

# MARGINAL SULCUS

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## MARGINAL SULCUS

**Primary Disciplinary Field(s):** Neuroanatomy, Neuroscience

### 1. Core Definition

The Marginal Sulcus is an essential anatomical feature located on the medial surface of the human brain's cerebral hemisphere. Fundamentally, it represents the superior or terminal portion of the **cingulate sulcus**, which is one of the brain's major fissures. While often considered a distinct structure due to its significant role in demarcating critical functional areas, it is perhaps most accurately described as the **marginal branch of the cingulate sulcus**. This distinction is crucial in neuroanatomical discussions, as the sulcus marks the point where the cingulate sulcus, having tracked horizontally along the corpus callosum, turns sharply upwards towards the superior border of the hemisphere. This upward trajectory defines its anatomical identity and separates it from the main body of the cingulate sulcus, contributing significantly to the complex folding pattern, or gyrification, characteristic of the human cerebral cortex.

A sulcus, by definition, is a groove or depression that separates gyri (convolutions or ridges) on the surface of the brain. The primary function of sulci is to increase the total surface area of the cerebral cortex, thereby accommodating a vast number of neurons and complex neural circuitry within the confines of the skull. The Marginal Sulcus specifically contributes to this surface area maximization in the medial parietal and frontal lobes. Its upward course is pivotal for defining the boundaries of the **paracentral lobule** and segments of the superior frontal gyrus. Recognition of the Marginal Sulcus is vital for neurosurgeons and radiologists, as its location is a reliable landmark for identifying underlying functional areas, particularly those related to motor and sensory processing for the lower limbs.

The concept of the Marginal Sulcus highlights the intricate organizational structure of the cerebral hemispheres. Its location serves not merely as an arbitrary boundary but as a structural delineation that often corresponds to functional transitions. Being a terminal segment, its morphology can vary slightly between individuals, yet its relationship to surrounding structures--the **corpus callosum** inferiorly and the superior medial surface of the cortex superiorly--remains consistent. Understanding the precise orientation and termination of the Marginal Sulcus is foundational for detailed study of medial hemispheric organization and connectivity, which is often involved in high-level executive functions and primary somatic sensation.

### 2. Anatomical Location and Course

The Marginal Sulcus is exclusively situated on the medial aspect of the brain, meaning it is visible when the two cerebral hemispheres are separated, lying deep within the longitudinal fissure. Its

course begins as a continuation of the cingulate sulcus, which runs horizontally above the cingulate gyrus. As the cingulate sulcus approaches the posterior superior aspect of the hemisphere, usually near the boundary of the frontal and parietal lobes, it makes a decisive vertical turn. This superiorly directed segment is the Marginal Sulcus. It ascends, running parallel to the central sulcus, which is located on the lateral (outer) surface of the brain, though the Marginal Sulcus only marks the medial termination of the central sulcus and surrounding regions.

The anatomical relationship of the Marginal Sulcus to its adjacent gyri is perhaps its most defining characteristic. As it turns upward, it primarily separates two key structures. Anteriorly (towards the front), it is bordered by the medial extension of the **Superior Frontal Gyrus**, which is involved in complex planning and movement initiation. Posteriorly (towards the back), it demarcates the anterior edge of the **precuneus**, a region critical for self-consciousness and memory, while also running directly alongside the **paracentral lobule**. The paracentral lobule itself is a crucial convolution that contains the medial extensions of both the primary motor cortex and the primary somatosensory cortex, responsible for controlling and receiving sensation from the lower extremities, torso, and perineum.

The significance of the Marginal Sulcus's positioning cannot be overstated, as it provides a reliable, visible boundary on the medial surface where other key landmarks, such as the central sulcus, are not always clearly visible or identifiable from surface inspection. The superior boundary of the Marginal Sulcus typically terminates shortly before reaching the dorsal (top) edge of the hemisphere, effectively capping the cingulate system's superior reach. Furthermore, the anterior-posterior positioning of the Marginal Sulcus often aligns vertically with the medial terminus of the central sulcus, establishing the posterior boundary of the paracentral lobule's motor component and the anterior boundary of its sensory component, making it an indispensable landmark in functional brain mapping.

### 3. Relationship to the Cingulate Sulcus and Gyrus

The Marginal Sulcus is structurally inseparable from the **cingulate sulcus**, acting as its posterior termination point. The cingulate sulcus itself is an extensive fissure that runs concentrically around the corpus callosum, separating the cingulate gyrus (limbic lobe structure) from the overlying frontal and parietal lobes (isthmus and subparietal gyrus). The cingulate gyrus and its surrounding sulcus form a critical part of the limbic system, involved in emotion formation, learning, and memory. The main body of the cingulate sulcus is often divided into anterior and posterior segments, with the Marginal Sulcus forming a distinct, vertically oriented branch arising from the posterior segment.

This relationship underscores the organizational hierarchy of the medial cortex. The cingulate sulcus serves as a long, foundational boundary, and the Marginal Sulcus represents the point

where this boundary turns away from the corpus callosum and penetrates the superior cortex. Because the cingulate system is so ancient and functionally conserved, the consistency of the Marginal Sulcus's location provides a reliable anchor point for comparing cortical anatomy across individuals and even across primate species, despite variations in overall brain size and folding complexity. Its upward turn physically separates the limbic-associated cingulate cortex from the neocortical regions responsible for voluntary movement and spatial orientation (paracentral lobule and precuneus).

Variations in the continuity of the cingulate sulcus are common; in some individuals, the sulcus may be segmented or discontinuous. However, the Marginal Sulcus, even when the parent cingulate sulcus is fragmented, usually maintains its characteristic vertical trajectory and definitive location relative to the paracentral lobule, reinforcing its importance as a functional boundary marker. This termination point is not random; it sits precisely at the posterior limit of the primary motor cortex's medial representation, ensuring that structures involved in basic motor control are clearly segregated from more posterior areas involved in spatial processing and integration of sensory information.

#### 4. Function and Associated Cortical Areas

While the sulcus itself is a structural groove and not a direct functional area, its primary significance lies in the crucial functional areas it delineates. The Marginal Sulcus provides the posterior boundary for the medial aspect of the **paracentral lobule**, which is arguably the most critical area adjacent to the sulcus. The paracentral lobule is unique because it contains the medial extensions of both the **Primary Motor Cortex** (Area 4) and the **Primary Somatosensory Cortex** (Areas 1, 2, 3), specifically representing the homuncular map for the lower limbs, feet, and genital region. Therefore, damage or stimulation near the Marginal Sulcus profoundly affects these specific bodily functions.

Posterior to the Marginal Sulcus lies the **Precuneus**, a large medial region of the parietal lobe. The precuneus is one of the most metabolically active brain regions and is strongly implicated in complex cognitive functions, including visuospatial imagery, episodic memory retrieval, and self-processing operations (e.g., sense of self, agency). The Marginal Sulcus thus acts as a dividing line between areas dedicated primarily to execution (motor/sensory) and those involved in advanced integration and self-reflection. This structural separation facilitates specialized processing within each lobe, preventing functional overlap and maintaining the integrity of the neural pathways serving these distinct cognitive domains.

The anterior border of the Marginal Sulcus is the **Superior Frontal Gyrus (SFG)**, a key part of the prefrontal cortex involved in working memory, sustained attention, and strategic planning. The medial aspect of the SFG contributes to supplementary motor areas (SMA) which are critical for

planning and sequencing voluntary movements. Therefore, the Marginal Sulcus helps define the precise posterior limit of the planning and executive motor regions before they transition into the primary motor execution areas housed in the paracentral lobule. The consistent neuroanatomical presence of the Marginal Sulcus allows researchers and clinicians to reliably locate these functional regions, facilitating studies on connectivity, functional specialization, and the effects of focal lesions.

## 5. Clinical Significance and Related Disorders

The accurate identification of the Marginal Sulcus holds considerable clinical significance, particularly in neurosurgical planning and the interpretation of neurological deficits. Because the Marginal Sulcus borders the paracentral lobule, it is a primary landmark for locating the cortical representation of the lower extremities. Lesions, such as tumors, strokes, or trauma that affect the tissue immediately surrounding or deep to the Marginal Sulcus, often result in specific neurological syndromes.

A common clinical manifestation of damage to the paracentral lobule, directly bordered by the Marginal Sulcus, is **crural paresis** or **paralysis**--weakness or complete loss of movement in the legs and feet, often without significant involvement of the arms or face. Furthermore, since the paracentral lobule mediates sensory input from the lower body, damage can also result in corresponding sensory deficits. Moreover, the medial cortex in this region is also intricately involved in the control of micturition (urination) and defecation; thus, lesions in the vicinity of the Marginal Sulcus can sometimes present with urinary or fecal incontinence, indicating a disruption of the supraspinal control centers for these autonomic functions.

In surgical contexts, such as the resection of deep gliomas or the placement of electrodes for epilepsy monitoring, the Marginal Sulcus serves as a critical guide. Neurosurgeons rely on its consistent position to predict the location of the primary motor cortex for the lower limbs, helping them navigate complex anatomical terrain while maximizing tumor removal and minimizing post-operative motor deficits. Precision is especially paramount in this region, as the motor and sensory strips are closely packed. Advances in functional magnetic resonance imaging (fMRI) often use the Marginal Sulcus as a starting point for anatomical normalization, ensuring that functional maps are accurately registered across different patient brains.

## 6. Key Characteristics and Nomenclature

**Terminal Nature:** The Marginal Sulcus is characterized by its identity as the terminal segment of the **cingulate sulcus**, marking the end of the cingulate fissure system's posterior trajectory on the medial surface.

**Upward Trajectory:** It possesses a distinctive upward turn, or superior course, which is essential

for defining the medial boundaries between the frontal and parietal lobes, particularly concerning the medial termination of the central sulcus.

**Landmark Function:** It serves as a highly reliable anatomical landmark, consistently defining the posterior boundary of the **paracentral lobule** and the anterior boundary of the precuneus, facilitating the localization of the lower limb motor and sensory cortices.

**Alternative Naming:** It is frequently referenced in older or comparative anatomical texts as the **marginal branch of the cingulate sulcus**, emphasizing its subordinate relationship to the larger cingulate structure. However, its functional and structural importance warrants its recognition as a key fissure in its own right due to its consistent location relative to functional cortical areas.

## 7. Significance and Impact

The Marginal Sulcus's primary impact on neuroscience is its role in providing structural clarity to the intricate folding of the medial cortex. Prior to advanced neuroimaging, surface landmarks like the Marginal Sulcus were paramount for post-mortem anatomical studies and gross functional mapping. Its reliability ensures that studies on hemispheric asymmetry, evolutionary neuroanatomy, and developmental gyrification processes have a stable reference point for comparison across different species, ranging from primates to humans. The complexity of the sulcal patterns, including the depth and continuity of the Marginal Sulcus, can sometimes be correlated with genetic factors and cognitive abilities, making it an area of ongoing research interest in developmental neuroscience.

Furthermore, in the context of connectivity studies, the gyri bordered by the Marginal Sulcus--the paracentral lobule and the precuneus--are known to be highly interconnected with broader networks, including the **Default Mode Network (DMN)**, in which the precuneus is a central hub. By defining the boundary between these distinct networks, the Marginal Sulcus helps delineate the transition zones where primary motor processing interfaces with complex cognitive processes like spatial navigation and self-referential thought. This anatomical segregation is fundamental to understanding how specialized regions maintain their functional integrity while contributing to larger, integrated neural systems.

## Further Reading

[Cingulate Sulcus and its Branches \(Wikipedia\)](#)

[Neuroanatomy, Paracentral Lobule \(StatPearls/NCBI\)](#)

[Anatomy of the Superior Frontal Gyrus \(Wikipedia\)](#)