Determination Of Projections of Intracerebral Structures on The Skull Surface Using Craniometric Points

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Abstracts: One of the most important conditions for the correct performance of cranial osteopathic techniques is the topography of extra- and intracranial structures. Without accurate positioning of the hands for further layer-by-layer palpation, it is impossible to correctly perform techniques on brain structures. In this paper, based on the data obtained from magnetic resonance imaging of the head and intracranial structures, an attempt is made to mathematically accurately project intracranial and intracerebral structures onto the external landmarks of the skull.

Keywords: Skull, Intracerebral Structures, Tomography, Superimposition, Measurement, Ratio, Ventricles, Hypothalamus, Thalamus, Epiphysis, Basal Nuclei, Reticular Formation, Axial Plane, Frontal Plane, Sagittal Plane.

1. INTRODUCTION

In cranial osteopathy, accurate placement of the hands on the skull is essential, especially during layer-by-layer palpation of intracerebral structures. However, we did not find the necessary information about the projections of intracerebral structures on the skull in the available sources on stereotactic neurosurgery, sectional anatomy atlases, MRI and CT atlases, as well as in the specialized osteopathic literature. The only exception was the exact lateral projection of the pituitary gland (Turkish saddle) onto the skull. This projection is known to doctors of radial diagnostics and is determined 1.5-2 cm above the border of the posterior and middle thirds of the line connecting the outer edge of the eye socket with the external auditory canal (orbito-meatal line). B.I. Farberov (1941) describes the projection of the pituitary gland 2 cm posterior to the outer edge of the eye socket and 2 cm upward from the above line. The direct anterior projection is in the *glabella* region.

Purpose of the study: on the basis of brain MRI images, using a mathematical method, determine the projections of intracerebral structures on the skull in three planes.

2. MATERIALS AND METHODS

The method of mathematical modeling based on the basic property of proportion was used to solve the problem. All projections were obtained by comparing MRI tomography data in three different mutually perpendicular projections (sagittal, frontal, and axial), based on tomogram measurements with the help of a measuring circular (this type of circular is convenient because it is fixed with an adjusting screw, which does not allow the legs of the circular to diverge during measurements). This method has an advantage over cadaver section due to the absence of postmortem changes in the human body.

MRI of the brain in T1 and T2 modes, including contrast-enhanced MRI based on Omniscan (INN: Gadodiamide, IUPAC1 gadolinium (III) 5,8-bis (carboxylatomethyl)-2-[2-(methylamino)-2-oxoethyl]-10-oxo-2,5,8,11-

tetraazododecane-1-carboxylate hydrate) were used in the study. For the calculations, a formula was derived and the data obtained were entered into it.

The following notations were used to derive the formula:

- Length (L) of the skull (C) in natura - LC

- Skull length on MRI (MRI) - LCMRI

- Length of intracerebral structure (IC) in nature - Lic

- Intracerebral structure length on MRI (ICMRI) – Licmri

Let's make a formula:

$$\frac{Lc}{Lcmri} = \frac{Lic}{Licmri}$$

It follows from the formula:

$$Lic = \frac{Licmri\ x\ Lc}{Lcmri}$$

Thus, with the known data of the skull length on MRI and in vivo, as well as the length of the intracerebral structure on MRI, the length of the intracerebral structure can be calculated. Using craniometric points, the boundaries of the projections of the studied intracerebral structures were determined.

3. RESULTS

Lateral ventricles

- Axial plane (top view)
- For definition of anterior border it is necessary to draw a line connecting zygions, parallel to frontal axis, lateral borders of the segment are perpendicular lines passing through the edges of parieto-occipital suture when considering the skull from above.
- For definition of a posterior border it is necessary to construct an isosceles triangle with the base located on the line connecting eurions, the vertex opposite to the base is located on obelion, then it is necessary to construct the middle line connecting middles of lateral sides which corresponds to a posterior border.
- For definition of lateral borders it is necessary to connect conditionally lateral points of front and back borders.

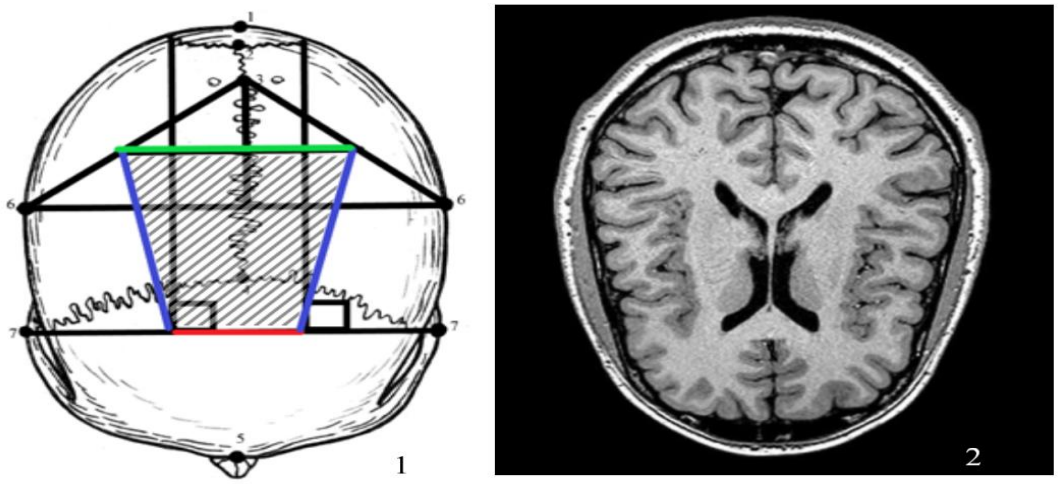


Fig. 1. Location of the boundaries of the lateral ventricles on the axial plane (anterior boundary marked in red, posterior boundary in green, lateral boundaries in blue) and tomogram: 1 - opisthocranion; 2 - lambda; 3 - obelion; 4 - bregma; 5 - nasion; 6 - eurion; 7 - zygion.

Fig. 2. MRI attached to Fig. 1 in the axial plane.

- Sagittal plane (lateral view):

- To define the upper border, two parallel lines are drawn through metopicion and eurion perpendicular to the vertical axis, between these parallel lines is the upper border of the lateral ventricles

- The inferior border runs along a line joining the pteryon and glabella.

- The anterior border corresponds to the line passing through the stephanion and pteryon.

- The posterior border corresponds to a line through the asterion, parallel to the vertical axis.

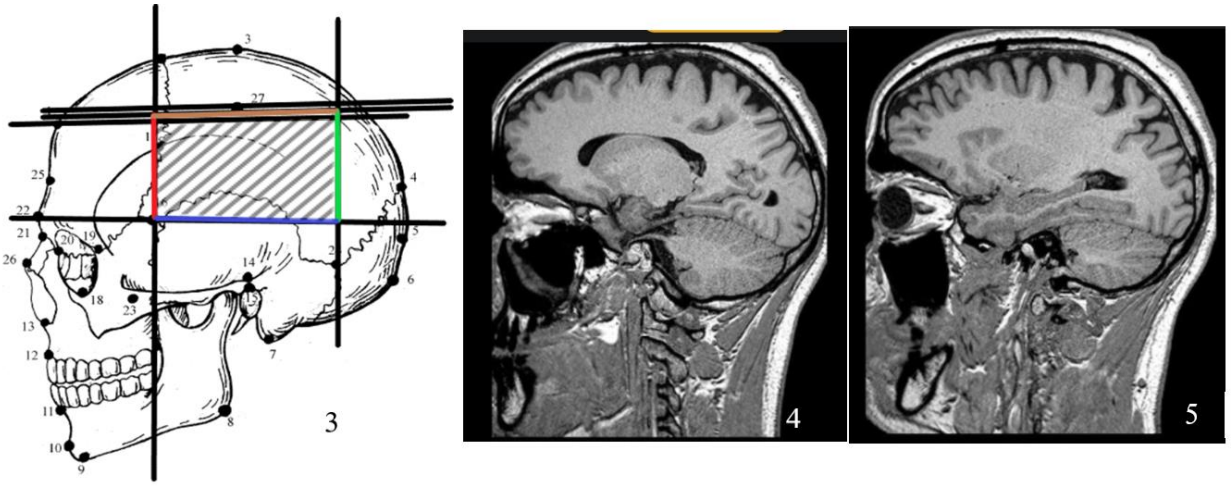


Fig. 3. Location of the borders of the lateral ventricles on the sagittal plane (the anterior border is marked in red, the posterior border in green, the upper border in brown, and the lower border in blue): 1 - metopion; 2 - bregma; 3 - vertex; 4 - lambda; 5 - inion; 6 - opisthocranion; 7 - mastoidale; 8 - gonion; 9 - gnathion; 10 pogonion; 11 - infradentale; 12 - prostion; 13 - nasospinale; 14 - auricularis; 15 - porion; 16 - pterion; 17 - stephanion; 18 - orbitale; 19 - frontal-maxillary eye point (frontomalare); 20 - dacrion; 21 - nasion; 22 - glabella; 23 - zygion; 24 - asterion; 25 - ophrion; 26 - rhinion; 27 - eurion.

Fig. 4-5. Enclosed to Fig. 3 MRI in the sagittal plane.

- Frontal plane:
    - Frontal view
- Upper border - a line crossing the metopicon parallel to the frontal axis.
- Inferior border - a line connecting the paired points of the frontomalare.
- Lateral - a line passing through the middle of the upper margin of the eye socket parallel to the vertical axis.
    - Posterior view
- For definition of an upper border we construct an isosceles triangle the base of which is a line connecting eurions, and the apex opposite to the base is obelion, then we draw a midline parallel to the base. The middle line in the obtained isosceles triangle corresponds to the upper boundary.
- The lower boundary is the line connecting the asterions.
- To find the lateral boundaries, we take the line connecting the asterions, find the middle, then on each side of the segments from the middle of the line to the asterion we find the middle of the segments and draw a line parallel to the vertical axis. These lines are the lateral borders of the lateral ventricles.

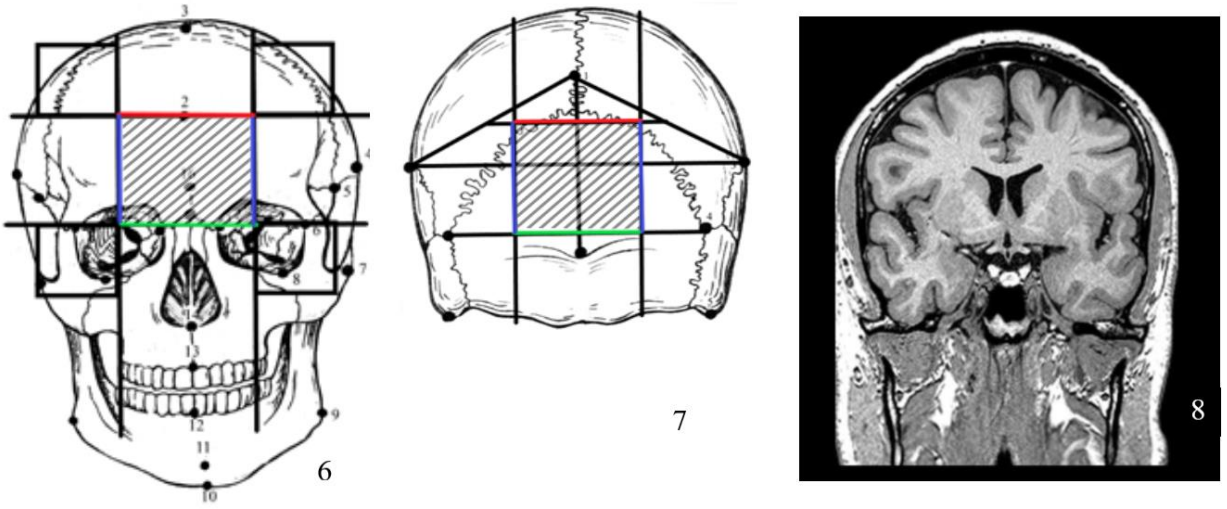


Fig. 6. Location of the borders of the lateral ventricles on the frontal plane from the front - (upper border marked in red, lower in green, lateral in blue) 1 - nasion; 2 - metopion; 3 - bregma; 4 - eurion; 5 - pteryon; 6 - frontomalare (frontal-maxillary eye point); 7 - zygion; 8 - orbitale; 9 - gonion; 10 - gnathion; 11 - pogonion; 12 - infradentale; 13 - prostion; 14 - nasospinale; 15 - dacrion; 16 - glabella.

Fig. 7. Location of the boundaries of the lateral ventricles on the frontal plane posteriorly (upper boundary indicated in red, lower boundary in green, laterals in blue) 1 - obelion; 2 - inion; 3 - eurion; 4 - asterion; 5 - mastoidalee

Fig. 8. Attached to figs. 6 и 7. MRI in the frontal plane.

Given the variability in the size of the lateral ventricles, it is impossible to accurately describe the size of these structures.

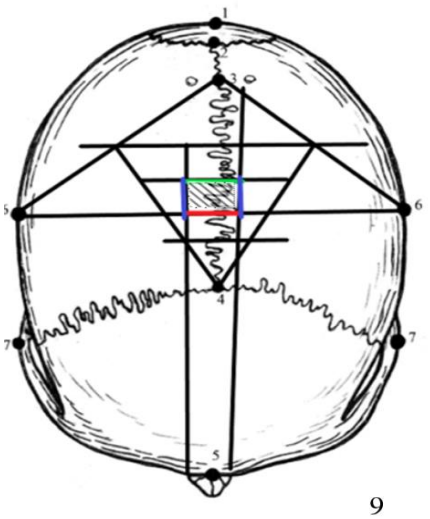
Third ventricle

- Axial plane:

- The anterior border is the line connecting the eurions.

- For definition of a posterior border it is necessary to construct at first an isosceles triangle, with the base on a line connecting eurions, and the apex opposite to the base - obelion, then it is necessary to find a midline which will be a base for another isosceles triangle where the apex opposite to the base corresponds to bregma. The midline of the resulting triangle corresponds to the back boundary.

- We draw two planes through the lateral edges of the nasal bones, parallel to the sagittal plane, when the anterior and posterior borders of the third ventricle intersect, the lateral borders are formed.



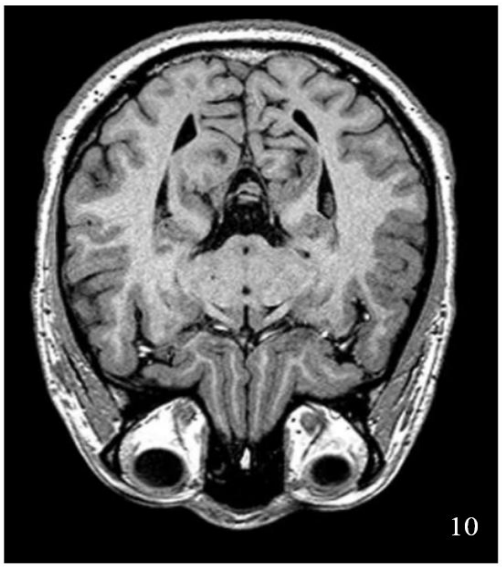


Fig. 9. Location of the boundaries of the third ventricle on the axial plane (anterior boundary marked in red, posterior boundary in green, lateral boundaries in blue): 1 - opisthocranion; 2 - lambda; 3 - obelion; 4 - bregma; 5 - nasion; 6 - eurion; 7 - zygion,

Fig. 10. MRI attached to Fig. 9 in the axial plane.

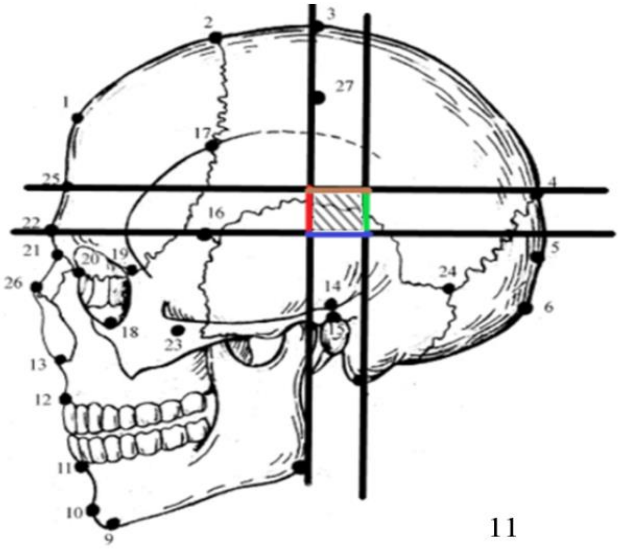
- Sagittal plane (lateral view):

- The upper border runs along a line connecting the ophryon and lambda.

- The inferior border runs along a line crossing the glabella, parallel to the sagittal axis.

- The anterior border passes through a line through the eurion, parallel to the vertical axis.

- Posterior border passes through a line through the mastoidale, parallel to the vertical axis.



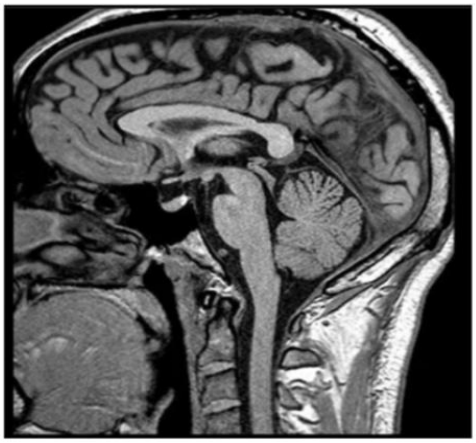


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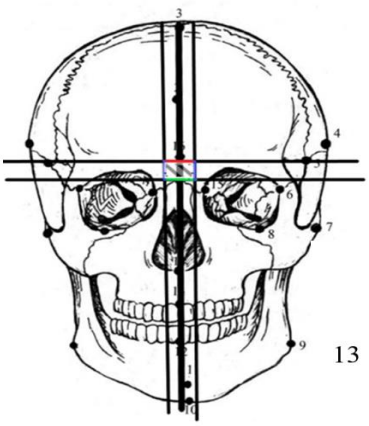
Fig. 11: Location of the borders of the third ventricle on the sagittal plane (the anterior border is marked in red, the posterior border in green, the upper border in brown, and the lower border in blue). 1 - metopion; 2 - bregma; 3 - vertex; 4 - lambda; 5 - inion; 6 - opisthocranion; 7 - mastoidale; 8 - gonion; 9 - gnathion; 10 pogonion; 11 - infradentale; 12 - prostion; 13 - nasospinale; 14 - auricularis; 15 - porion; 16 - pterion; 17 - stephanion; 18 - orbitale; 19 - frontal-maxillary eye point (frontomalare); 20 - dacrion; 21 - nasion; 22 - glabella; 23 - zygion; 24 - asterion; 25 - ophrion; 26 - rhinion; 27 - eurion.
Fig. 12 attached to Figure 11 is an MRI fragment in the sagittal plane.

- -Frontal plane:
- Front view
- The upper boundary passes through the line connecting the pteryons.
- The inferior border passes through a line crossing the nasion parallel to the frontal axis.
- The lateral border passes through a line passing through the lateral margin of the nasal bones.
- Rear view
- The upper boundary is the line connecting the eurions.
- To determine the lower boundary it is necessary to construct an isosceles triangle, the base of which is the line connecting the mastoidale, and the vertex opposite the base is the obelion, then it is necessary to draw a midline opposite the base, and then between the midline and the upper boundary draw a parallel line along the middle, it is along this line that the lower boundary is drawn.



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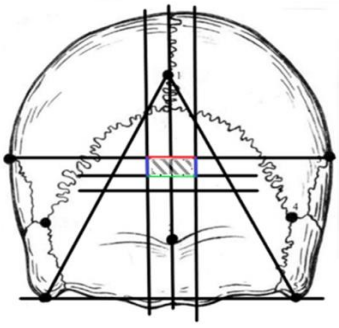

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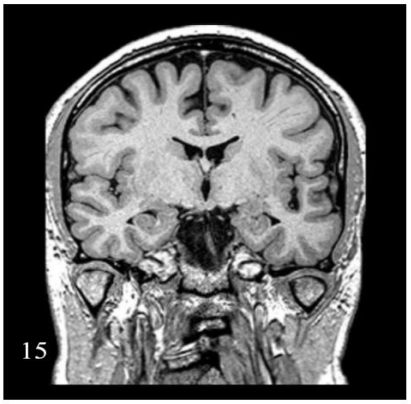

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Fig. 13. Location of the borders of the third ventricle on the frontal plane from the front - (upper border marked in red, lower in green, lateral in blue) 1 - nasion; 2 - metopion; 3 - bregma; 4 - eurion; 5 - pteryon; 6 - frontomalare (frontal-maxillary eye point); 7 - zygion; 8 - orbitale; 9 - gonion; 10 - gnathion; 11 - pogonion; 12 - infradentale; 13 - prostion; 14 - nasospinale; 15 - dacrion; 16 - glabella.
Fig. 14. Location of the borders of the third ventricle on the frontal plane posteriorly - (upper border marked in red, lower border in green, lateral borders in blue): 1 - obelion; 2 - inion; 3 - eurion; 4 - asterion; 5 - mastoidale.
Fig. 15: Frontal plane MRI attached to Fig. 13 and 14.

Taking into account the variability of the size of the third ventricle, it is impossible to accurately describe the size of this structure, it may depend on the age of the patient under study and the presence of certain changes in the structure of the brain.

Fourth ventricle

- Axial plane

- For definition of front boundary it is necessary to construct an isosceles triangle the base of which is the line connecting eurions, and the top opposite to the base is obelion, then it is necessary to draw the middle line opposite to the base, namely on this line passes front boundary.

- To determine the posterior boundary it is necessary to construct an isosceles triangle, the base of which is the line connecting eurions, and the apex is lambda, then it is necessary to draw a midline opposite the base, it is along this line the posterior boundary passes.

- We draw two planes through the lateral edges of the nasal bones, parallel to the sagittal plane, at the intersection of the anterior and posterior borders of the fourth ventricle, the lateral borders are formed.

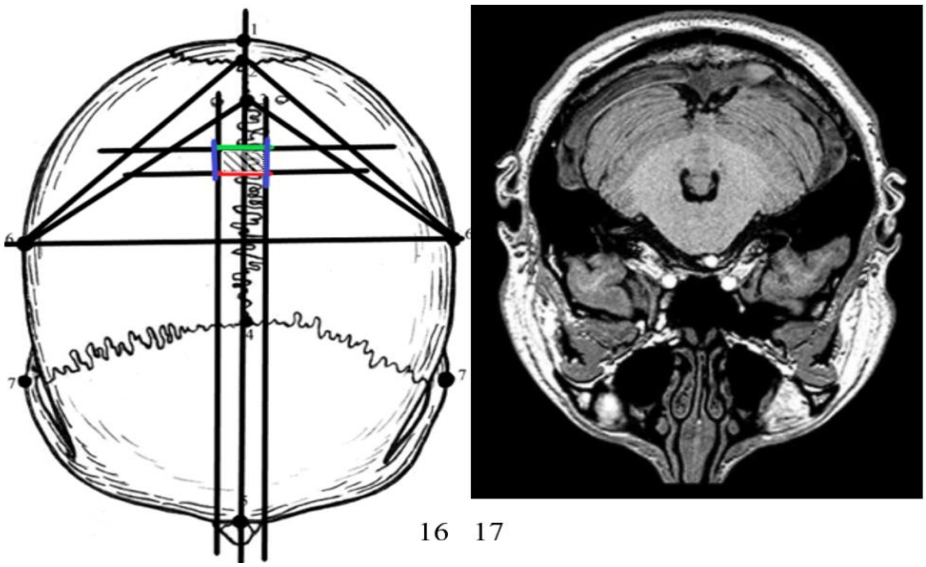

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Fig. 16. Location of the borders of the fourth ventricle on the axial plane (anterior border marked in red, posterior border in green, lateral borders in blue) 1 - opisthocranion; 2 - lambda; 3 - obelion; 4 - bregma; 5 - nasion; 6 - eurion; 7 - zygion.
Fig. 17: MRI in the axial plane attached to Fig. 16.

- Sagittal plane (lateral view)

- The upper border runs along a line crossing the inion, parallel to the sagittal axis.

- The lower boundary is along a line crossing the opisthocranion, parallel to the sagittal axis.

- For definition of a back border two parallel vertical lines are carried out, the first through asterion, the second through porion, then we build the third parallel line strictly on the middle between these two lines, exactly this line corresponds to a back border.

- To determine the front boundary, a line parallel to the vertical axis is drawn through mastoidale.

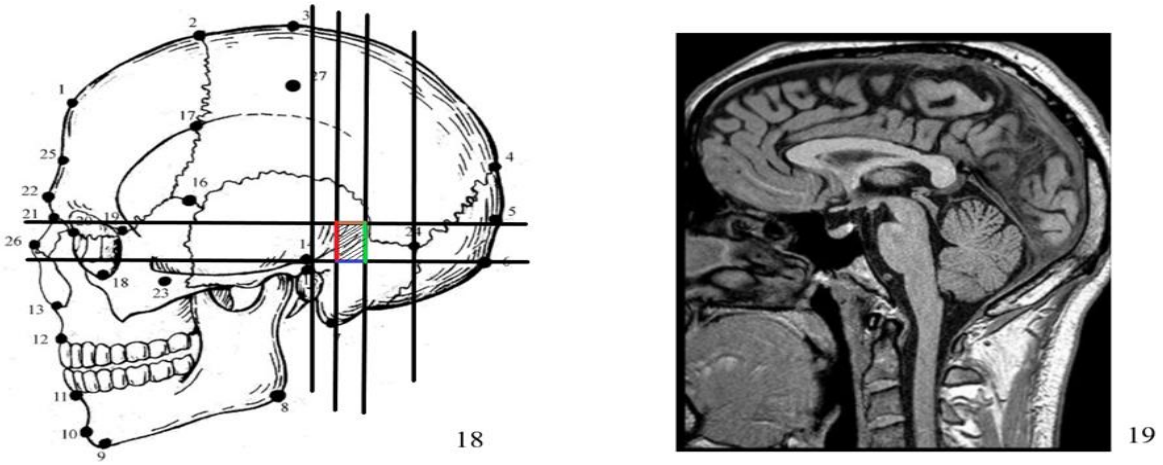

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Fig. 18. Location of the borders of the fourth ventricle on the sagittal plane (the anterior border is marked in red, the posterior border in green, the upper border in brown, and the lower border in blue) 1 - metopion; 2 - bregma; 3 - vertex; 4 - lambda; 5 - inion; 6 - opisthocranion; 7 - mastoidale; 8 - gonion; 9 - gnathion; 10 pogonion; 11 - infradentale; 12 - prostion; 13 - nasospinale; 14 - auricularis; 15 - porion; 16 - pterion; 17 - stephanion; 18 - orbitalis; 19 - frontal-maxillary eye point (frontomalare); 20 - dacrion; 21 - nasion; 22 - glabella; 23 - zygion; 24 - asterion; 25 - ophrion; 26 - rhinion; 27 – eurion.
Fig. 19: MRI in the sagittal plane attached to Fig. 18

- Frontal plane

- Frontal view
  - The upper boundary passes through the line crossing the nasion parallel to the frontal axis
  - The inferior border passes through a line connecting the orbitales
  - Lateral border passes through a line passing through the lateral margin of the nasal bones.
- Posterior view
  - The lower boundary is a line passing through the inion parallel to the frontal axis.
  - To determine the upper boundary it is necessary to construct an isosceles triangle, the base of which is the line connecting the mastoidale, and the apex opposite the base is the obelion, then it is necessary to draw a midline opposite the base, it is along this line that the lower boundary runs

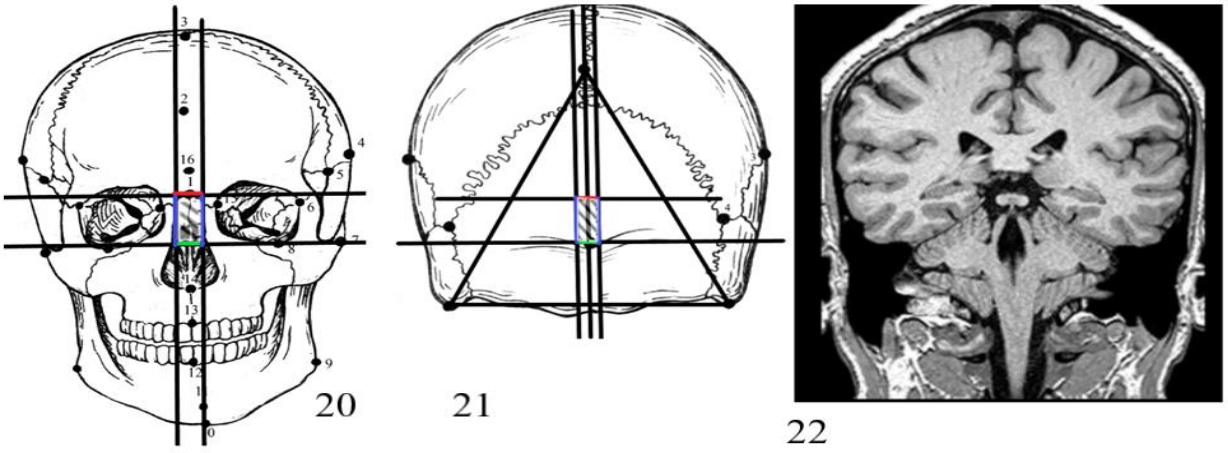


Fig. 20. Location of the borders of the fourth ventricle on the frontal plane from the front (the upper border is marked in red, the lower in green, the lateral in blue) 1 - nasion; 2 - metopion; 3 - bregma; 4 - eurion; 5 - pteryon; 6 - frontomalare (frontal-maxillary eye point); 7 - zygion; 8 - orbitale; 9 - gonion; 10 - gnathion; 11 - pogonion; 12 - infradentale; 13 - prostion; 14 - nasospinale; 15 - dacrion; 16 - glabella.
Fig. 21: Location of the borders of the fourth ventricle on the frontal plane posteriorly (upper border marked in red, lower in green, lateral in blue) 1 - obelion; 2 - inion; 3 - eurion; 4 - asterion; 5 - mastoidale.
Fig. 22: MRI attached to Figures 20 and 21 in the frontal plane.

Given the variability in the size of the third ventricle, it is impossible to accurately describe the size of this structure, it may depend on the age of the patient under study and the presence of certain changes in the structure of the brain.

Basal nuclei

- Axial plane:
  - To the front boundary corresponds the line connecting zygions.
  - Posterior border corresponds to the line connecting eurions.
  - Lateral borders pass at a level corresponding to upper margin of ocellar cavity.

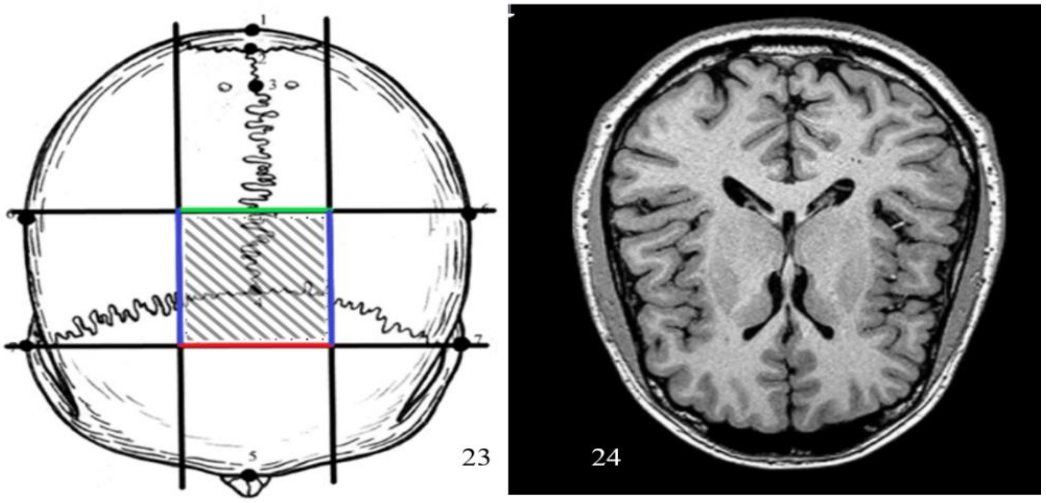


Fig. 23. Location of basal nuclei boundaries on the axial plane (anterior boundary is marked in red, posterior boundary in green, lateral boundaries in blue): 1 - opisthocranion; 2 - lambda; 3 - obelion; 4 - bregma; 5 - nasion; 6 - eurion; 7 - zygion.
Fig. 24. MRI attached to Fig. 23 in the axial plane.

- Sagittal plane:
  - To the posterior border corresponds a line parallel to the vertical axis passing through the mastoidale.
  - To the front border there corresponds a line parallel to vertical axis passing through bregma.
  - To upper border there corresponds a line parallel to sagittal axis passing through metapion.
  - The line parallel to sagittal axis passing through glabella corresponds to lower border.

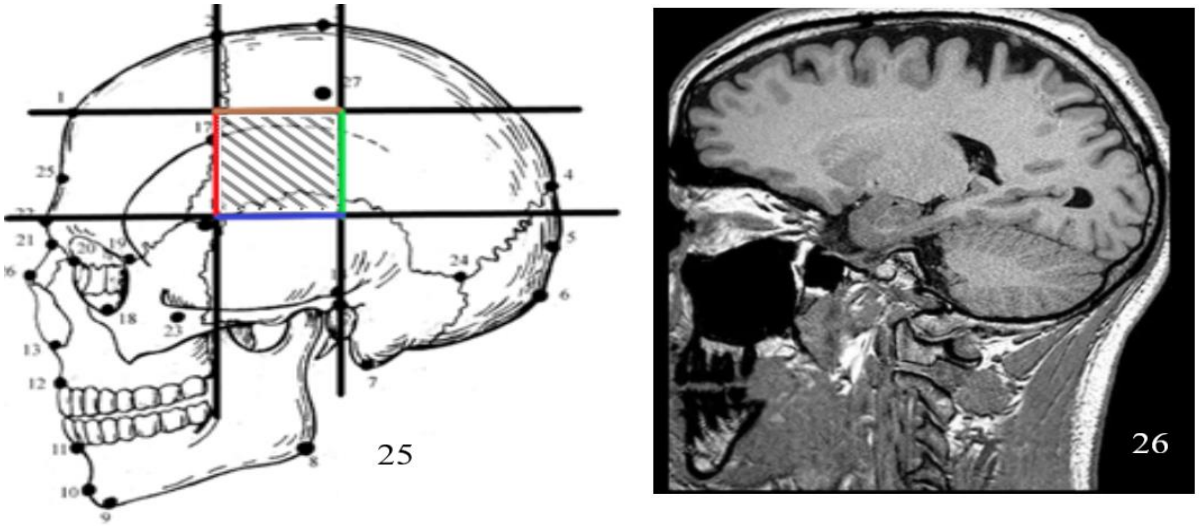
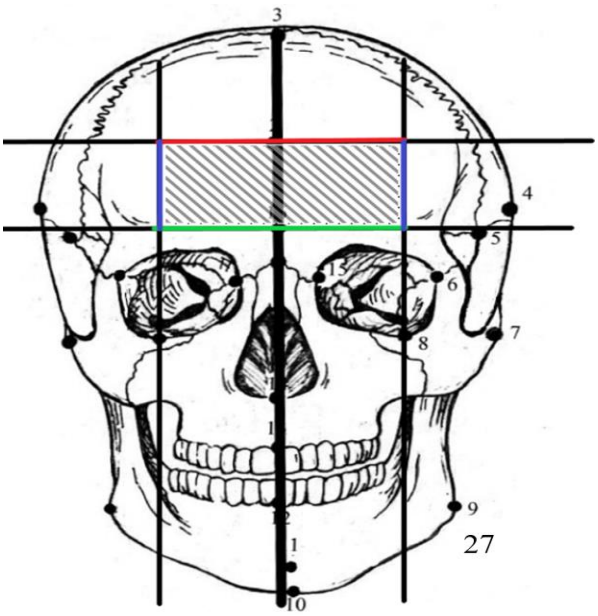


Fig. 25: Location of basal nuclei boundaries on the sagital plane (anterior boundary is marked in red, posterior boundary in green, upper boundary in brown, and lower boundary in blue). 1 - metopion; 2 - bregma; 3 - vertex; 4 - lambda; 5 - inion; 6 - opisthocranion; 7 - mastoidale; 8 - gonion; 9 - gnathion; 10 pogonion; 11 - infradentale; 12 - prostion; 13 - nasospinale; 14 - auricularis; 15 - porion; 16 - pterion; 17 - stephanion; 18 - orbitale; 19 - frontal-maxillary eye point (frontomalare); 20 - dacrion; 21 - nasion; 22 - glabella; 23 - zygion; 24 - asterion; 25 - ophrion; 26 - rhinion; 27 - eurion.
Fig. 26: MRI in sagittal plane attached to Fig. 25.

- Frontal plane (front)

- To the upper border there corresponds a line passing through metapion parallel to frontal axis.
- To lower border there corresponds a line passing through glabella, parallel to frontal axis.
- To lateral border there corresponds a line passing through orbital parallel to vertical axis.



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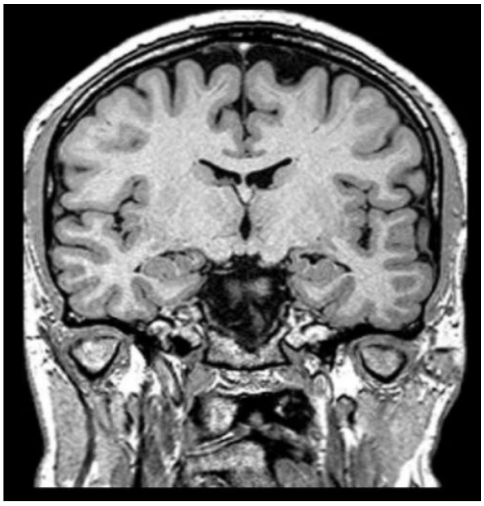

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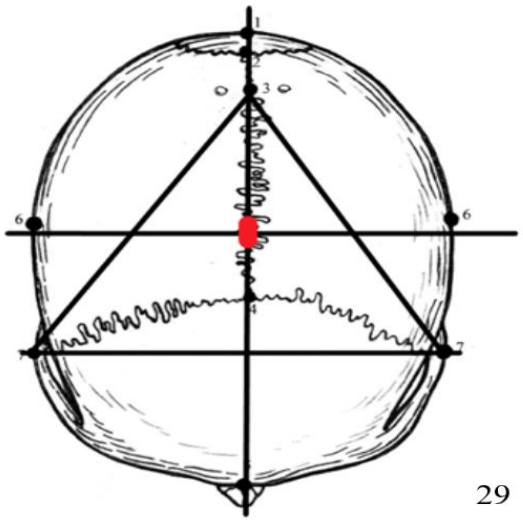
Fig. 27. Location of the boundaries of the basal nuclei on the frontal plane from the front (upper boundary marked in red, lower boundary in green, lateral in blue) From the front 1 - nasion; 2 - metopion; 3 - bregma; 4 - eurion; 5 - pteryon; 6 - frontomalare (frontal-maxillary eye point); 7 - zygion; 8 - orbitale; 9 - gonion; 10 - gnathion; 11 - pogonion; 12 - infradentale; 13 - prostion; 14 - nasospinale; 15 - dacrion; 16 - glabella.
Fig. 28. MRI in the frontal plane attached to Fig. 28.

Epiphysis

Axial plane - To determine the projection of the epiphysis, it is necessary to construct an isosceles triangle, the base of which is a line connecting the zygions and the vertex opposite the base is an obelion, then it is necessary to draw a midline opposite the base



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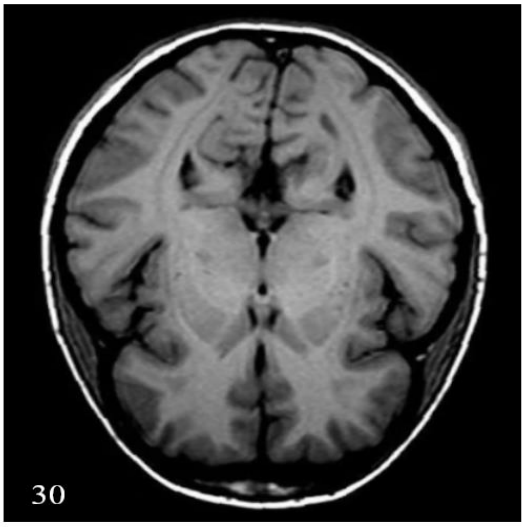

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Fig. 29. Projection of the epiphysis on the axial plane, the place is marked with a dot because of the small size of the organ. 1 - opisthocranion; 2 - lambda; 3 - obelion; 4 - bregma; 5 - nasion; 6 - eurion; 7 - zygion. The epiphysis is marked with a red dot.

Fig. 30. MRI in the axial plane attached to Fig. 29.

- Sagittal plane - to determine the projection of the sagittal plane it is necessary to draw a line parallel to the vertical axis, passing through the mastoidale and the line connecting the ophryon with the lambda, the point of intersection of these lines corresponds to the projection of the epiphysis.

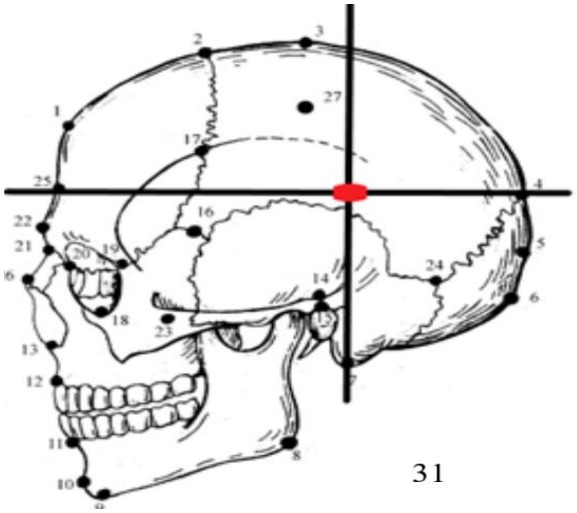


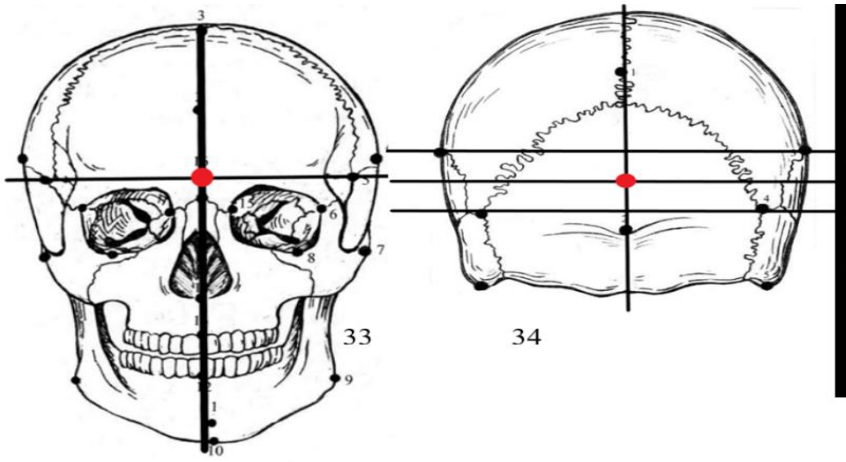
Fig. 31. Projection of the epiphysis on the sagittal plane, the place is marked with a dot because of the small size of the organ. 1 - metopion; 2 - bregma; 3 - vertex; 4 - lambda; 5 - inion; 6 - opisthocranion; 7 - mastoidale; 8 - gonion; 9 - gnathion; 10 pogonion; 11 - infradentale; 12 - prostion; 13 - nasospinale; 14 - auricularis; 15 - porion; 16 - pterion; 17 - stephanion; 18 - orbitale; 19 - frontal-maxillary eye point (frontomalare); 20 - dacrion; 21 - nasion; 22 - glabella; 23 - zygion; 24 - asterion; 25 - ophrion; 26 - rhinion; 27 - eurion.

Fig. 32. The attached MRI in the axial plane to Fig. 31 MRI in the axial plane.

- Frontal plane:

- Anterior view - epiphysis projection superimposed on the glabella.

- Back view - to determine the projection, 2 parallel lines are drawn (the 1st one connects eurions, the 2nd one - asterions), then 3 parallel lines are drawn strictly along the middle between these lines, at the intersection, we form a segment, the borders of which correspond to the borders of the skull, the middle of this segment corresponds to the projection of the epiphysis..



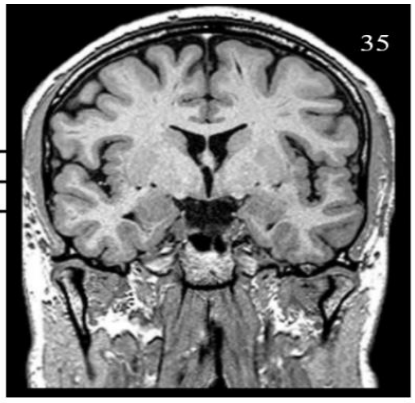


Fig. 33. Projection of the epiphysis on the frontal plane from the front, the place is marked with a dot because of the small size of the organ 1 - nasion; 2 - metopion; 3 - bregma; 4 - eurion; 5 - pterion; 6 - frontomalare (frontal-maxillary eye point); 7 - zygion; 8 - orbitale; 9 - gonion; 10 - gnathion; 11 - pogonion; 12 - infradentale; 13 - prostion; 14 - nasospinale; 15 - dacrion; 16 - glabella.

Fig. 34. Projection of the epiphysis on the frontal plane from the front, the place is marked with a dot because of the small size of the organ: 1 - obelion; 2 - inion; 3 - eurion; 4 - asterion; 5 - mastoidale.
Fig. 35. Enclosed with Figs. 33 and 34 MRI in the frontal plane.

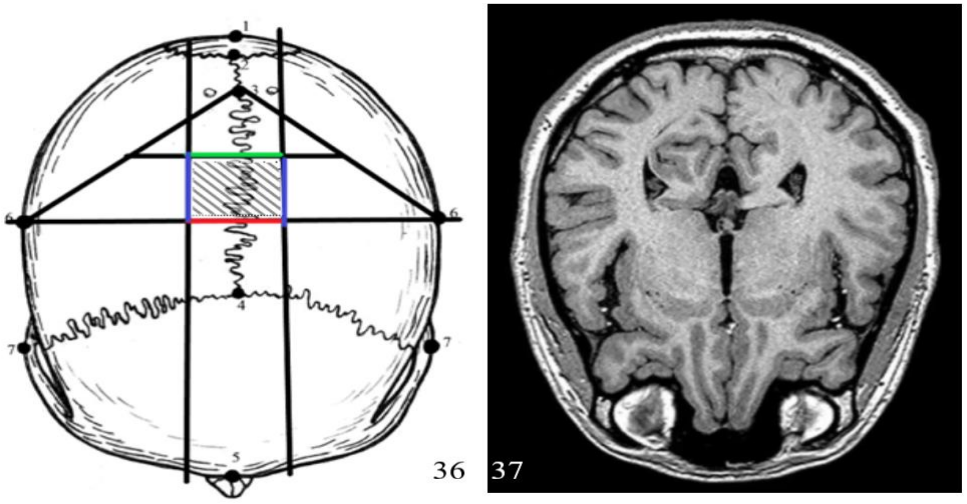
Thalamus and hypothalamus

- Axial plane

- The line connecting eurions corresponds to the anterior boundary

- To determine the posterior boundary it is necessary to construct an isosceles triangle, the base of which is the line connecting the eurions, and the vertex opposite the base is the obelion, then it is necessary to draw a midline opposite the base, it is along this line that the posterior boundary is drawn

- The lateral border corresponds to a line parallel to the sagittal axis passing through the superior medial margin of the eye socket.



36 37

Fig. 36. Location of the boundaries of the thalamus and hypothalamus on the axial plane (anterior boundary marked in red, posterior boundary in green, lateral boundaries in blue). 1 - opisthocranion; 2 - lambda; 3 - obelion; 4 - bregma; 5 - nasion; 6 - eurion; 7 - zygion.
Fig. 37. Enclosed to Fig. 36 MRI in the axial plane.

- Sagittal plane (side view):

- The posterior border corresponds to a line parallel to the vertical axis passing through the mastoidale.

- To determine the front boundary it is necessary to draw two parallel lines of the vertical axis, then on the middle between these lines it is necessary to draw a third parallel line, which corresponds to the front boundary.

- The line parallel to the sagittal axis passing through the ophryon corresponds to the upper boundary.

- A line parallel to the sagittal axis passing through the glabella corresponds to the lower boundary.

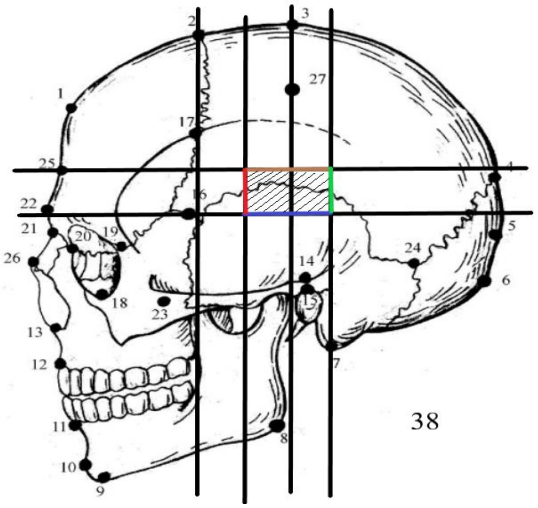
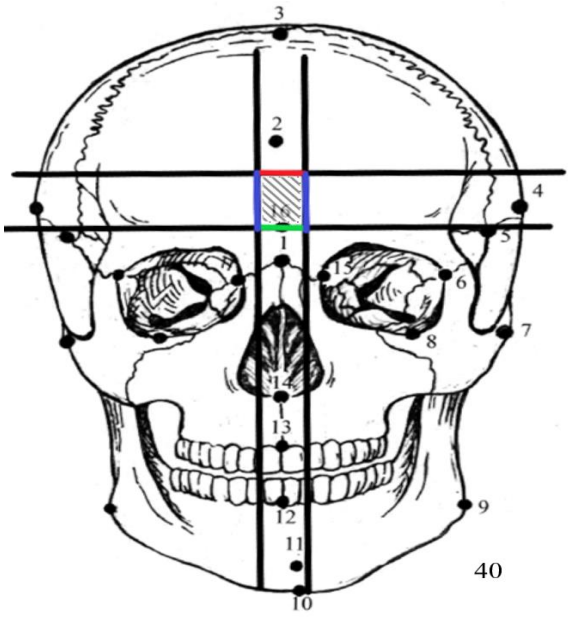


Fig. 38. Location of the boundaries of the thalamus and hypothalamus on the sagittal plane (the anterior boundary is marked in red, the posterior boundary in green, the upper boundary in brown, and the lower boundary in blue). 1 - metopion; 2 - bregma; 3 - vertex; 4 - lambda; 5 - inion; 6 - opisthocranion; 7 - mastoidale; 8 - gonion; 9 - gnathion; 10 pogonion; 11 - infradentale; 12 - prostion; 13 - nasospinale; 14 - auricularis; 15 - porion; 16 - pterion; 17 - stephanion; 18 - orbitale; 19 - frontal-maxillary eye point (frontomalare); 20 - dacrion; 21 - nasion; 22 - glabella; 23 - zygion; 24 - asterion; 25 - ophrion; 26 - rhinion; 27 - eurion.
Fig. 39. Appendix to Fig. 38 MRI in the sagittal plane.

- Frontal plane (frontal view) - upper border - corresponds to a line parallel to the frontal axis passing through the ophryon, lower border - a line parallel to the frontal axis passing through the glabella, lateral borders pass through lines passing through the lateral edge of the nasal bones



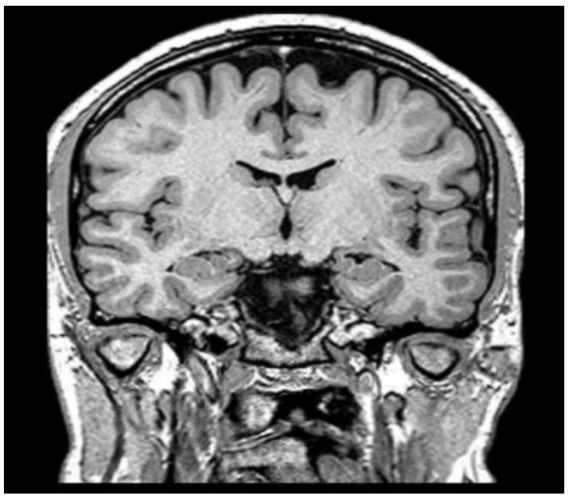


Fig. 40. Location of the boundaries of the thalamus and hypothalamus on the frontal plane from the front (the upper boundary is marked in red, the lower boundary in green, the lateral ones in blue). From the front 1 - nasion; 2 - metopion; 3 - bregma; 4 - eurion; 5 - pterion; 6 - frontomalare (frontal-maxillary eye point); 7 - zygion; 8 - orbitale; 9 - gonion; 10 - gnathion; 11 - pogonion; 12 - infradentale; 13 - prostion; 14 - nasospinale; 15 - dacrion; 16 - glabella.
Fig. 41. Enclosed to Fig. 40 MRI in the frontal plane.

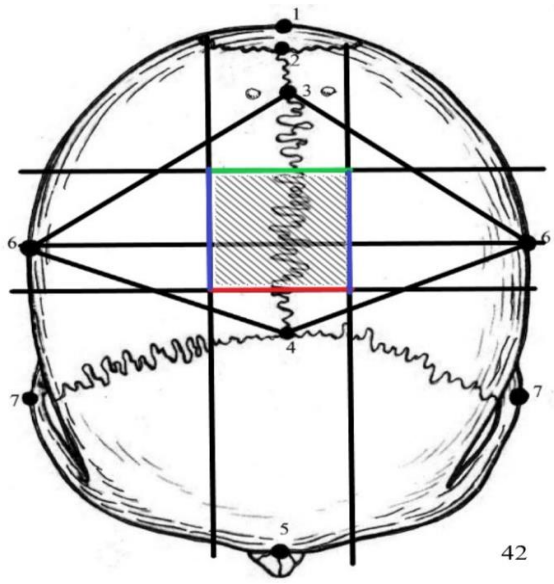
Reticular formation

- Axial plane:

- To determine the anterior boundary, construct an isosceles triangle with its base on the line connecting the eurions and its opposite base with the vertex corresponding to the bregma, the midline of this triangle corresponds to the anterior boundary

- To define the rear boundary it is necessary to construct an isosceles triangle with the base on the line connecting eurions, and opposite to the base a vertex corresponding to bregma, the midline of this triangle corresponds to the rear boundary.

- Lateral borders pass through lines parallel to the sagittal plane, passing through the superior medial margin of the eye socket.



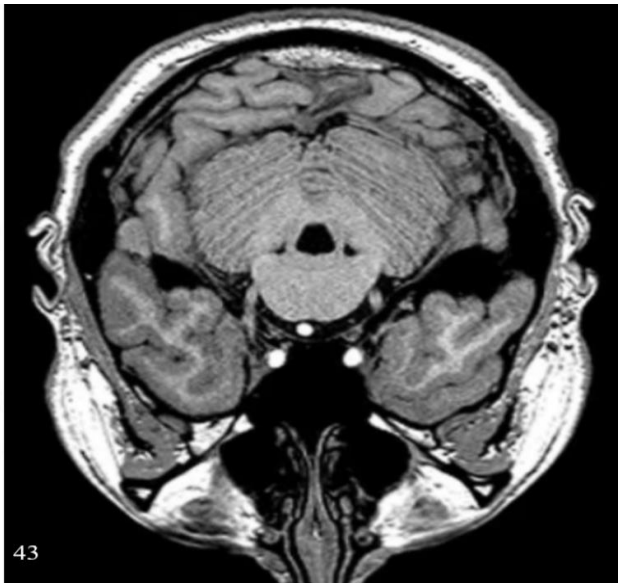


Fig. 42. Location of the boundaries of the reticular formation on the axial plane (the anterior boundary is marked in red, the posterior boundary in green, and the lateral boundaries in blue). 1 - opisthocranion; 2 - lambda; 3 - obelion; 4 - bregma; 5 - nasion; 6 - eurion; 7 - zygion.
Fig. 43. Enclosed to Fig. 42 MRI in the axial plane.

- Sagittal plane (lateral view):

- To determine the anterior boundary, two lines parallel to the vertical axis are drawn, the first of them passing through bregma and stephanion and the second through asterion, then we draw a third parallel line passing through the middle between these lines, which corresponds to the anterior boundary.

- For definition of a back border two parallel lines are constructed parallel to a vertical axis the first of them passes through vertex and eurion, and the second of them passes through vertex and eurion, then we construct the third parallel line passing on the middle between these lines which corresponds to a back border.

- The upper border - passes through the line passing through ophrion parallel to sagittal axis.

- The lower border corresponds to the line passing through zygion parallel to sagittal axis.

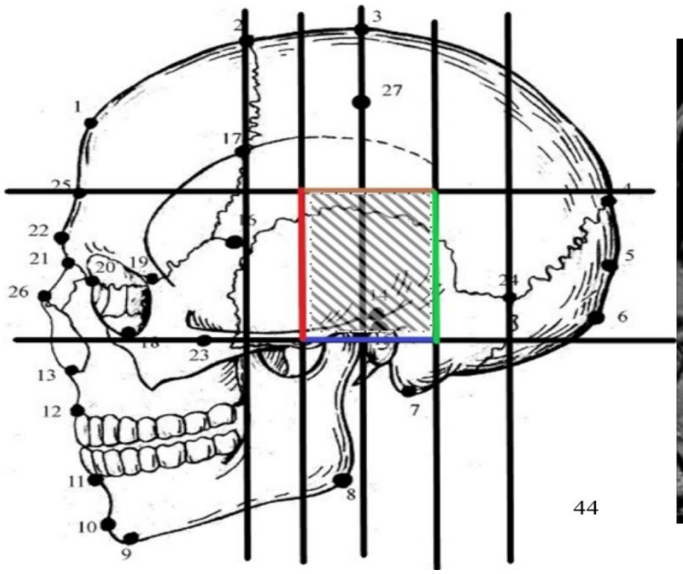


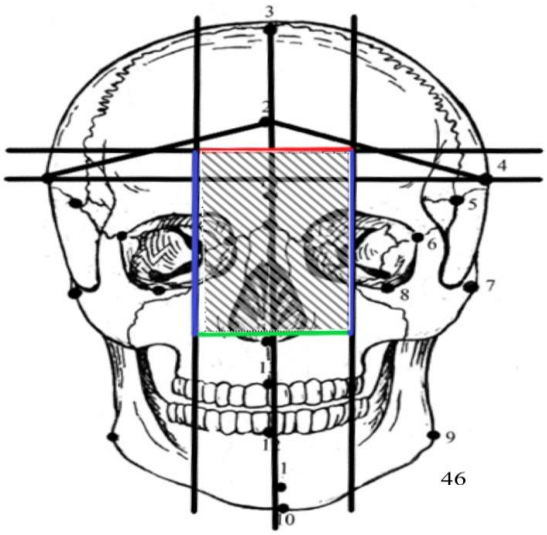
Fig. 44. Location of the boundaries of the reticular formation on the sagittal plane (the anterior boundary is marked in red, the posterior boundary in green, the upper boundary in brown, and the lower boundary in blue). 1 - metopion; 2 - bregma; 3 - vertex; 4 - lambda; 5 - inion; 6 - opisthocranion; 7 - mastoidale; 8 - gonion; 9 - gnathion; 10 pogonion; 11 - infradentale; 12 - prostion; 13 - nasospinale; 14 - auricularis; 15 - porion; 16 - pterion; 17 - stephanion; 18 - orbitale; 19 - frontal-maxillary eye point (frontomalare); 20 - dacrion; 21 - nasion; 22 - glabella; 23 - zygion; 24 - asterion; 25 - ophrion; 26 - rhinion; 27 - eurion.
Fig. 45. Appendix to Fig. 44 MRI in the sagittal plane.

- Frontal plane (Front view)

- For definition of the upper border it is necessary to construct an isosceles triangle with the base on the line connecting eurions, and the vertex opposite to the base in metopion, the midline of this triangle corresponds to the upper border

- The lower border corresponds to the large opening of the skull

- The lateral border is formed by lines parallel to the vertical axis passing through the upper medial edge of the eye socket.



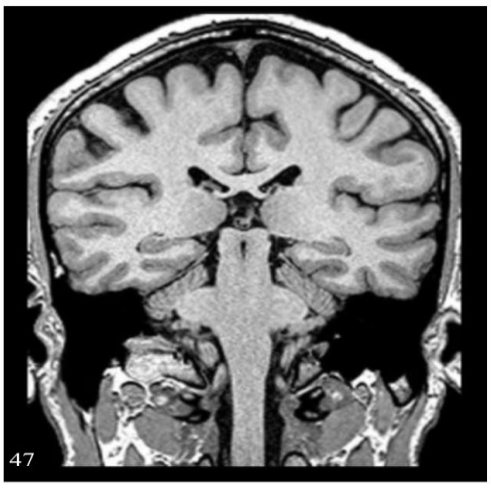


Fig. 46. Location of the boundaries of the reticular formation on the frontal plane from the front (the upper boundary is marked in red, the lower one in green, the lateral ones in blue). From the front 1 - nasion; 2 - metopion; 3 - bregma; 4 - eurion; 5 - pterion; 6 - frontomalare (frontal-maxillary eye point); 7 - zygion; 8 - orbitale; 9 - gonion; 10 - gnathion; 11 - pogonion; 12 - infradentale; 13 - prostion; 14 - nasospinale; 15 - dacrion; 16 - glabella.

Fig. 47. Annexed to Fig. 47 MRI in the frontal plane.

CONCLUSION

On the basis of comparison of brain MRI and simple mathematical calculations, the projections of intracerebral structures were determined, which is the most important condition for palpatory layer-by-layer diagnosis and correction of deep brain structures. The effectiveness of osteopathic techniques in cranial osteopathy directly depends on the accuracy of hand placement.

Appendix

• ***Auriculare (ear point), auriculare*** - is located on the root of the zygomatic process of the temporal bone at the place of its intersection with a vertical line drawn through the center of the external auditory canal. In craniology, it is used to measure the width of the skull base (the distance between the two ear lines - biauricular width).

• ***Alveolar point, alveolare -*** located in the sagittal plane on the lower edge of the alveolar arch of the maxilla (between the medial incisors). In craniology, it is used to measure the height of the upper face (the distance between the points alveolare and nasion).

• ***Asterion, asterion (from the Greek word for "star") -*** located at the junction of the lambdoid, parieto-parietal and occipital-parietal sutures. This point is projected on the scalp along the line connecting the external auditory canal with the external occipital protrusion (1-3.5 cm above and behind the external auditory canal.

• ***Basion, basion (from the Greek word "base")*** - the lowest point of the skull at the intersection of the anterior edge of the greater occipital foramen and the median plane. In craniology, it is used to determine two indicators: a) the height of the skull (distance between the basion and bregma); and b) the length of the skull base (distance between the nasion and basion). In the living person, it corresponds to the ossicle of the auricle.

• ***Bregma, bregma (from the Greek word "vertex") -*** the point of connection of the frontal and both parietal bones. It is located at the intersection of the sulcus and coronal sutures. In craniology it is used to determine the height of the skull (distance from the bregma to the basion).

• ***Vertex, vertex -*** the most upwardly projecting point on the skull vault. It is located in the median plane when the skull is positioned in the auriculo-ocular horizontal.

• ***Glabella (supraperiosteum), glabella -*** the most forward point of the frontal bone between the inner edges of the supraorbital arches. It is located in the median plane at the position of the skull in the auric-ocular horizontal. It is used as an anterior point when measuring the longitudinal diameter (length) of the skull (distance from the glabella point to the opisthocranium point).

• ***Orbitale (ocular point), orbitale -*** the lowest point of the suborbital margin. It is used in measuring the vertical dimension of the eye socket.

• ***Gnathion (chin point), gnathion -*** located in the median plane on the lower edge of the mandible. In craniology, it is used in measuring the full height of the face (the distance between the gnathion and the nasion).

• ***Gonion (angle point), gonion -*** corresponds to the apex of the angle of the mandible (the place of transition of the lower edge of the mandible to the posterior edge of its branch.

• ***Dacrion (eye socket point), dacroon*** - located at the junction of the frontal and lacrimal bones with the frontal process of the maxilla. It is used in measuring the horizontal size of the eye socket.

• ***Zygion (zygomatic point), zygion -*** the most outwardly projecting point on the zygomatic arch. In craniology, it is used to measure the zygomatic diameter (the distance between the zygion points on both sides).

• ***Inion, inion (from the Greek word "occiput") -*** a point at the convergence of the upper ileal lines. It is located in the median plane and corresponds to the apex of the external protrusion of the occipital bone. In craniology, it is used to determine the longitudinal diameter of the skull (between the glabella and the inion).

• ***IUPAC - International Union of Pure and Applied Chemistry (IUPAC)*** is an international non-governmental organization comprising scientific organizations of 57 countries (academies of sciences, chemical societies and scientific councils) and chemists. It is best known for its work on the standardization of nomenclature in chemistry. The IUPAC Interdepartmental Committee on Nomenclature and Symbols (IUPAC Nomenclature) is the recognized world authority in the development of standards for the designation of chemical elements and compounds.

• ***Lambda, lambda -*** the point of junction of the occipital and two parietal bones. It is located at the intersection of the sagittal and lambdoid sutures.

• ***Mastoidale (mastoid point), mastoidale -*** located at the apex of the mastoid process.

• ***Metopion (metopion) -*** the point of intersection of the median plane with the line connecting the most convex areas of both frontal cusps.

• ***Nasion (nasal point), nasion -*** located at the junction of the nasal and frontal bones. It corresponds to the intersection of the median plane with the frontal-nasal suture. In craniology, it is used to determine the length of the skull base (distance from the nasion to the opisthion) and the profile angle.

• ***Ophrion, ophrion (from the Greek word ophros - eyebrow)*** - is located at the intersection of the median sagittal plane and the horizontal line corresponding to the smallest cross-section of the forehead.

• ***Obelion, obelion (from the Greek word "rod")*** - is located at the intersection of the line connecting the centers of the parietal foramen with the sagittal suture***.***

• ***Opisthion, opisthion (from the Greek word for "behind")*** - located at the intersection of the median plane with the posterior edge of the greater occipital foramen***.***

• ***Opisthocranion, opisthocranion -*** the most posteriorly projecting point on the occipital bone. It is located in the median plane and is as far as possible from the glabella. In craniology, it is used as a posterior landmark in determining the length of the skull (from glabella to opisthocranion).

• ***Pogonion, pogonion*** - the most forward-protruding point on the jawline. It is located in the median plane.

• ***Porion, porion (from the Greek word for "hole") -*** located in the middle of the upper edge of the external auditory canal.

• ***Prostion, prosthion -*** the most forward-protruding point of the upper jaw. It is located in the medial plane between the medial incisors. In craniology, it is used to determine one of the components of the profile angle of the skull (the line between the prosthion and nasion points).

• ***Pterion, pterion (from the Greek word "wing") -*** located at the junction of the large wing of the cuneiform bone with the parietal, temporal and frontal bones.

• ***Rhinion, rhinion -*** located at the most forward point of the suture of the nasal bones.

- ***Stephanion, stephanion (from the Greek word for "wreath") -*** located at the intersection of the venus suture with the upper temporal line.

- ***Euryon, eurion, eurion (from the Greek word "broad")*** - is located on the most protruding to the outside parts in the area of parietal tubercles. It corresponds to the points on the lateral surface of the skull that are the most distant from the median plane. In craniology, it is used to determine the transverse diameter of the skull (the distance between the euryon on both sides)***.***

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The group of authors testifies that there is no conflict of interest in preparation for the publication of their article.

REFERENCES

[1] Farberov B.I. The Turkish saddle in intracranial tumors: (Radiological study). - Kharkov, 1941. - 138 c.

[2] Sapin M.R., Bryksina Z.G., Chava S.V. Human Anatomy. Moscow: GEOTAR-Media, 2015. - 376 c.

[3] Novoseltsev S.V. Osteopathy Osteopathy 1 : Textbook for higher educational institutions / S.V.Novoseltsev. - 2nd ed. - M.: MEDpress-Inform, 2022. - 688 c.

[4] Nazarov V.V.. Application of navigation in skull base surgery // Journal "Voprosy neurosurgery" named after N.N. Burdenko. 2019; 83(5):109 - 118.

[5] Labzin V.I., Rodionov A.A. Projection lines, areas and points on the human body. Study guide. - Blagoveshchensk, 2005. - 151 c.

[6] Trufanov G.E. The norm of CT and MRI images of the brain and spine. Atlas of images. - 4th ed. - SPb, ELBI, 2022. - 144 c.

[7] Møller T.B., Reif E. Atlas of human sectional anatomy with examples of CT and MRI sections: in 3 vols. - 6th ed. - Vol. 1. Head and neck. Moscow: MEDpress-Inform, 2021. - 360 c.

[8] Gaivoronsky A.I., Kondakov E.N., Svistov D.V., Gulyaev D.A. Operative accesses in neurosurgery; edited by Academician of the Russian Academy of Sciences B.V. Gaidar SPb.: Spetslit, 2015. Vol. 1. - 239 p.

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