FUNCTIONAL ANATOMY OF THE SKULL

1. **Ontogenesis of the skull**

2. **Morphological peculiarities of the skull**

3. **Varians of the skull**

4. **Abnormalities of the skull**

Lecturer: PhD, Professor Tamara Hacina

Skeleton of the head = the skull

22 bones

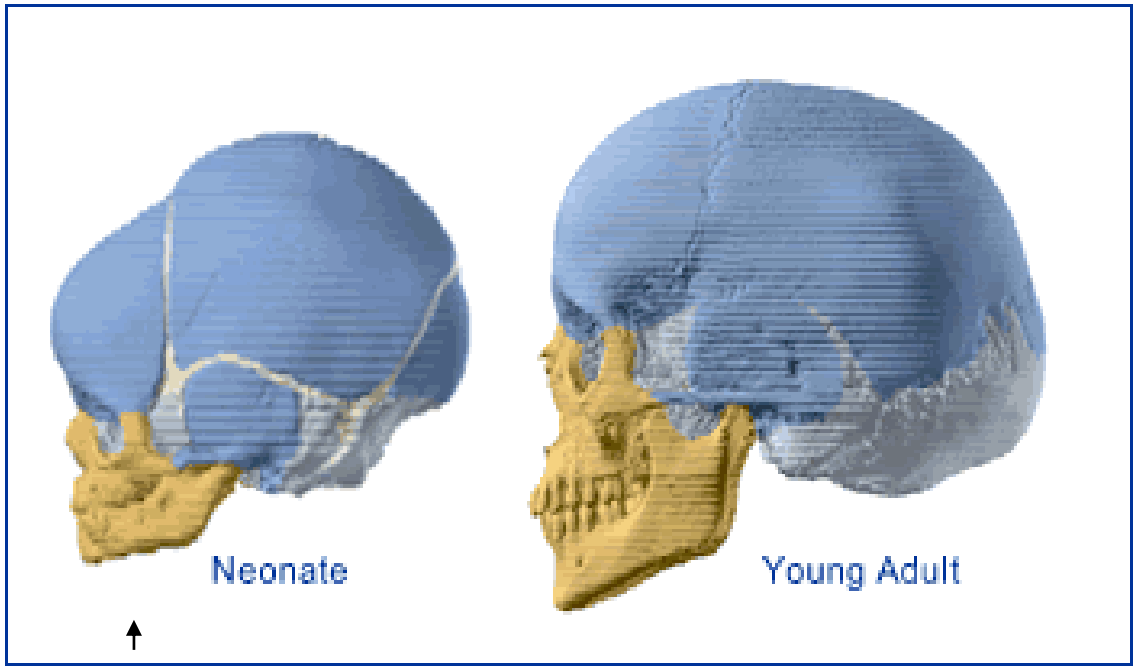
Cerebral skull = neurocranium /8/

Facial skull = viscerocranium /14/

Calvaria=skull-cap

Base

These three subdivisions may be considered as separate units, but they are interrelated, and changes in any one of these parts may effect the development of the other parts.



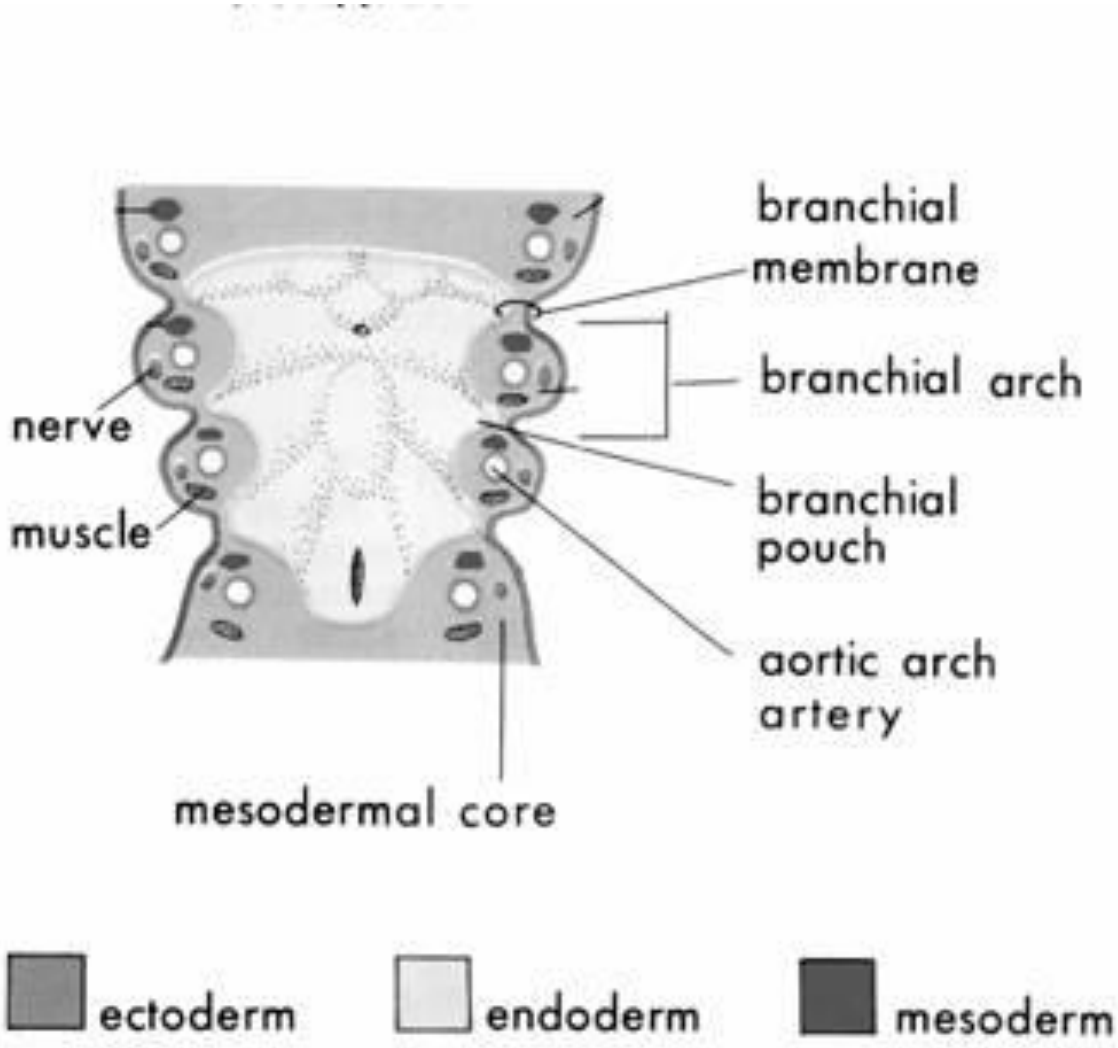
Ontogenesis of the skull

- The skull is the most complex arrangement of bones within the body. It protects the central nervous system, the oral cavity and nasal cavity, the ears and the eyes within its inner, outer and directly related structures

- The bones of the skull are formed in two different ways: ***intramembranous ossification*** and ***endochondral ossification*** are responsible for creating compact cortical bone or spongy bone. During the maturation of the skull, it is categorically divided into two main parts: the viscerocranium and the neurocranium. These two terms account for the bones of the face and the bones of both the cranial base and the cranial vault respectively. The cranial vault is further divided into membranous neurocranium and cartilaginous neurocranium.

- Lateral plate mesoderm found in the neck region, paraxial mesoderm and neural crest cells all contribute to the development and existence of the skull in its entirety.

Development of the facial skull



derived from structures known as pharyngeal arches.

All bones of the viscerоskull are derived from cells of the *neural crest*. Also, all of the following structures emerge from *the first* and *second pharyngeal arches*.

-There are five pharyngeal arches numbered from 1 to 6; the viscerocranium is primarily formed from Arch 1 and 2.

-Each arch contributes not only to the development of a particular portion of the skull, but also to the creation of specific muscles, nerves, and blood vessels.

-The basic pattern and creation of facial bones is concentrated to weeks 4-10 of embryonic development.

-The bony and cartilaginous structures of the viscerocranium also develop by both

Pharyngeal (branchial) arches

•Definition: the pharyngeal arches **are 6 curved cylindrical mesodermal thickenings on each side of the primitive pharynx. Each arch forms a swelling on the outher surface of the embryo and a swelling on the wall of the pharynx internally.**

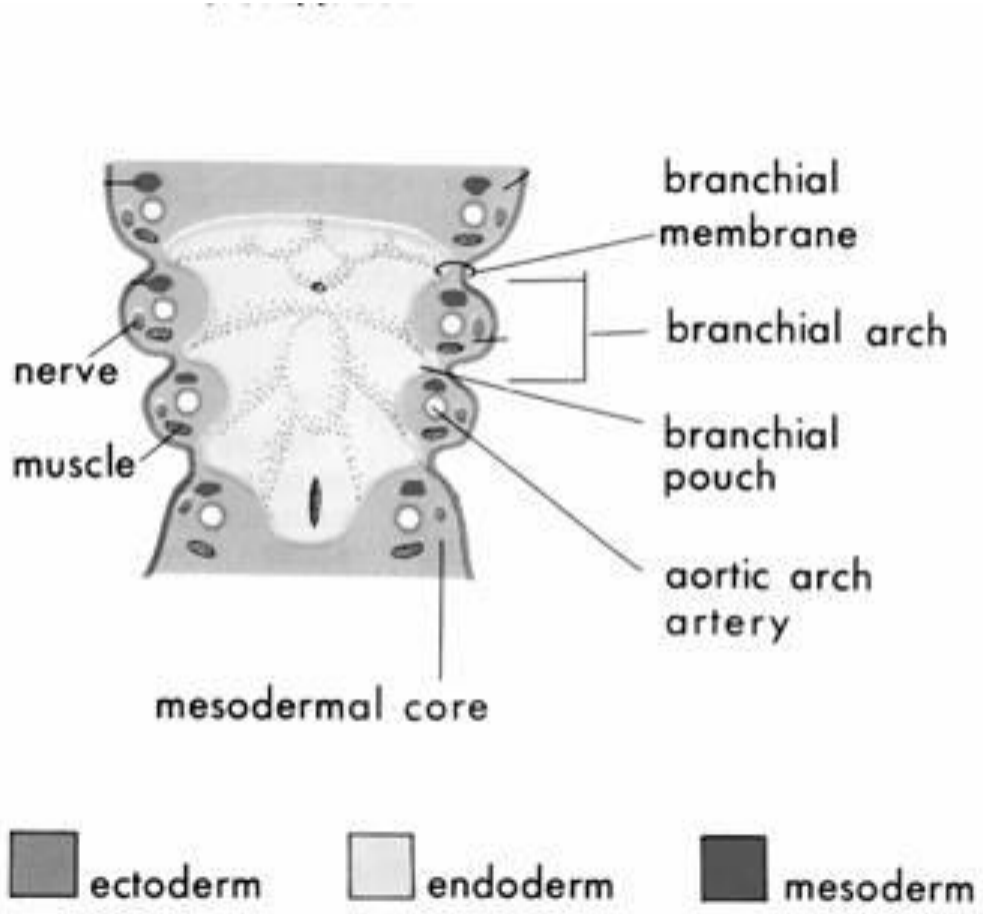
Formation: they are produced by the proliferation of the mesoderm of the lateral wall of the pharynx forming 6 arched thickenings.

Each arch consists of:

an outher ectodermal covering,
an inner endodermal lining,
a mesodermal core between the ecto- and endoderm.
The arches are separated from each other externally by 5 grooves called *pharyngeal clefts*;
internally – 4 grooves – *pharyngeal pouches*.

Time of appearance: 4-5 weeks of embryonic life.

Fate: after 5 weeks they become transformated into bones, cartilages ligaments, muscles and vessels of the head and neck.



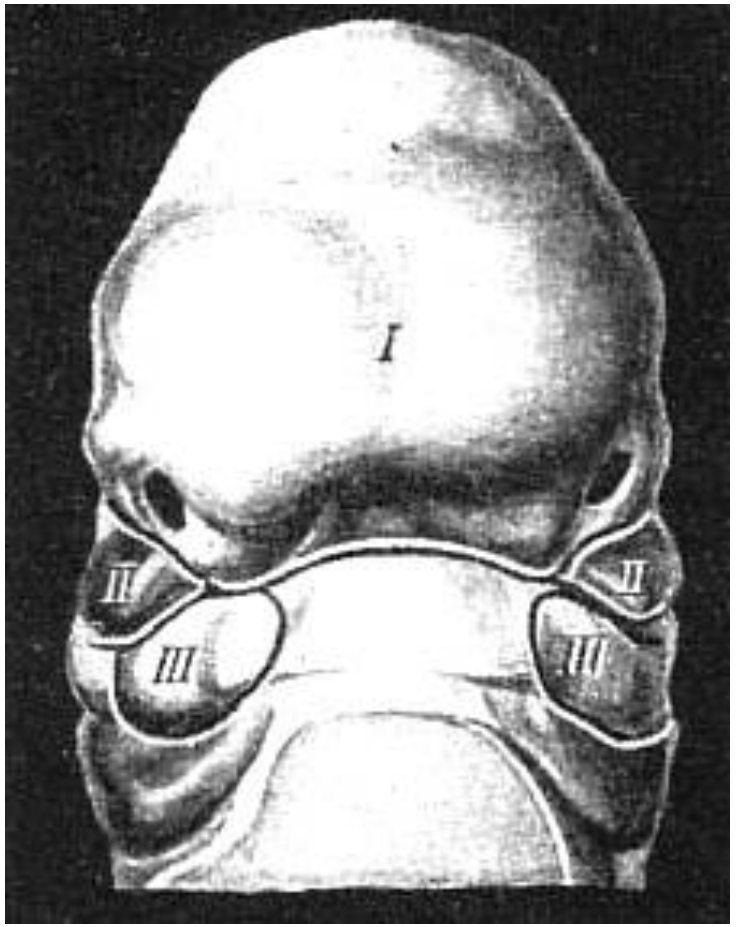
Skeletal derivatives of the pharyngeal arches

Arch	Derivatives
I	Dorsally: incus, malleus Ventrally: anterior part of the body of mandible (the rest of mandible develops by membranous ossification)
II	Stapes, styloid process, Lesser horn and upper part of the hyoid body
III	Greater horn and lower part of the hyoid body Stapes
IV	Thyroid cartilage of the larynx
V	Degenerates
VI	All cartilages of the larynx except the thyroid

Development of the face

I. Formation of 5 processes around the stomodeum

The upper part of the head fold projects downward and forwards to form the *frontonasal process*.
The pericardial swelling project upwards.
A depression (*stomodeum =primitive mouth*) is formed between the previous 2 swellings.
Pharyngeal arches appear on either side of the pharyngeal gut.



The first pharyngeal arch develops 2 processes: *mandibular* and ***maxillary*.**

The stomodeum becomes surrounded by 5 processes:
***Frontonasal* – cranially;**
***2 maxillary* – on each side;**
***2 mandibular* – caudally.**

II. Differentiation and fusion of the 5 processes

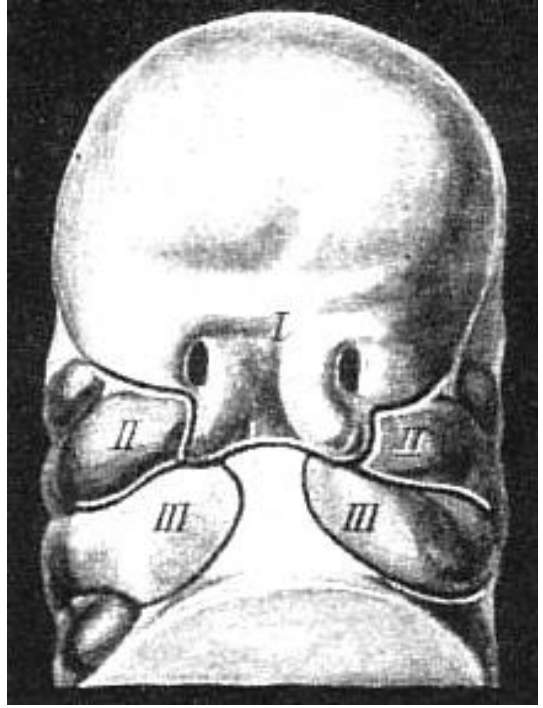
The frontonasal process **gives rise to the nose, nasal cavity, the filtrum of the upper lip; the anterior part of the maxilla and hard palate.**

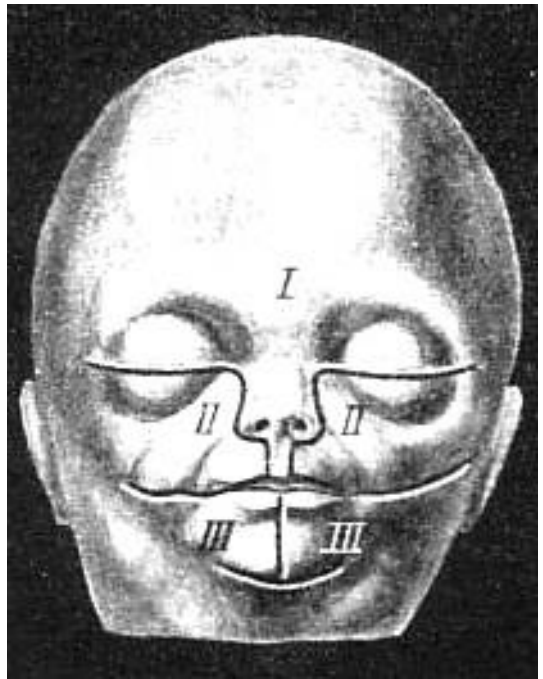
Each maxillary process **grows medially and approaches the medial and lateral nasal folds but remains separated from them by nasolacrimal groove which later will form nasolacrimal duct.**

The maxillary processes fuse with the medial nasal folds of the frontonasal process to form the upper lip (except filtrum).

Each maxillary process unites: <u>anteriorly</u>: with the lateral nasal fold along the side of the nose;
<u>posteriorly:</u> with mandibular process to form the cheek.

The mandibular processes:
fuse above with the maxillary process forming the cheeks;
fuse with each other medially to form the lower lip and cheek.





Development of the neurocranium

Base of the skull

Develop by cartilaginous ossification (secundary bones) of 6 pairs of cartilages: 3 lateral şi 3 medial.

Skull cap

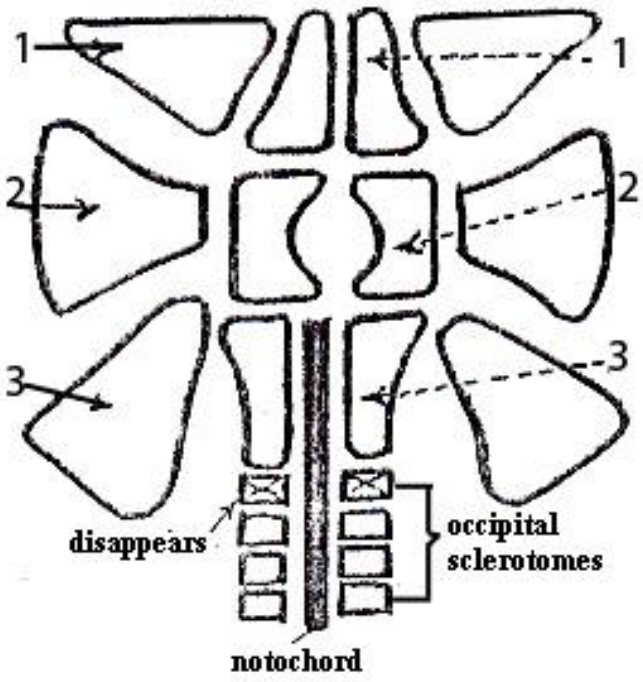
Develop by membranous ossification (primary bones)

Lateral cartilages:

1.The orbitosphenoid – forms the lesser wing of sphenoid

2.The ali-sphenoid - forms the greater wing of sphenoid

3.The periotic capsule – forms the petrous and mastoid parts of the temporal bone



Medial cartilages:

1.Cranial trabeculae – fuse to form the ethmoidbone

2. Hypophyseal cartilages - fuse to form the body of sphenoid bone

3. Parachordal cartilages - fuse with 3 occipital sclerotomes to form the basilar and lateral parts of occipital bone

Development of the cerebral skull

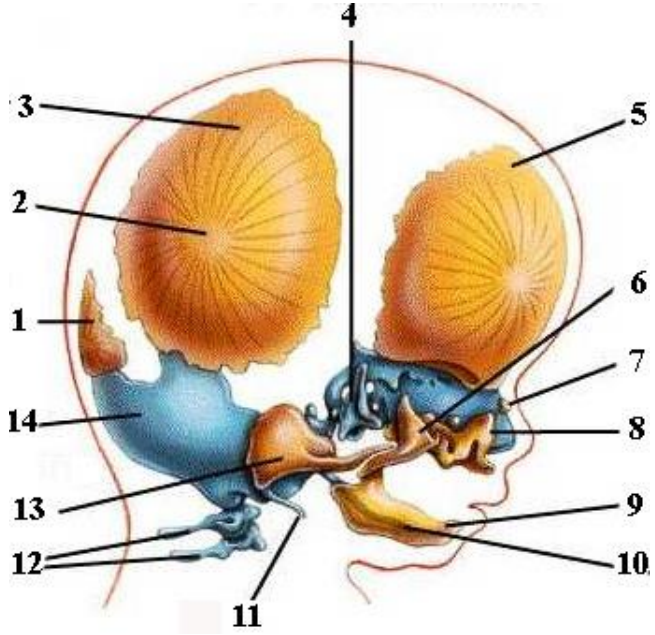
The bones of the neurocranium are derivatives of 3-4 pairs of the cephalic sclerotomes.

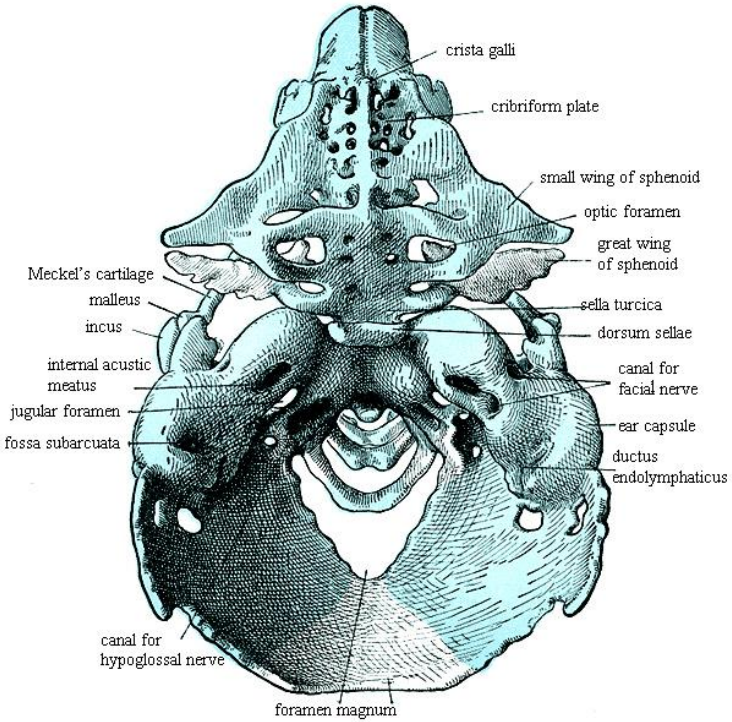
At III-d week of the intrauterine life mesenchyme is transformed into the *membranous skull.*

Membranous ossification of the skull callote (skull cap) starts at the central part of each bone and spreads radially in all directions by apposition of the bone substance on the periphery.

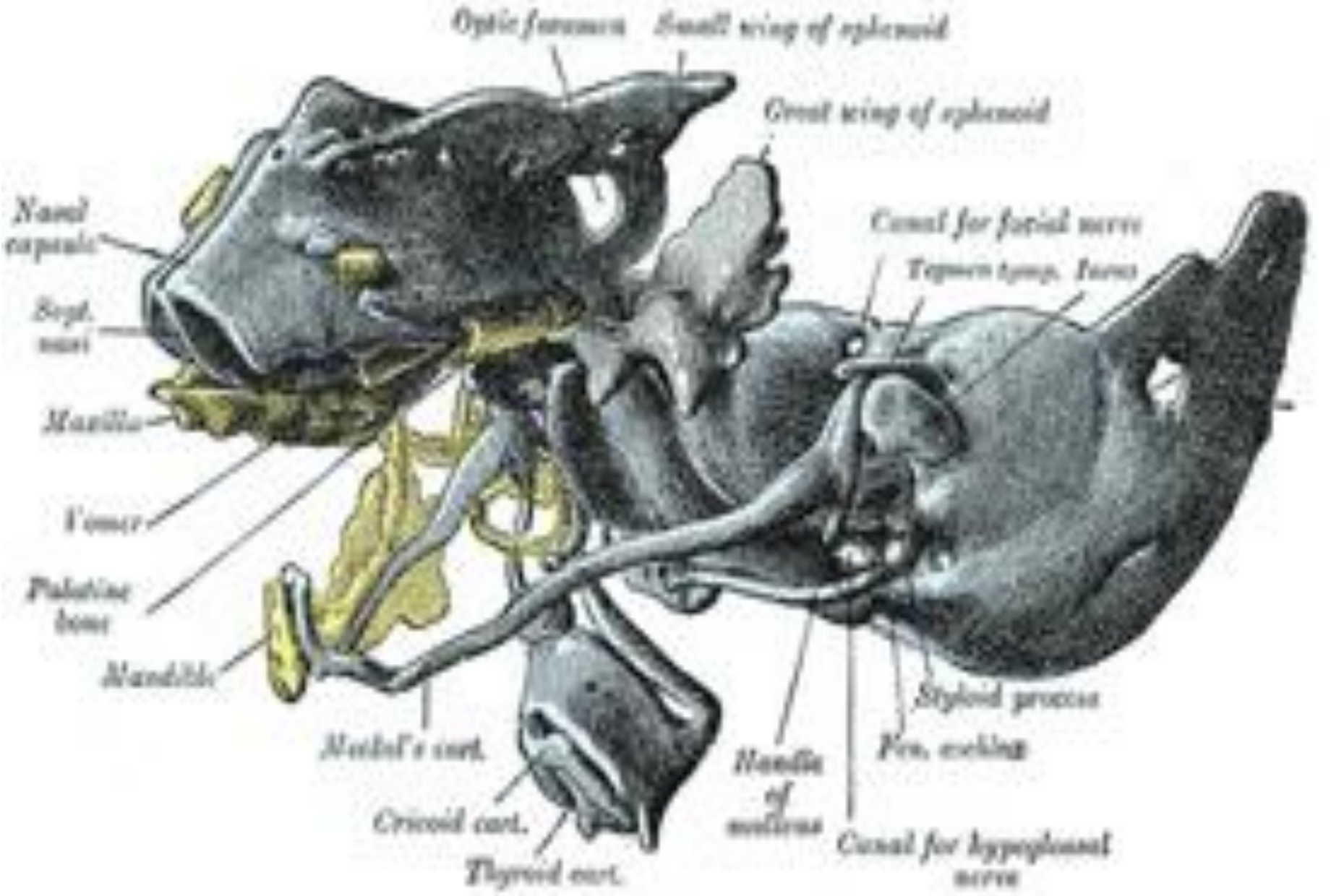
The skull cap bones are primary, those of the skull base – are secondary.

At VIIth week - formation of the cartilaginous base of the skull .





Cartilaginous stage of the skull bones



Ossification of skull bones

Membranous ossification:

- Frontal
- Parietal
- Maxillary
- Zygomatic
- Nasal
- Lacrimal
- Palatine

Cartilaginous ossification:

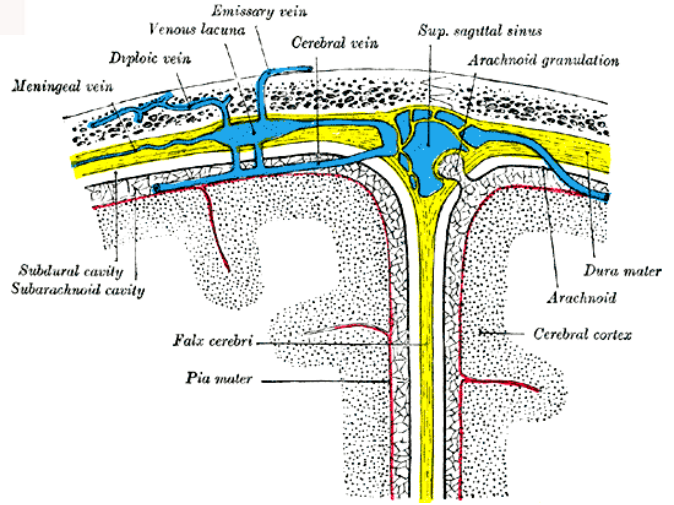
- Ethmoid
- Conchae of the nose

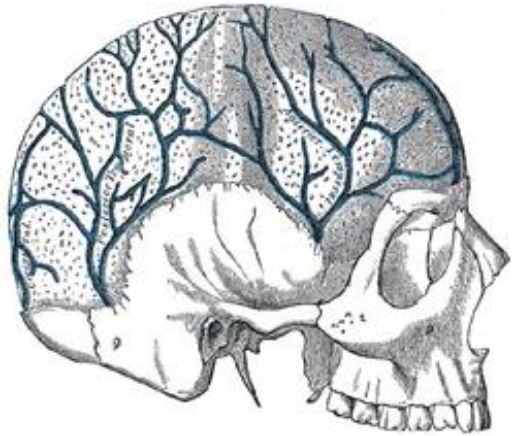
Membranous and cartilaginous ossification:

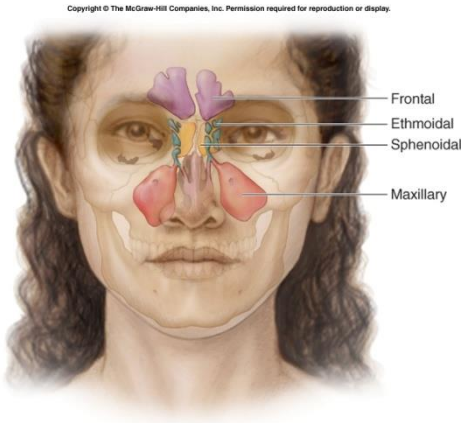
- Occipital
- Sphenoid
- Temporal
- Mandible

Morphological peculiarities of the skull bones

1. **Complex structure**: they consist of some parts.
2. They are composed of **2 lamelae of compact bony tissu** (external lamina – hard and resistent; internal – reach in mineral solts, fragile). The soft spongy material (**diploe**) between the inside table and outside table (the interior and exterior bony plates) of the skull. The diploe contains bone marrow and diploic veins .
3. Existance of foramina for the emissary veins diploic veins. The **emissary veins** are veins which normally drain external veins of the skull into the dural venous sinuses. .
4. Some skull bones contain **air cavity**.
5. **The areas of resistance** (regions of compact bone which transmit mastication power to the calvaria and base of the skull).



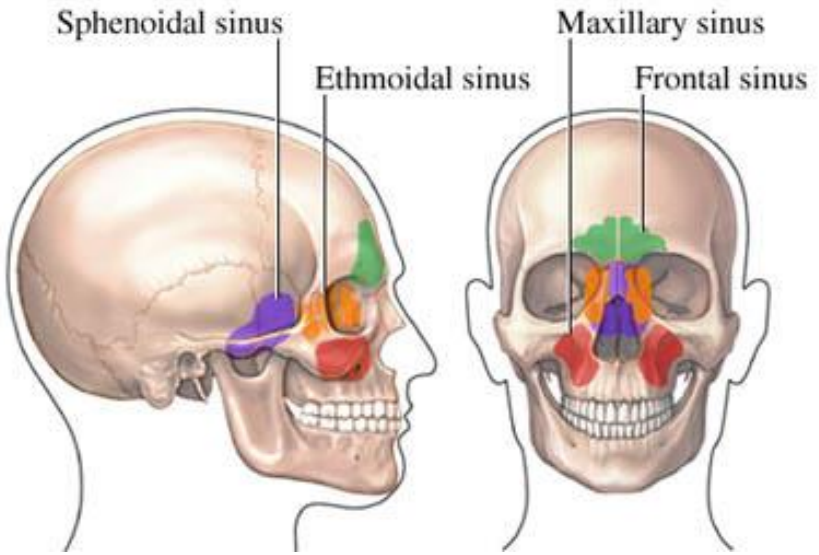




Pneumatic bones

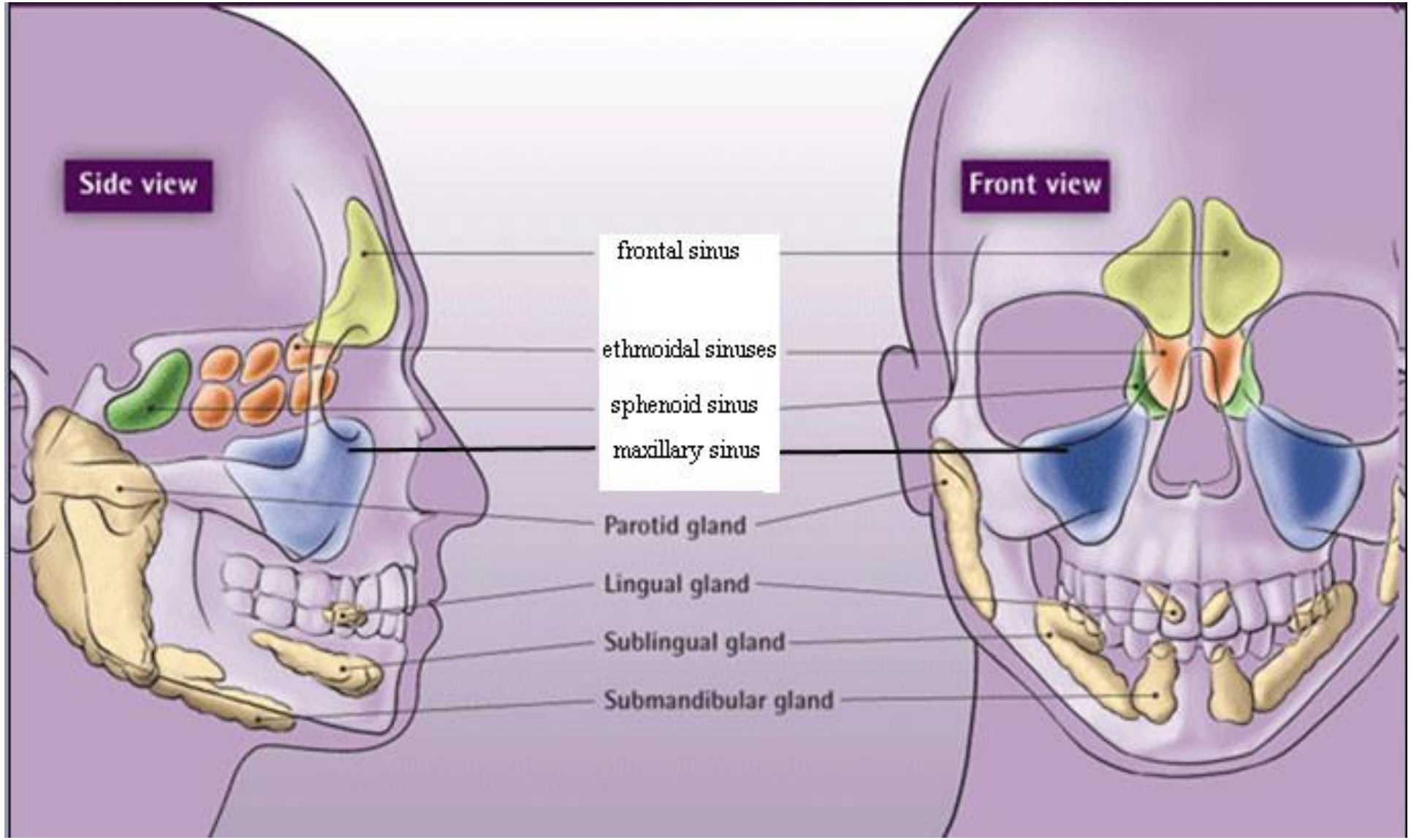
There are 5 pneumatic bones: frontal, ethmoid, sphenoid, maxillary, temporal.

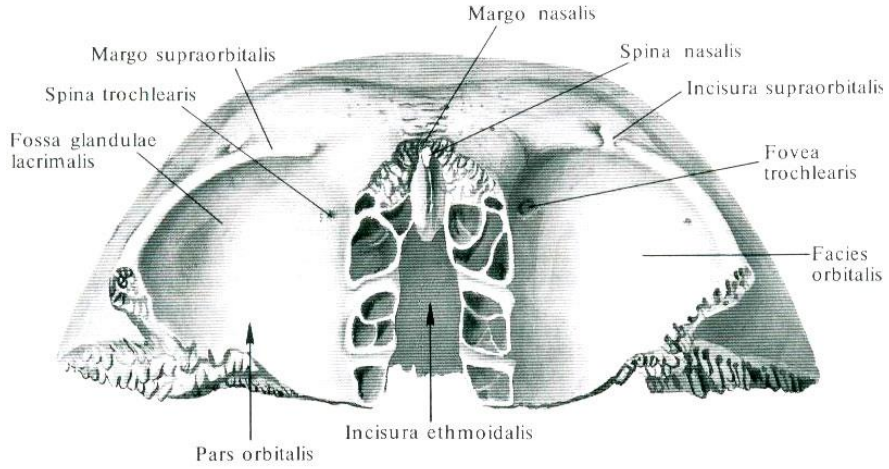
Functions of the paranasal sinuses

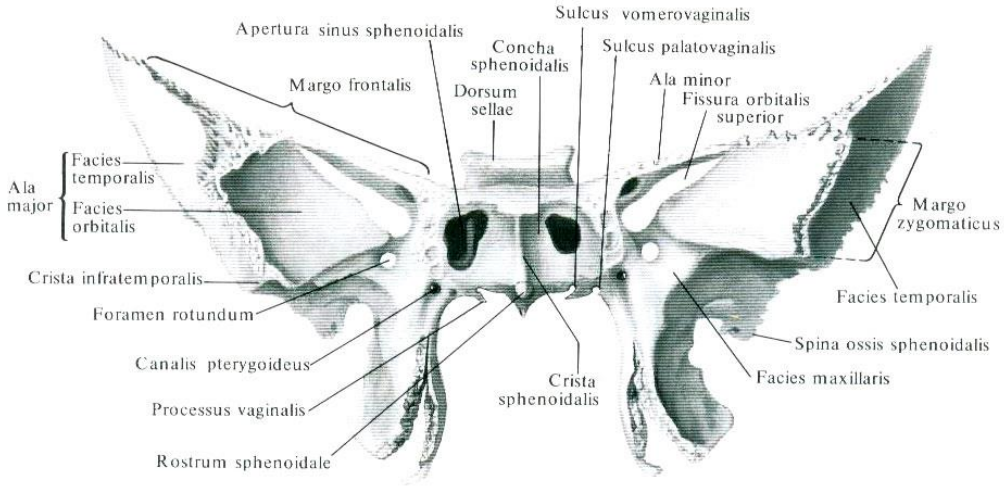


- **Decreasing the relative weight of the front of the skull, and especially the bones of the face.**
- **Increasing resonance of the voice.**
- **Providing a buffer against blows to the face.**
- **Insulating sensitive structures like dental roots and eyes from rapid temperature fluctuations in the nasal cavity.**
- **Humidifying and heating of inhaled air because of slow air turnover in this region.**

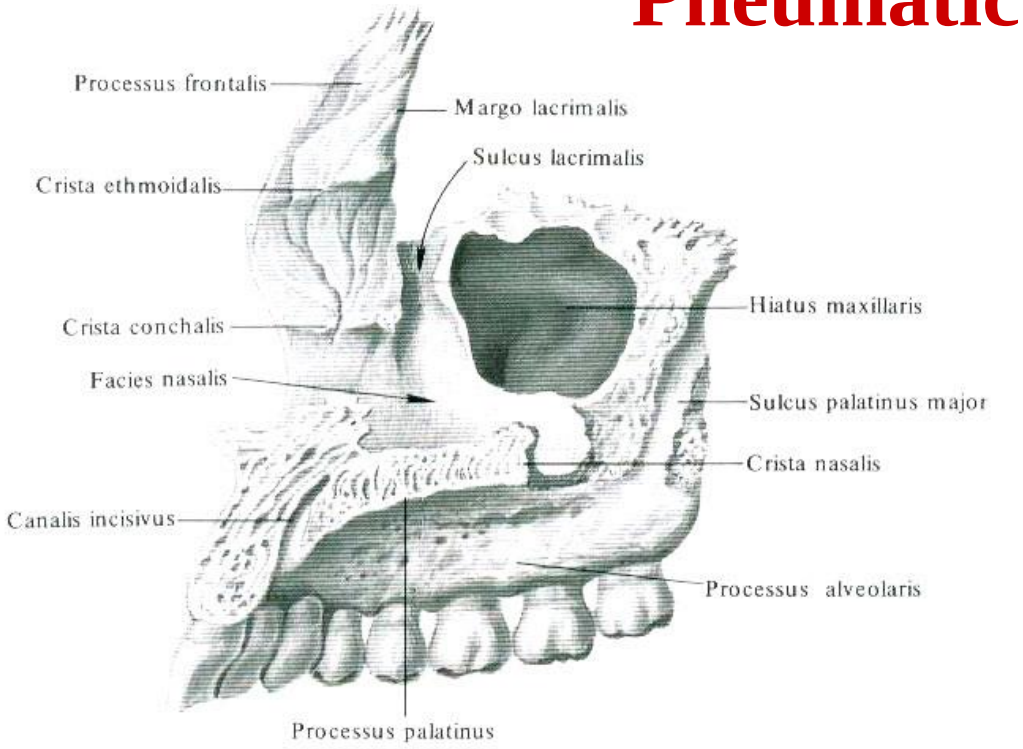
- **The paranasal sinuses are not the only sinuses within the skull: the mastoid cells in the mastoid bone around the middle ear are also a type of sinus.**

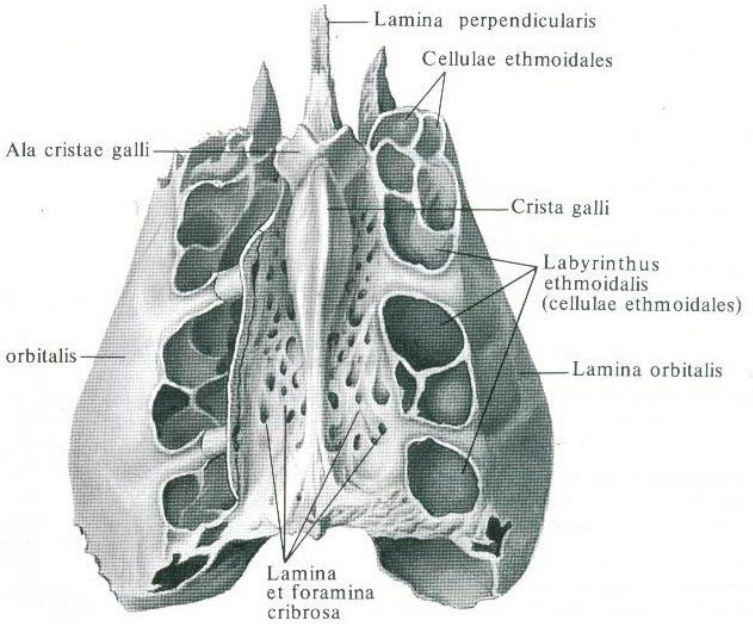

Side view
Front view
frontal sinus
ethmoidal sinuses
sphenoid sinus
maxillary sinus
Parotid gland
Lingual gland
Sublingual gland
Submandibular gland





Pneumatic bones





Resistant areas of the skull

- ***Resistance of the skull bones*** is due the fortified areas called ***pillars of strength***.

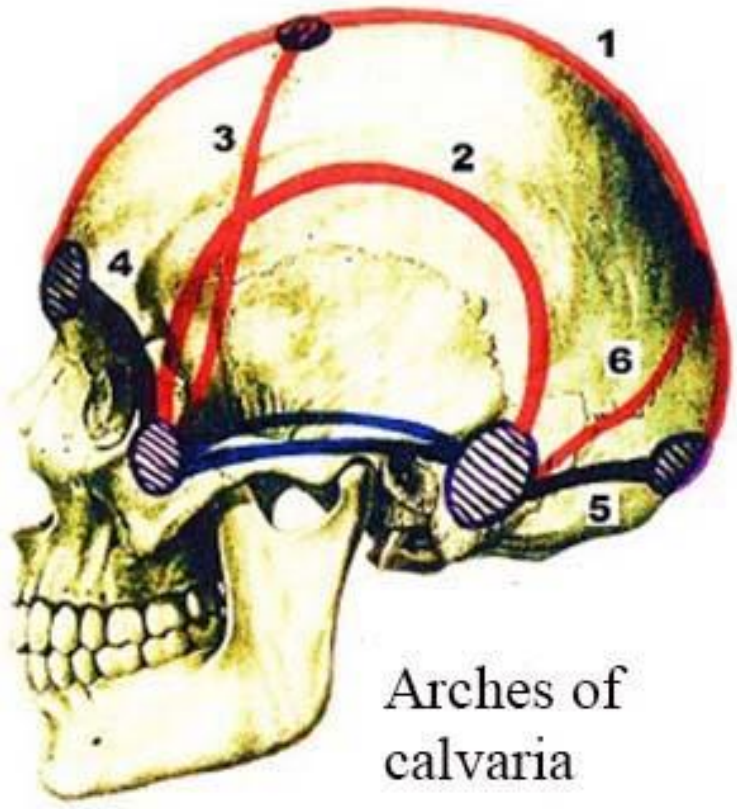
• Distribution of these areas is determined by masticatory forces of the facial skull transposed to the cerebral skull.

• Formation of resistant functional areas of the skull is manifested in:

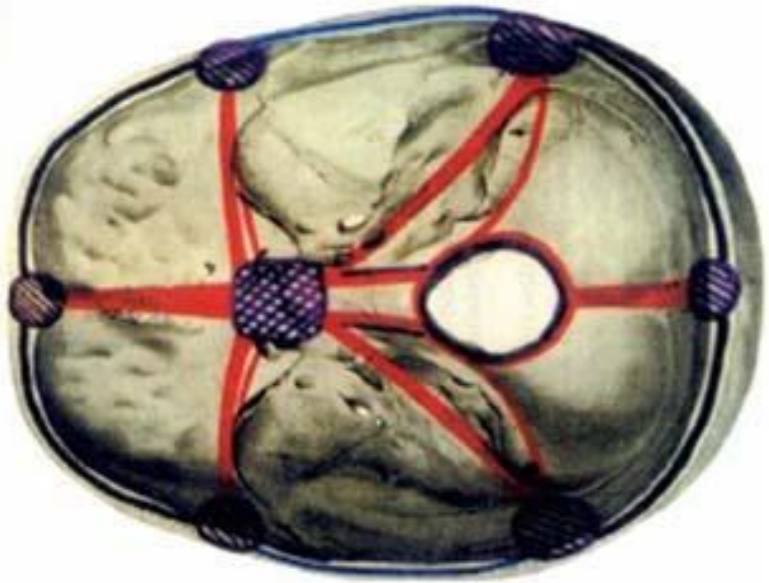
- trajectories of the spongy bone tissue in relation to the forces of pressure available during mastication
- thickness of compact bone tissue and the appearance of the prominent structures on the external and internal surface of the skull.

- Classically, the functional resistance structures that offer strengthen to the neurocranium are: ***vault arches***, ***rafters of the base, pillars*** at the meeting between arches and rafters.
- Pillars are binding the resistance structures of the neural and visceral cranium.

Vault arches, rafters of the base, pillars (resistance knots)



Arches of calvaria

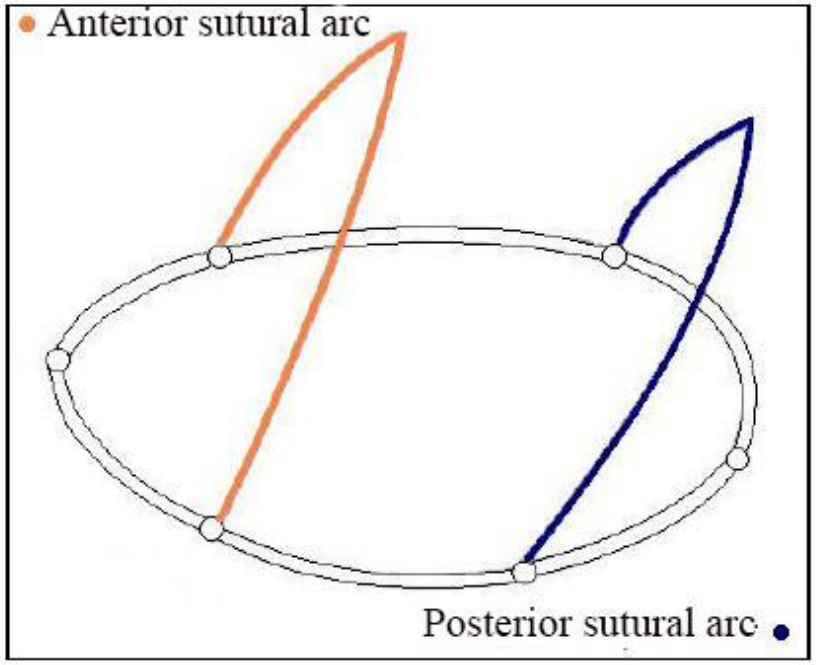


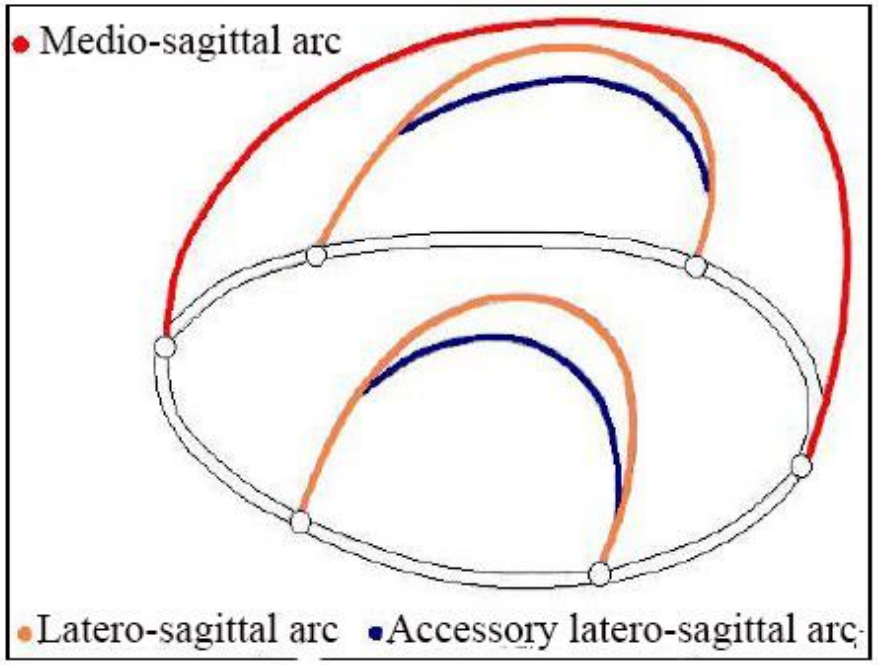
Rafters of the base

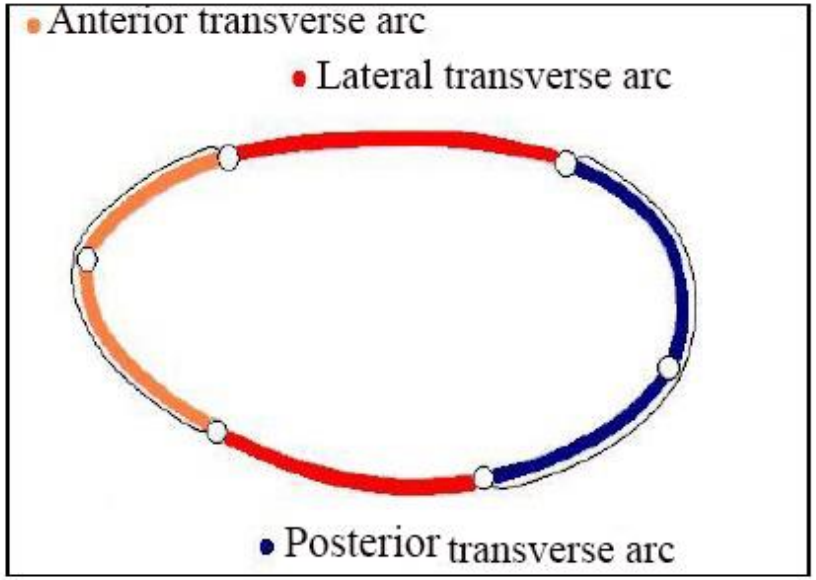
Pillars

Arches of resistance

- ***Arches of resistance*** are located on the calvaria and are classified into the ***sagittal, transverse*** and ***sutural***.
- There are ***three sagittal arches*** of the skull: ***one medio-sagittal*** and ***two latero-sagittal***.
- Each latero-sagittal arc has an upper portion with lower facing concavity and a lower portion – horizontal.

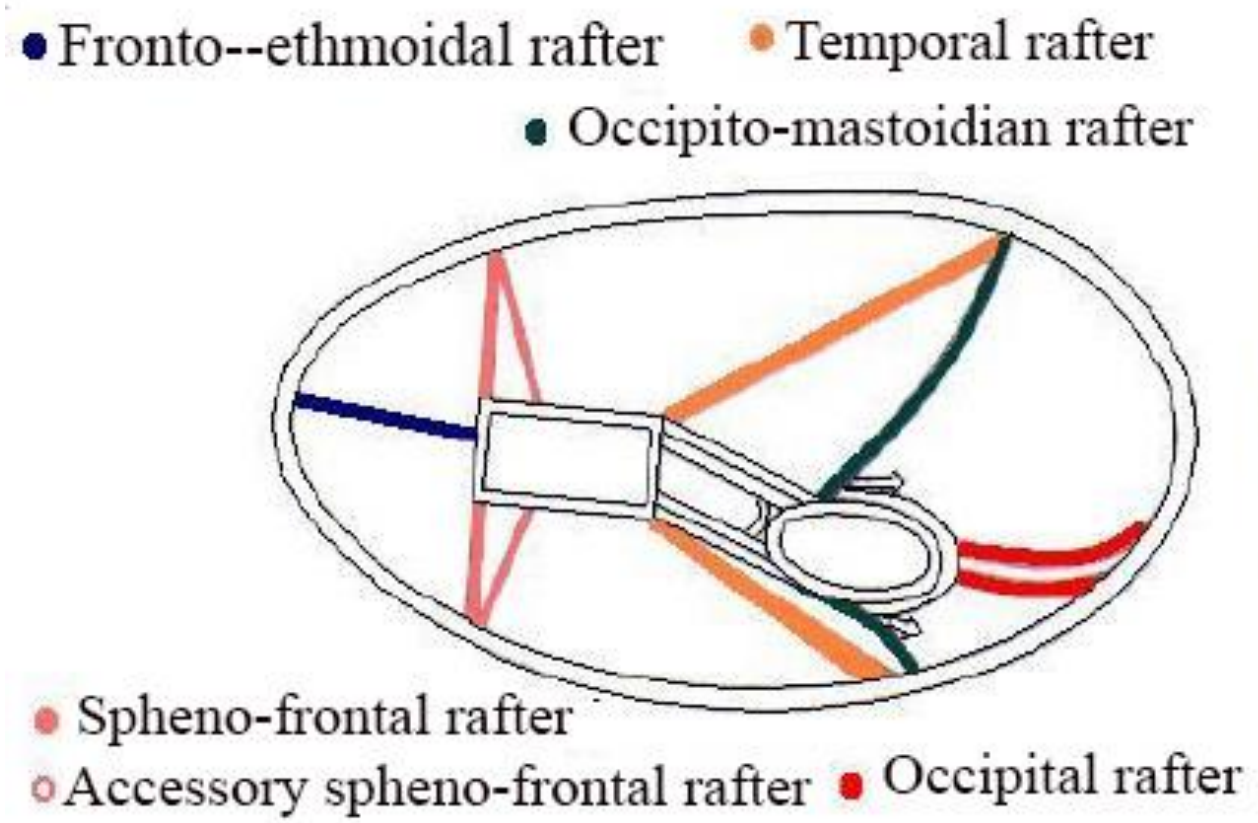


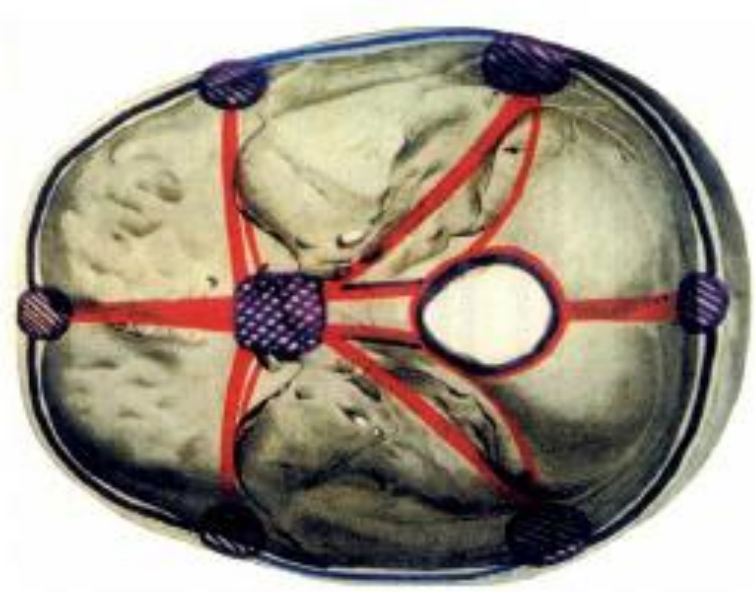




Rafters of the skull resistance

- The following rafters have been described: ***fronto-ethmoidal***, ***two spheno-frontal*** (right and left)**,** ***two temporal*** (right and left)**,** ***occipital*** described by some authors as a single rafter, and others as a paired structure.



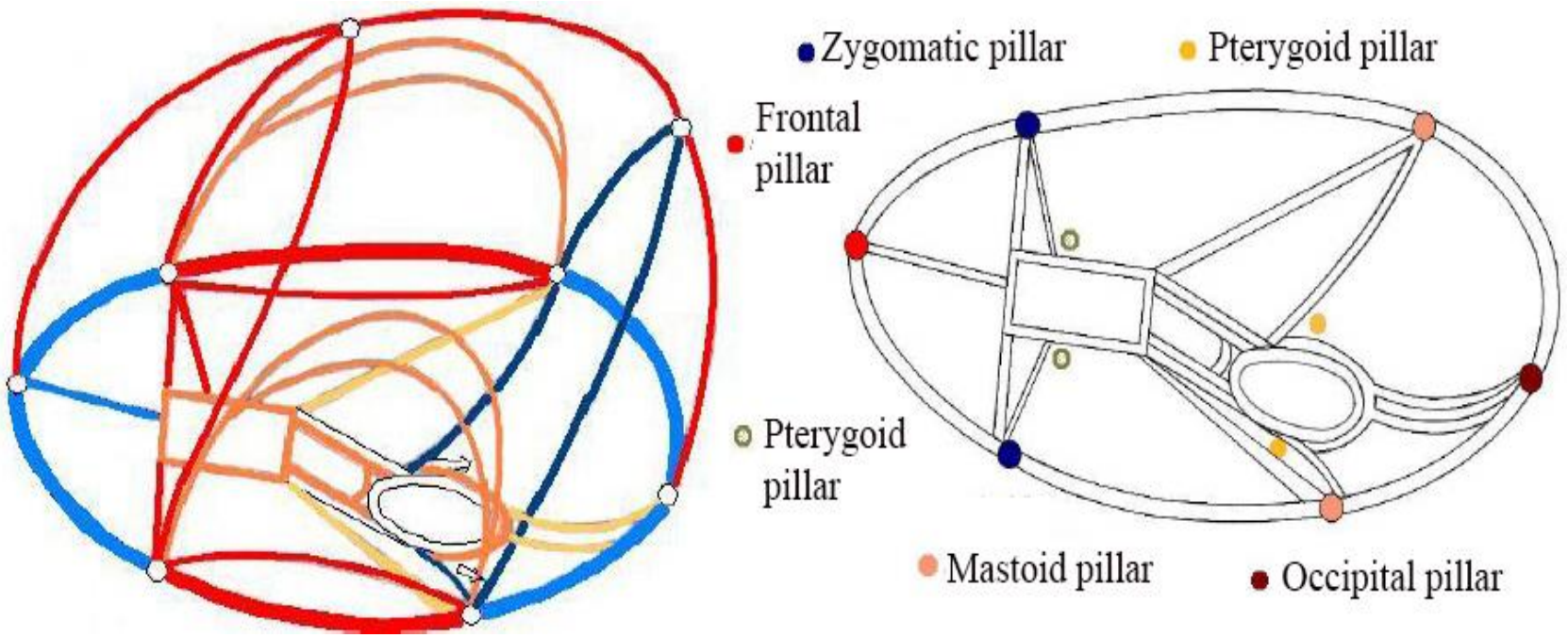


Pillars or knots of the resistance

- The pillar concept marks the union place between the vault arches and rafters of the base and also the meeting of the functional resistance structures of the neurocranium and viscerocranium.

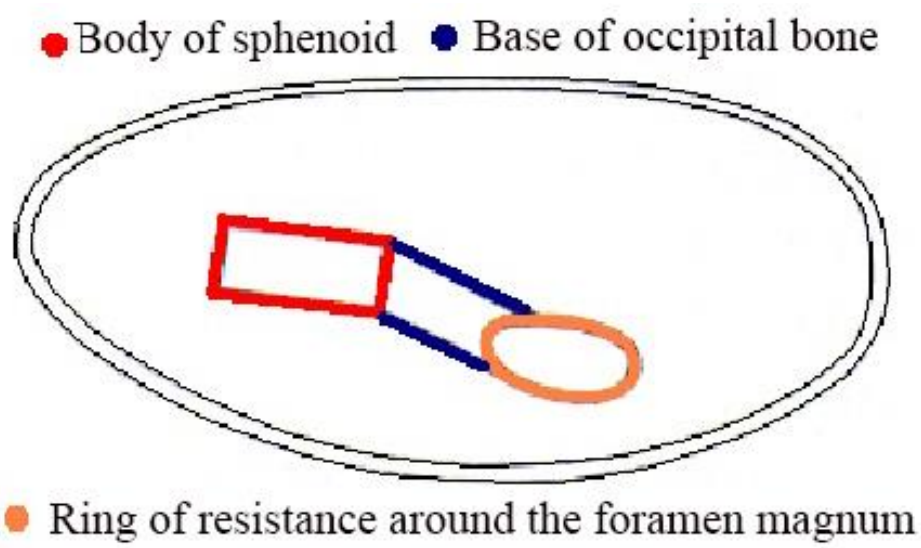
- The ***main pillars are***: one frontal, one occipital, two zygomatic and two mastoid pillars.

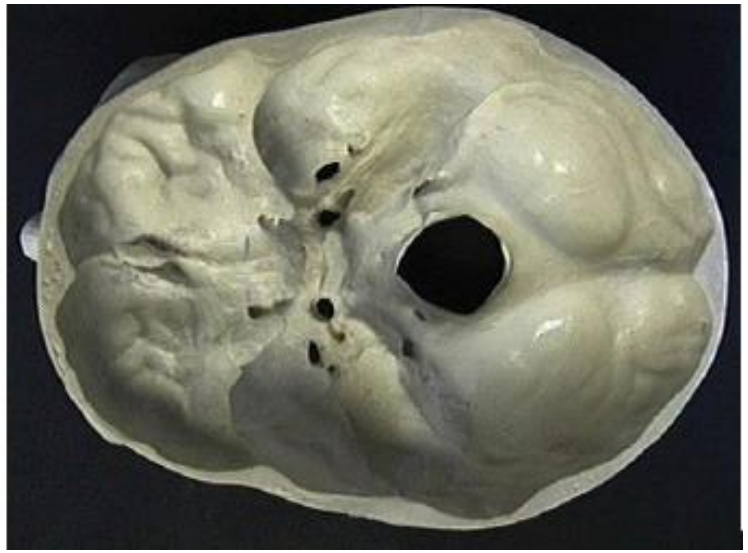
- The ***accessory pillars are*** the pterygoid, condylar, bregmatic and lambdoid pillars.



Center of resistance of the skull base

- The body of sphenoid bone, basilar part of the occipital bone and the ring of resistance surrounding the greater occipital foramen are placed in the ***center of the resistant areas of the skull base***.
- Almost all of the resistant belts of the neurocranium pass through this center.





Belts of resistance

- The ***belts of resistance*** are unique structures that incorporate arches of the calvaria and rafters of the base of the skull.

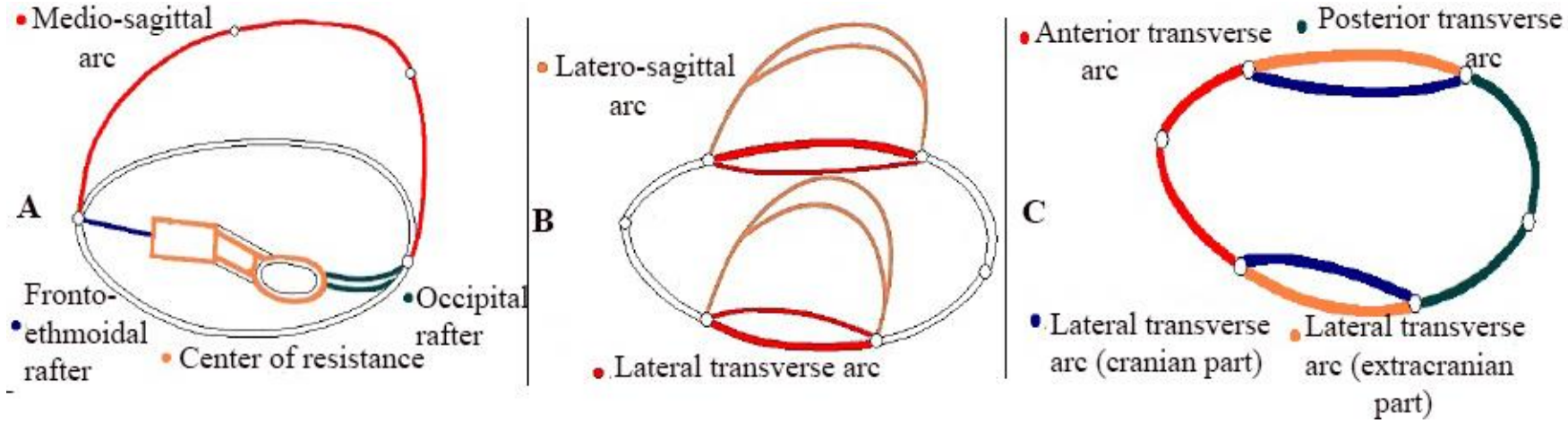


Fig.6 . Mediosagittal, lateral sagittal and transverse resistance belts (V. Niculescu, M. Niculescu).

- There are ***belts in the transverse, sagittal, frontal*** and ***oblique planes.***

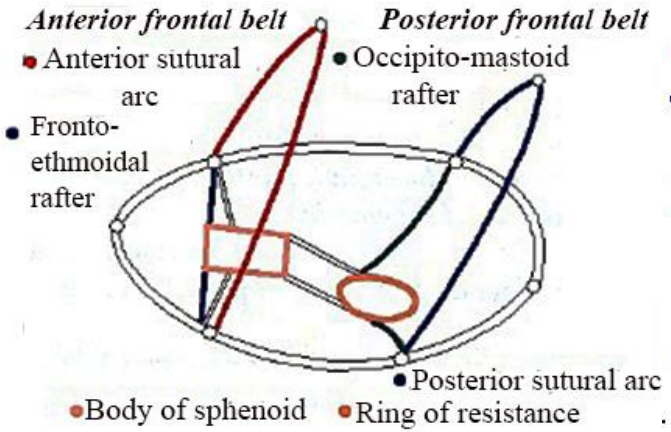


Fig.8 . Frontal belts of resistance (V.

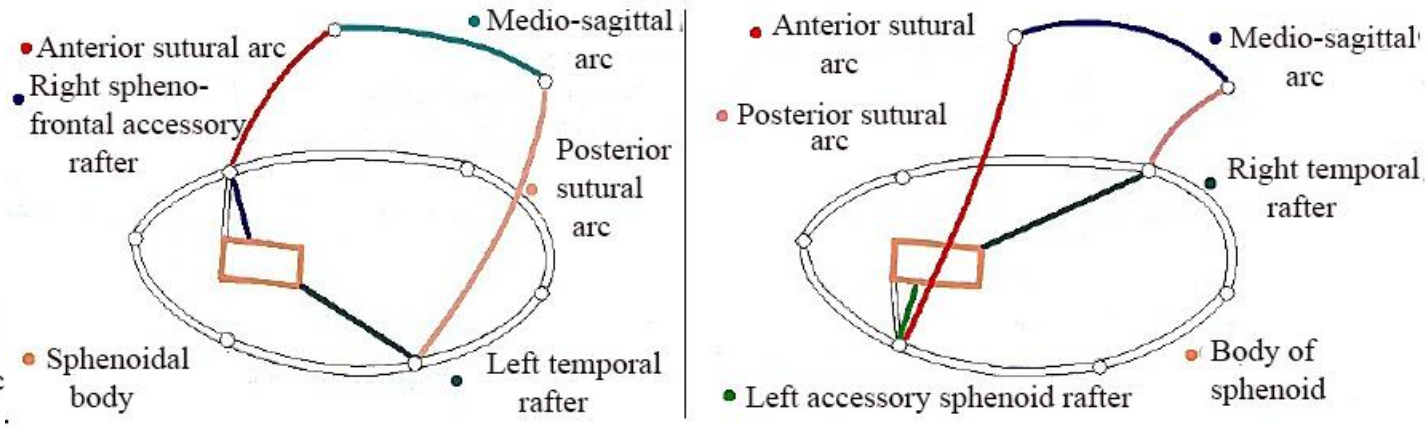


Fig.9 . Oblique belts of resistance (V. Niculescu, M. Niculescu). A – right; B – left.

Resistant areas of the upper part of the facial skull

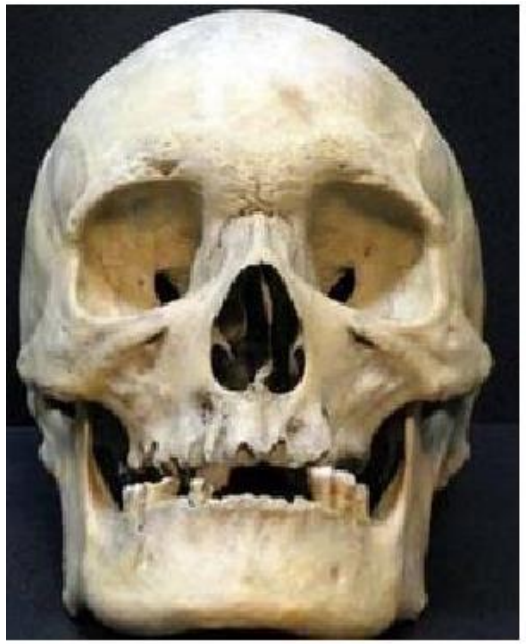
1. ***Frontonasal pylon.*** It takes origin from the upper incisors and canine, ascends and divides into three parts: – *median branch* finishes at the frontal pillar of resistance, its *lateral branches* (superior and inferior) pass along the supraorbital and infraorbital borders.

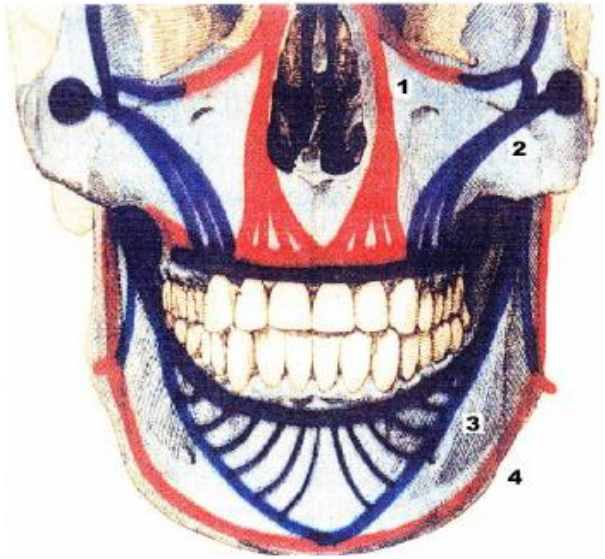
2. ***Zygomatic pylon.*** It starts from the upper premolars and the first molar; ascends and divides into three parts: *lateral* branch is directed to the zygomatic pillar; two *medial branches* (superior and inferior) pass along the supraorbital and infraorbital borders and meet those frontonasal.

3. ***Pterygopalatine pylon:*** begins from the second and third upper molars, ascends (maxillary tuber – pterygoid process of the sphenoid bone – body of the sphenoid bone) and finishes on the pterygoid pillar of resistance.

4. ***Median vertical pylon:*** starts from the palatine vault; it includes the vomer, perpendicular plate of the ethmoid bone and sphenoid body.

5. Horizontal pylons. There are three plates: superior, middle, inferior.

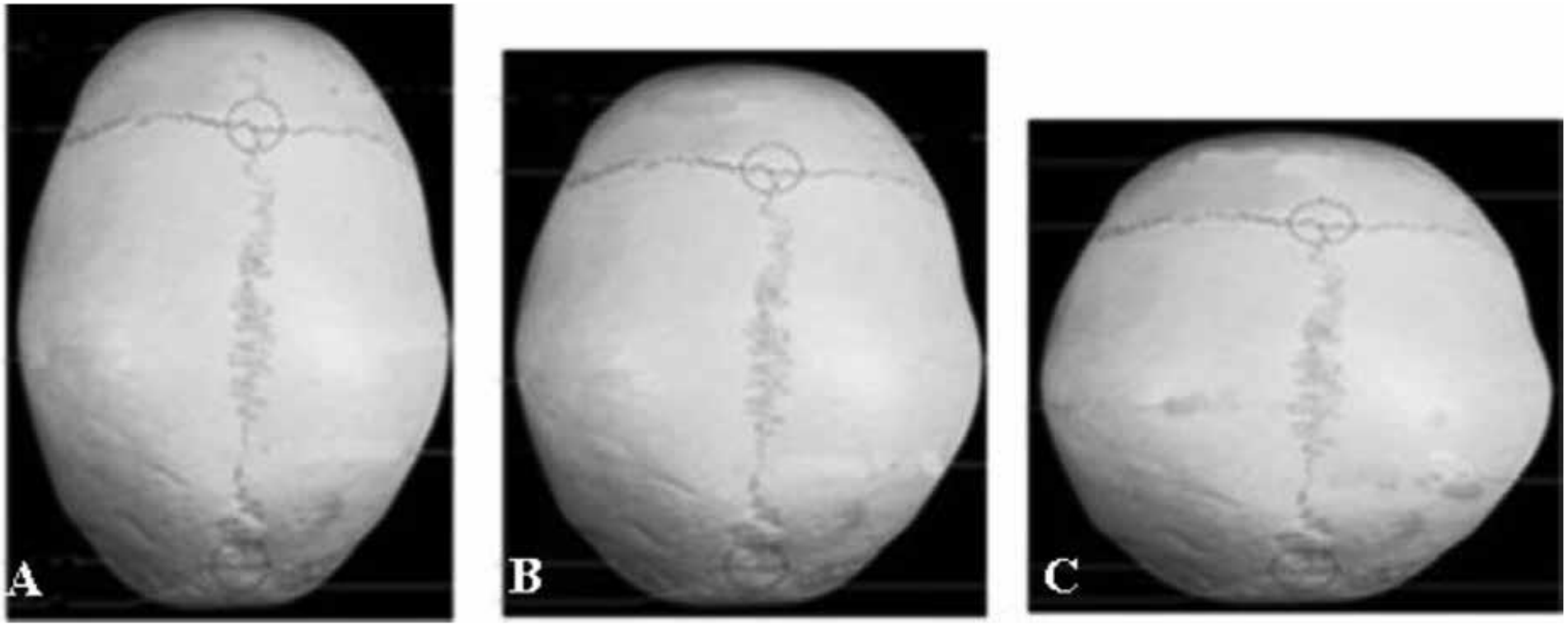




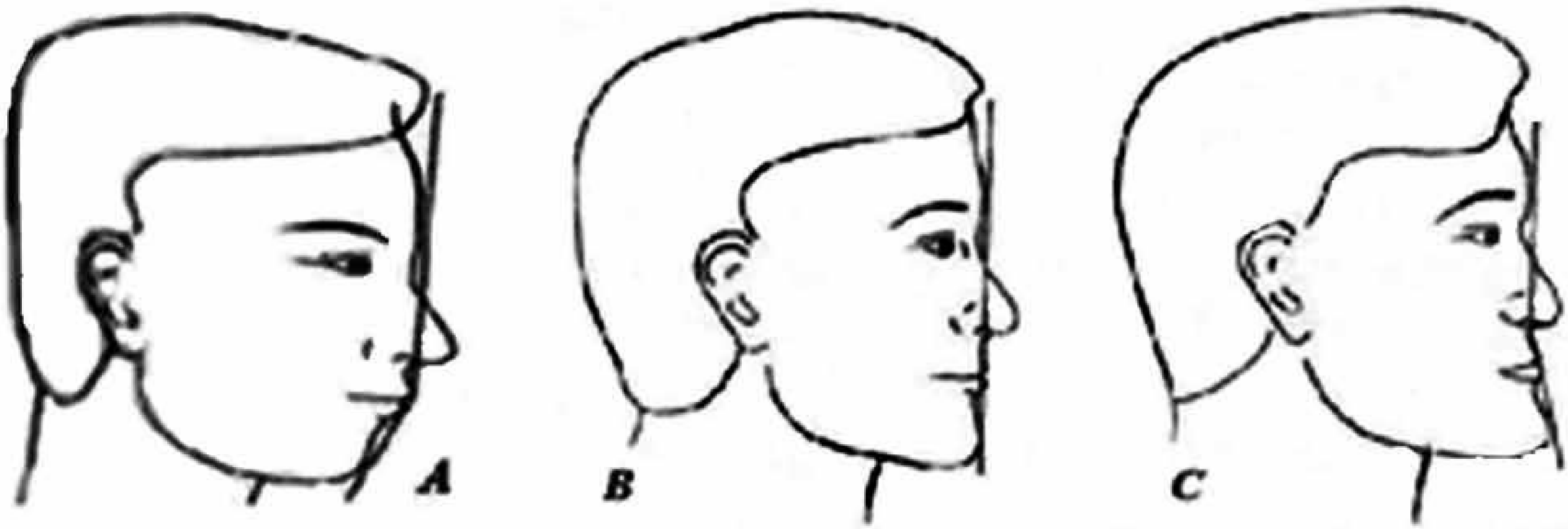
Resistant areas of the lower part of the facial skull

Mandibular pylon: lower dental arch – neck and head of mandible – temporal bone.

Variants of the skull



Shapes of the skull. A - dolichocephalic, B – mesocephalic, C – brachycephalic.



Facial profiles: convex (A), stright (B), concave (C).

Facial index and facial angle

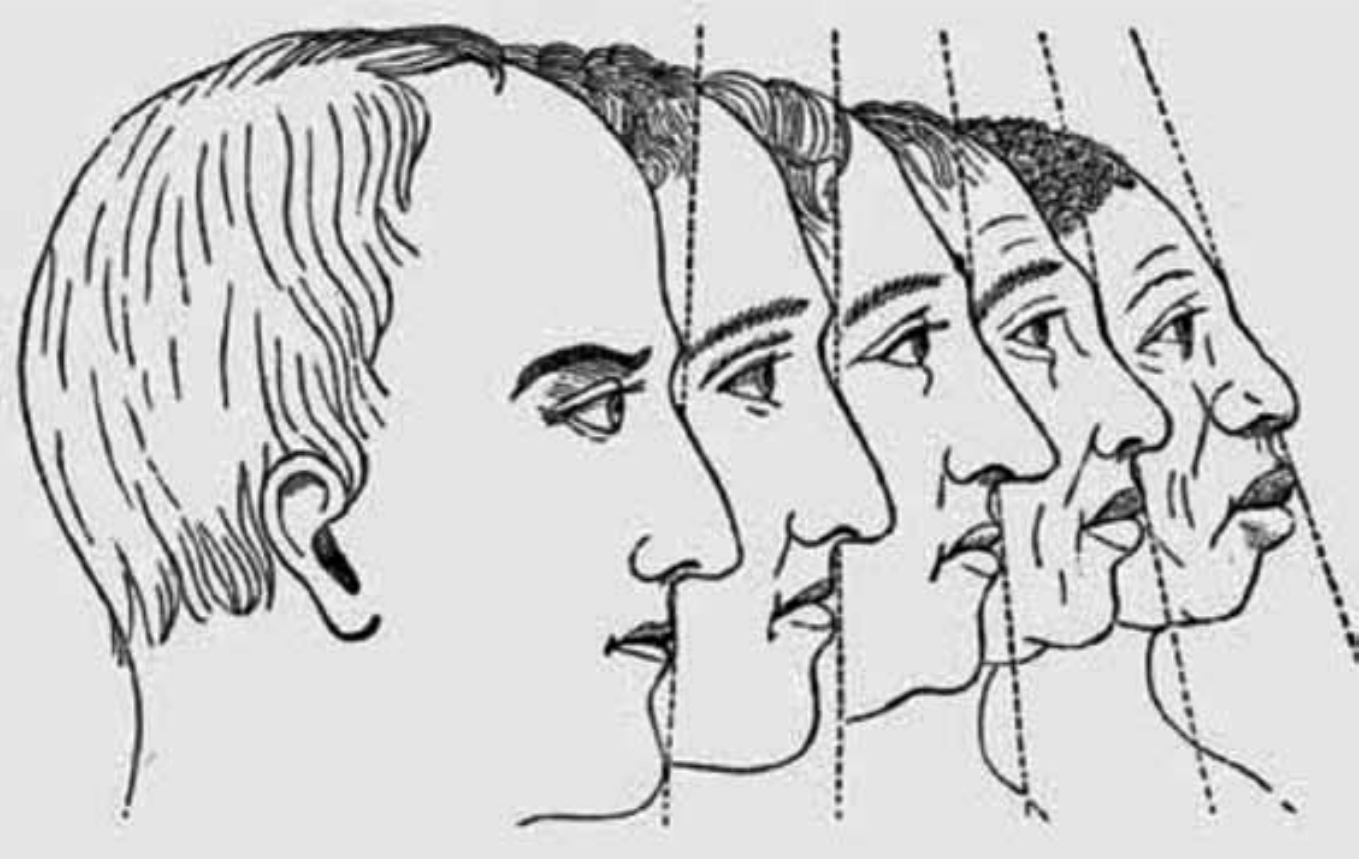
•***Ophryoalveolar line*** (in cm) - *the point of intersection of the frontal minimal diameter with the median line till menton* ***x 100*** reported to the ***bizygomatic diameter*** = ***the facial index*** (the ratio of the height to the width of the face).

•It has a value from ***62 to 74.***

•An index with a value ***more*** than this indicates an ***elongated face,*** and an index with a value ***less*** than this indicates a ***wide face.***

•Position of the facial cranium reported to the cerebral one may be characterized by ***facial angle.***

The ***facial angle*** (also the Camper's or the Topinard's facial angle) represents ***the profile line*** (traced between the nasion and prostion) and ***the horizontal Frankfurt plane*** measured in degrees.



Anomalies of the facial skull

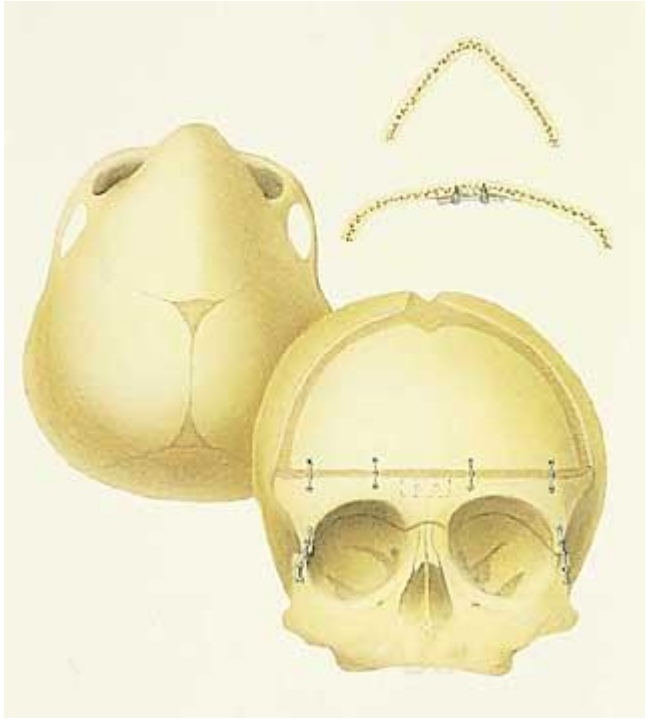
"U" shaped cleft palate "V" shaped cleft palate

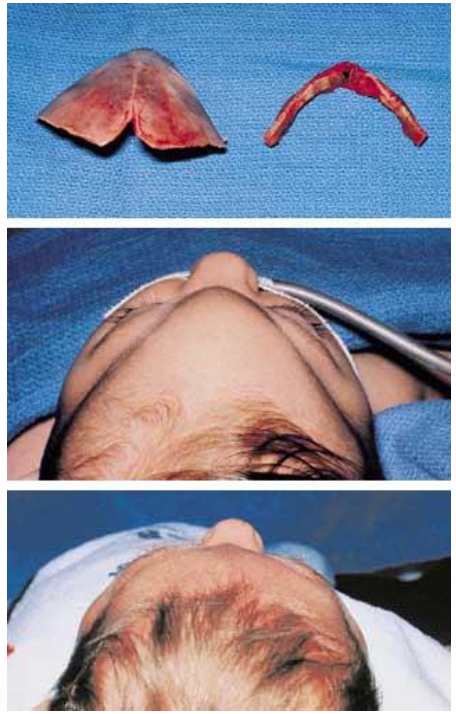
Anomalies of the cerebral skull

Terminology of Craniosynostosis		
FUSED SUTURE	**NAME**	**DESCRIPTION**
Sagittal	**Scaphocephaly**	**Boat Skull**
Metopic	**Trigonocephaly**	**Triangular Skull**
Unilateral Coronal	**Plagiocephaly**	**Asymmetric Skull**
Bicoronal	**Brachycephaly**	**Short Skull**
Lambdoid	**Plagiocephaly**	**Asymmetric Skull**

Premature closure of the ***sagittal suture***, the longitudinal suture on the top of the head, stops growth laterally producing a narrow

head - ***scaphocephaly***.





The ***metopic suture*** runs down the midline of the forehead. Premature fusion of this suture results in a triangular shaped forehead called

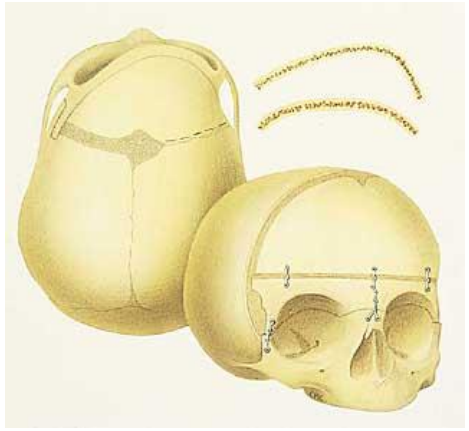
trigonocephaly

Premature fusion of the ***coronal sutures*** results in an ***asymmetric forehead and brow.*** On the affected side the forehead is flattened and recessed with the brow and supraorbital rim both elevated and recessed.
The contralateral forehead may exhibit compensatory bulging or bossing. This ultimately results in a very asymmetric

malformation called **plagiocephaly.**

Bicoronal suture fusion results in a flat retruded forehead with increased height to the skull. This condition is also called **brachycephaly** due to the short anteroposterior diameter. As a result of this shortening there is a compensatory bulging of

the transverse diameter or width of the skull.



Abnormalities of the skull

• ***Microcephalia*** – the skull does not grow because the brain stops its development.

• ***Cranioschisis*** – the absence of the vault of the skull.

• ***Macrocephalia*** – great disproportional dimensions of the skull.

• ***Hidrocephalia*** – voluminous skull (when there is a lot of cerebrospinal fluid inside the cerebral ventricles).

• ***Persistence of the craniopharyngeal canal*** in the Turkish saddle (it contains remnants of the pharyngeal recess).

• ***Common spinosum*** and ***ovale orifices.***

• ***Clinoideocarotid foramen*** (when the anterior clinoid process is connected with the body of the sphenoid bone).

• ***Assimilation of the atlas by the occipital bone (occipitalization).***

• ***Presence of the paramastoid process*** (when there is additional process in close relationship with the mastoid one).

Variants of the bones of the viscerocranium

The lacrimal bone

The shape and dimensions of this bone are not constant, and in case of its absence it is substituted by the excessive growth of the frontal process of the maxilla or by the orbital plate of the ethmoid bone.

The maxilla

The dental sockets may frequently vary in number and shape. Sometimes an additional incisive bone which is characteristic for mammals can be present. The incisive canal and the maxillary sinus may vary in shape and size. The most redoubtable developmental abnormality of the maxilla is the fissure of the hard palate (palatum fissum).

The inferior nasal concha

This bone frequently varies in shape and size, but its processes vary most.

The vomer

The vomer can be curved to the right or to the left side.

The mandible

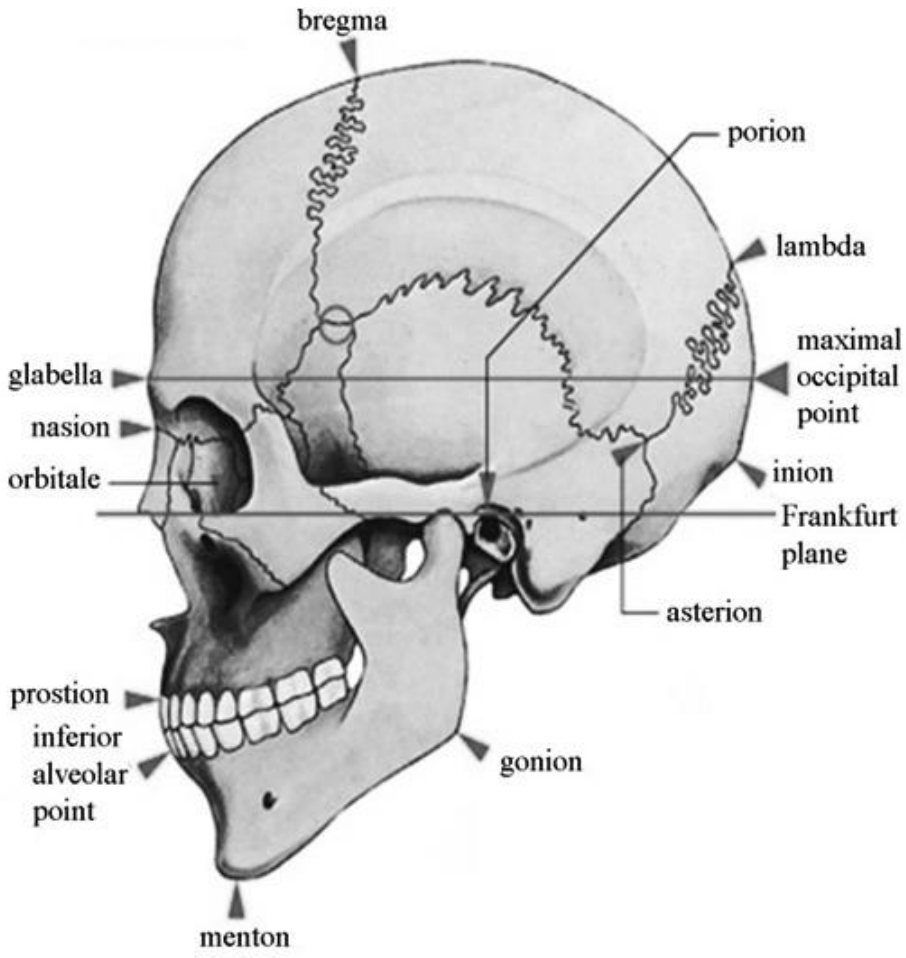
The right and left sites of its body often are asymmetrical. The mandibular and mental orifices can be double, and so can the mandibular canal.

The hyoid bone

Dimensions

Median craniometrical points

- ***Gnation*** **–** the lowest point of the chin.
- ***The mental (symphysian) point*** **–** the most prominent point of the mental eminence**.**
- ***The inferior incisive point (infradental)*** **–** situated on the alveolar arch, between the median incisors.
- ***The superior incisive point (prostion)*** **–** which is situated on the alveolar process of the maxilla between medial incisors.
- Naso***spinal point (spinal)*** **–** located on the anterior nasal spine.
- ***Rhinion*** **–** the inferior point of the suture between the both nasal bones.
- ***Nasion*** **–** the point of intersection of the frontonasal suture with the median line.
- ***Glabela*** **–** corresponds to the median area situated between the superciliary arches.
- ***Ofrion*** **–** the point of intersection of the frontal minimal diameter with the median line; (the frontal minimal diameter is the least distance between the both temporal crests of the frontal bone).
- ***Bregma*** **–** the point of intersection of the coronarian suture with the sagittal one corresponding to the vertex of the vault, or to the highest point of the skull.
- ***Obelion*** **–** the point in which the sagittal suture is intersected by the line which unites to each other both parietal orifices.
- ***Lambda*** **–** the point which unites the sagittal suture with the lambdoid one.
- ***Opistocranion*** **–** the most posterior point of the sagittal plane of the skull.
- ***Innion*** **–** the point which corresponds to the external occipital protuberance.
- ***Opistion*** **–** the median point of the posterior border of the foramen magnum.
- ***Basion*** **–** the median point of the anterior border of the foramen magnum.



Lateral craniometrical points

- ***The maxillofrontal point*** is situated at the level of the suture between the frontal process of the maxilla and the frontal bone.
- ***Dacrion*** is the point where the lacrimofacial and lacrimofrontal sutures meet.
- ***The malar point*** is the most prominent point of the zygomatic bone.
- ***Pterion*** is the point where the squama of the temporal bone, the parietal bone and the greater wing of the sphenoid bone and the frontal bone meet.
- ***The coronarian point*** is the most lateral point of the coronarian suture.
- ***Stefanion*** is the point where the coronary suture meets the superior temporal line.
- ***Gonion*** corresponds to the angle of the mandible.
- ***The auricular point*** is situated in the middle of the external auditory meatus.
- ***Eurion*** is the highest point of the parietal eminence.
- ***Asterion*** is the point where the temporal bone, the parietal one and the occipital bone meet.