A Dozen Neuroanatomical Landmarks Every Radiologist Should Know

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Learning objectives

The aim of this educational exhibit is to review specific neuroanatomical landmarks that help to delineate functional areas of the brain in Magnetic Resonance Imaging (MRI). Each landmark will be demonstrated on MRI and supplemented with a description to aid in their identification.
Background

The widespread use of MRI provides access to high-resolution images of the brain, aiding the diagnosis, surgical planning and treatment follow-up for a vast number of intracranial pathologies. More recently, functional MRI (fMRI) has increased its presence as a useful tool for surgical and radiation therapy planning, as well as detecting deleterious physiological features caused by tumours, stroke, dementia and brain injury.

Knowledge of neuroanatomy is, therefore, essential to comprehensively interpret modern brain imaging. Neuroanatomical landmarks are especially useful in aiding the identification of specific areas of functional significance, allowing radiology reports to adequately convey the location of pathology to treating physicians and surgeons.
1. Marginal sulcus and sigmoidal hook sign (Fig.1) as landmarks for the central sulcus.
   - the central sulcus separates the primary motor cortex anteriorly (precentral gyrus in the frontal lobe) from the primary somatosensory cortex posteriorly (postcentral gyrus in the parietal lobe).
   - the marginal sulcus is the extension of the cingulate sulcus posterosuperiorly, separating the paracentral lobule from the precuneus on the medial surface of the cerebral hemispheres and assessed on the sagittal images.
   - on axial images, the marginal sulcus appears as a short sulcus, reaching the apex but not extending laterally. It helps to confirm the location of the central sulcus, which is located one sulcus anterior to the marginal sulcus.

2. Hook sign (Fig.1), also referred as hand knob, corresponding to a segment projecting posteriorly from the precentral gyrus that most often contains the motor hand function and is also a reliable landmark for identifying the precentral gyrus.

3. Pars triangularis and opercularis (Fig.2) as landmarks for Broca’s area.
   - the pars triangularis is located between the ascending and horizontal ramus of the lateral fissure.
   - the pars opercularis is located between the ascending ramus of the lateral fissure anteriorly and the precentral sulcus posteriorly.
   - both pars triangularis and pars opercularis are posterior parts of the inferior frontal gyrus, identified when scrolling through the sagittal images, and correspond to the Broca’s area (production of speech) in the dominant hemisphere.

4. Superior temporal gyrus, supramarginal gyrus, and angular gyrus (Fig. 3) as landmarks for Wernicke’s area.
   - the superior temporal gyrus is one of the three gyri of the temporal lobe and it is easily delimitated by the lateral sulcus above and the superior temporal sulcus below.
   - the supramarginal gyrus is the posterior continuation of the superior temporal gyrus located around the posterior ascending ramus of the lateral sulcus (Sylvian fissure).
   - the angular gyrus is the posterior continuation of the middle temporal gyrus.
   - Wernicke’s area has not clear limits and is located around the posterior portion of the superior temporal gyrus in the dominant cerebral hemisphere (left hemisphere in about 95% of right handed individuals and 60% of left handed individuals).
5. Calcarine sulcus (Fig.4) as a landmark for the visual cortex (separates the superior lip from the inferior lip of the visual cortex).

- it can be identified on sagittal images as a horizontally oriented sulcus that starts at the parieto-occipital fissure anteriorly and continues posteriorly reaching a variable distance toward or even beyond the occipital pole.
- the primary visual cortex is the main site of input of signals coming from the retina. It is located on the medial aspect of the occipital lobe, around the Calcarine sulcus.

6. Heschl's gyrus (Fig.5) as a landmark for the primary auditory cortex.

- it can be identified on axial images located in the recesses of the lateral fissure in the temporal lobe.
- the primary auditory cortex comprises part of the medial aspect of Heschl's gyrus in both hemispheres.

7. Anterior and posterior commissures (Fig.6, Fig.7) as landmarks to define the anterior commissure-posterior commissure (ACPC) line.

- both commissures are a bundle of nerve fibers connecting the two cerebral hemispheres across the midline.
- the anterior commissure is located in front of the columns of the fornix and the posterior commissure is located immediately dorsal to the cerebral aqueduct, where the aqueduct becomes continuous with the third ventricle.
- the ACPC line has been adopted as a convenient standard by the neuroimaging community, and in most instances is the reference plane for axial imaging in everyday scanning.

8. The parahippocampal gyrus (Fig.8) as a landmark to the perirhinal cortex (Brodmann areas 35 and 36) related to memory and memory impairments in normal ageing.

- the parahippocampal gyrus is part of the limbic system and is located on the inferomedial surface of the temporal lobe, surrounding the hippocampus. It can be identified as an inferior continuation of the cingulate gyrus when scrolling through paramedian images on sagittal MRI sequences. The uncus is an anterior extremity of the parahippocampal gyrus, lying medially and superiorly to it.
- the perirhinal cortex is an important region for memory and it is located in the anterior portion of the parahippocampal gyrus.

9. Tectal plate (Fig.9, Fig.10), also known as quadrigeminal plate, as a landmark for the junction of hippocampal body and tail.

- it is the dorsal portion of the midbrain upon which the superior and inferior colliculi sit and it is easily identified on both coronal and midline sagittal images.
• the level of the tectal plate corresponds approximately to the transition between body and tail of the hippocampus when assessing them on coronal or sagittal images.

10. Facial colliculus (Fig.11) as a dorsal pons landmark for the fibres from the motor nucleus of the facial nerve when looping over the abducens nerve's nucleus.

• it is an elevation on the floor of the fourth ventricle, easily identified on axial images, that corresponds to the fibres of the facial nerve arching backwards around the abducens nerve (6th cranial nerve) nucleus before turning forwards once more.

11. Pre-occipital notch (Fig.12) as a landmark for the lateral junction between temporal and occipital lobe.

• it is an small indentation observed in the ventrolateral edge of the brain in both sides when scrolling through the sagittal plane.

12. Medial and lateral geniculate bodies (Fig.13) as landmarks for the auditory and visual thalamic pathways.

• the lateral geniculate body (or nucleus) is a rostrolateral thalamic projection which is reciprocally connected with the primary visual cortex.
• the medial geniculate body (or nucleus) is a complex of three nuclei most related with auditory areas of the cortex.
• they are hard to identify just by a single image and need a dynamic approach done by scrolling through the images both on axial and coronal planes, following the post-chiasmatic optic nerves.
Fig. 1: Central Sulcus, Marginal Sulcus and Sigmoidal Hook Sign

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Fig. 2: Pars Triangularis and Pars Opercularis

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Fig. 3: Superior Temporal Gyrus, Supramarginal Gyrus and Angular Gyrus

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Fig. 4: Calcarine Sulcus

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Fig. 5: Heschl's Gyrus

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Fig. 6: Anterior Commissure and Posterior Commissure Axial

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Fig. 7: Anterior Commissure and Posterior Commissure Sagittal

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**Fig. 8:** Parahippocampal Gyrus

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Fig. 9: Tectal Plate

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Fig. 10: Tectal Plate

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Fig. 11: Facial Colliculus

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Fig. 12: Pre-Occipital Notch

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Fig. 13: Posterior Limb of Internal Capsule, Medial Geniculate Body, Lateral Geniculate Body and Optic Radiation

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Conclusion

These neuroanatomical landmarks are essential to ensuring brain imaging is correctly interpreted and described. By highlighting an approach to identifying clinically significant landmarks, neuroradiological reporting may be improved.
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