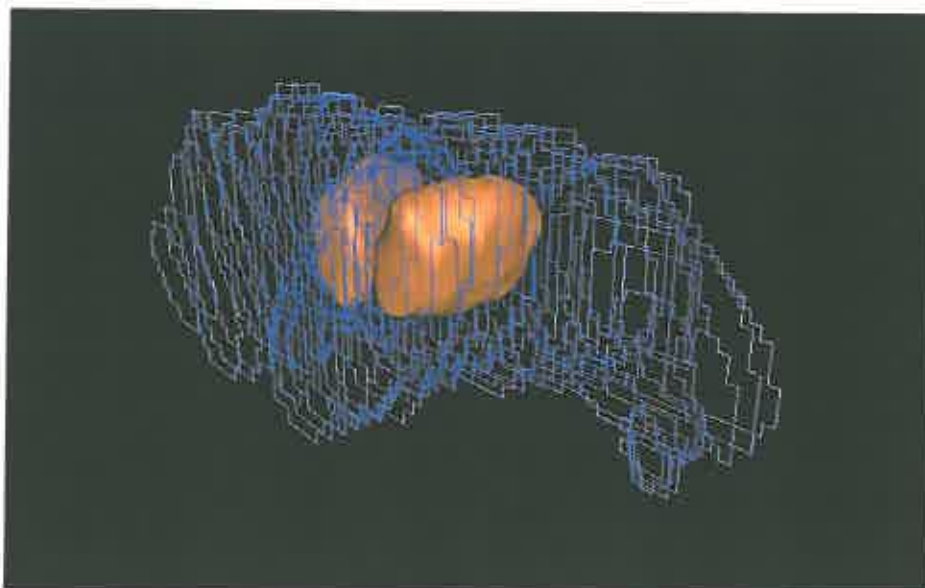


Figure 27

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