

BREGMA

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BREGMA

Primary Disciplinary Field(s): Anatomy, Neurosurgery, Physical Anthropology

1. Core Definition and Anatomical Location

Bregma is precisely defined as a fixed craniometric point located on the superior aspect of the skull, or the calvaria. This anatomical landmark marks the precise junction where two major cranial sutures meet: the **coronal suture** and the **sagittal suture**. Positioned near the midline of the skull vault, Bregma serves as a universally recognized reference point in both gross human anatomy and specialized fields requiring precise cranial measurement, such as anthropology and medicine. Its stability and consistency across individuals, once ossification is complete, make it an ideal anchor for three-dimensional coordinate systems used in imaging and surgical planning.

The point itself is formed by the intersection of four distinct bony margins originating from three separate bones. The **frontal bone** forms the anterior boundary of the junction, encompassing the area superior to the forehead. Posteriorly and laterally, the junction is completed by the two **parietal bones**, which form the bulk of the cranial vault. Although seemingly a simple point, Bregma represents a complex biological interface where the forces of bone growth converge, and its exact location can be mapped using external measurements (exocranially) or internal cranial views (endocranially).

Functionally, the Bregma represents the apex of the cranium along the sagittal plane when the head is viewed in anatomical position. Understanding its fixed relationship to underlying cortical structures is crucial for neurologists and surgeons. While the specific cortical area directly beneath the Bregma varies slightly depending on individual brain morphology, it generally overlays structures situated in the superior frontal or parietal lobes, providing a reliable surface marker for deeper anatomical references, which is indispensable for diagnostic imaging interpretation.

2. Sutural Relationships

The morphological definition of Bregma hinges entirely upon its relationship with the two adjacent sutures. The **coronal suture** extends laterally across the skull, acting as the primary dividing line between the frontal bone and the pair of parietal bones. It is named for its resemblance to a crown, running approximately in the frontal plane. This suture's integrity is vital, and its premature fusion (craniosynostosis) can lead to significant deformities of the skull structure, impacting brain growth and development.

The second essential component is the **sagittal suture**, which runs anteroposteriorly along the midline of the calvaria, separating the two parietal bones from one another. This suture is typically the longest of the cranial sutures and provides longitudinal rigidity to the skull vault. The precise

meeting of the coronal suture (running perpendicularly) and the sagittal suture (running longitudinally) creates a cruciform or T-shaped intersection that defines the Bregma. In an adult skull, this junction is characterized by highly irregular, interlocking bony edges held together by dense, fibrous connective tissue, ensuring high structural resistance against mechanical stress.

The structural characteristics of these sutures--their tortuosity, degree of interdigitation, and density--change significantly throughout life. In younger individuals, the sutures are smoother and less tightly interlocked, allowing for minor movements necessary for growth. As an individual ages, the sutures become increasingly rigid and may eventually undergo complete obliteration or synostosis, where the fibrous tissue is replaced by bone, fusing the respective cranial bones into a single unit. The Bregma point, therefore, represents a location of maximal structural convergence and high mechanical importance on the protective shell of the brain.

3. Developmental Significance

During infancy and early childhood, the anatomical location corresponding to the Bregma is not a rigid bony point but a soft, membranous space known as the **anterior fontanelle**. This is the largest and most prominent of the fontanelles found in the neonatal skull, possessing a distinct diamond or kite shape. This developmental feature is critical for two primary biological functions: first, it allows the bony plates of the skull to overlap slightly during parturition, facilitating passage through the narrow birth canal; and second, it accommodates the rapid expansion of the brain that occurs during the first year of life.

The anterior fontanelle is palpable in newborns and young infants, providing a direct clinical indicator of intracranial pressure and hydration status. A depressed fontanelle may indicate dehydration, while a bulging or tense fontanelle, especially when the infant is not crying, can signal elevated intracranial pressure, potentially due to conditions like hydrocephalus or meningitis. Clinicians routinely assess the size, tension, and pulsation of the fontanelle during routine physical examinations to monitor neurological health and development.

The transformation from the flexible fontanelle to the rigid Bregma is accomplished through the process of ossification. Typically, the anterior fontanelle begins to close as the surrounding bones expand and mineralize, a process that is usually complete between 12 and 18 months of age. Delayed closure can sometimes be associated with systemic diseases such as hypothyroidism or rickets, while premature closure, or craniosynostosis, can severely restrict brain growth and development, necessitating neurosurgical intervention to reshape the skull and provide adequate space for the growing brain.

4. Clinical Importance in Neurosurgery

The reliability of Bregma as a fixed anatomical marker makes it invaluable in modern clinical

practice, especially within neurosurgery and radiology. In general cranial imaging (CT and MRI), Bregma often helps to establish standard planes and coordinate systems for quantifying brain lesions, tumors, or anatomical variations. Because it is a readily identifiable surface feature, it acts as a predictable anchor point from which subsequent measurements of internal structures can be accurately derived and standardized across different imaging sessions and patient scans.

Bregma's most specialized application is in **stereotactic surgery**, a technique that employs a three-dimensional coordinate system to locate small targets inside the brain and perform interventions with minimal invasiveness. Although human stereotactic systems often use fiducial markers or complex imaging registration methods, the foundational principle relies on establishing an external reference point. Bregma historically served, and conceptually continues to serve, as a key component in determining this external reference frame, ensuring that the trajectory of surgical instruments, such as biopsy needles or deep brain stimulation (DBS) electrodes, is accurate within fractions of a millimeter.

For neurosurgeons, the use of Bregma, or derived points within the surgical frame, minimizes the necessity for large craniotomies, reducing patient trauma and recovery time. The precise localization afforded by stereotactic planning based on stable craniometric points like Bregma is essential for the success of procedures targeting deep nuclei for movement disorders (DBS), treating epilepsy, or performing highly focused radiation delivery (radiosurgery). This precision ensures that therapeutic effects are maximized while avoiding damage to eloquent cortical and subcortical areas.

5. Anthropometry and Craniometry

In the fields of physical anthropology, forensic science, and archaeology, Bregma is classified as a fundamental **craniometric landmark**. Craniometry involves the systematic measurement of the skull to study morphological variations, assess racial or population characteristics, determine sex and ancestry in skeletal remains, and track evolutionary changes in hominid lineages. Bregma's position at the intersection of the coronal and sagittal planes makes it a crucial point for defining various cranial indices and arcs.

Measurements originating from or passing through Bregma are used to calculate essential dimensions such as cranial length, height, and the sagittal arc. These standardized measurements allow anthropologists to compare skull shapes consistently across vast geographic regions and time periods. For instance, the distance from Bregma to the nasion (the point where the nasal bones meet the frontal bone) is a standard measurement used in facial reconstruction and assessment of prognathism.

In forensic contexts, the identification of Bregma is vital for establishing standardized photographic overlays and 3D reconstructions of unidentified human remains. By utilizing Bregma along with

other key points (like Lambda or Glabella), forensic specialists can accurately reconstruct the cranial vault shape, providing critical data for biological profiling and aiding in the identification process. The consistent application of Bregma as a reference point ensures that anthropological data remains comparable and reliable across research institutions globally.

6. Comparative and Experimental Anatomy

Beyond human anatomy, Bregma holds singular importance in comparative anatomy, specifically within experimental neuroscience utilizing animal models, most commonly rodents (mice and rats). Researchers rely on standardized brain atlases to conduct precise, repeatable experiments, and in these atlases, Bregma is almost universally adopted as the primary zero point for the three-dimensional **stereotactic coordinate system**.

To perform targeted research, such as injecting viral vectors, implanting chronic electrodes, or performing localized lesions in a rodent brain, the animal's head is fixed into a stereotactic frame. The coordinates for the target structure (e.g., the hippocampus or substantia nigra) are then defined in millimeters relative to the Bregma point along the three axes: anterior-posterior (AP), medial-lateral (ML), and dorsal-ventral (DV). This standardization, exemplified by the widely used Paxinos and Watson atlases, ensures high reproducibility of results across different laboratories worldwide.

The reliance on Bregma in experimental settings stems from its clear anatomical definition and relative ease of identification after surgical exposure of the skull surface. Because subtle variations in head angle can drastically alter the coordinates of deep structures, the Bregma is typically leveled with another caudal landmark, such as Lambda, to ensure the skull is perfectly horizontal and parallel to the experimental reference plane. This meticulous process transforms the anatomical point into the critical foundation for all quantitative neuroscientific experimentation involving targeted brain manipulation.

7. Key Characteristics

Defined Location: Bregma is the specific craniometric point situated on the superior aspect of the skull (calvaria).

Sutural Intersection: It is formed by the precise junction of the **coronal suture** and the **sagittal suture**.

Bones Involved: The junction involves the posterior border of the **frontal bone** and the anterior borders of the two **parietal bones**.

Developmental Precursor: During infancy, the anatomical space corresponding to Bregma is the **anterior fontanelle**, a large, diamond-shaped membranous area that typically closes between 12 and 18 months.

Clinical Reference: Serves as a fundamental reference point for establishing coordinate systems in stereotactic surgery, allowing for minimally invasive targeting of deep brain structures.

Anthropometric Use: It is a primary craniometric landmark utilized in physical anthropology and forensics for standardized skull measurement and classification.

Experimental Standard: In animal models (especially rodents), Bregma defines the absolute zero point for stereotactic atlases, ensuring precision and reproducibility in neuroscience research.

Further Reading

[Bregma \(Wikipedia\)](#)

[ScienceDirect: Craniometric Points](#)

[StatPearls: Anatomy, Head and Neck, Fontanelles](#)

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