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# ATLAS OF HUMAN SKELETAL ANATOMY

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Cranium I

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# Cranium

## The Skull- Anatomy

J. ARTNER

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### 2.1. Introduction

The skull is one of the most complex and difficult chapters in human anatomy. It is also one of the few anatomic structures, where almost all the different medical sectors or fields meet each other and use their anatomic knowledge:

Neurology and neurosurgery use their anatomic knowledge for the surgical access to the central nervous system, otorhinolaryngology specializes in the nasal and the auditory skull- parts, general surgery uses the topographic knowledge, craniofacial surgery works on almost all skull structures, ophthalmology specializes in the orbital structures, obstetrics needs the knowledge about newborn and fetal skulls to provide and control the birth, and the internal medicine needs the knowledge because of some metabolic and malignant disorders. As you can see, almost all medical fields are covered. Some special clinical topics will be described in the last chapter called Clinical Aspects.

First medical procedures on skulls are dated to earlier than 8000 B.C. when

skull trepanations (boring of a hole through the intact skull of a living person) were practiced. It is believed that trepanation was used to either relieve painful headaches, or to release demons from the skull. Later, surgical procedures on skulls became standard in the ancient Egyptian medicine and, although the surgical techniques have been modified in every period of time, most of them are still used in today's medicine. The above mentioned skull trepanation is for example today a standard emergency operation, used to relieve acute pressure on the brain during larger internal bleedings. Until the latest centuries this procedure had also a spiritual- religious character, because of the belief that an evil spirit lives in the head, which must be let out to cure psychosis and similar diseases.

Before we step right into the anatomic part of this chapter I would like to point at some facts about the learning and understanding of skull structures and the topography:

To understand the skull topography a good three- dimensional imagination is

required. When learning a special structure, please always try to imagine also the structure's position in the skull from different perspectives and if necessary, step some pages back and take a closer look at the illustrations until you understand the chapter.

The skull consists of 22 flat and irregular bones, forming a bony oval cavity which represents the braincase, and an anterior surface, which represents the bony face.



Fig. 2.1.: Head and skull from front

Following this topographic and functional relation, the skull can be divided into a facial part called *Viscerocranium* (the bones which form the face) and a *Neurocranium* (the braincase).

The primary function of the *Neurocranium* is the protection of the brain, the auditory system and the eyes. It consists of the brain case, called *Calvaria*, and of the posterior parts of the skull- base, called *Basis cranii*. Secondary functions of *Neuro-* and *Viscerocranium* are the support and protection of soft tissues, eyes and auditory system, providing of rigid attachments for muscles for the expression the head movement, the

support of mastication and the eye movement.

The following list shows an overview of skull bones:

Neurocranium	Os frontale
	Os parietale (2x)
	Os occipitale
	Os sphenoidale
	Os temporale (2x)
	Os ethmoidale
Viscerocranium	Os nasale (2x)
	Os lacrimale (2x)
	Os zygomaticum (2x)
	Concha nasalis inf (2x)
	Vomer
	Os palatinum (2x)
	Maxilla (2x)
	Mandibula

Fig. 2.2.: List of human skull bones  
Os hyoideum as well as the auditory ossicles (2x3) were not counted.

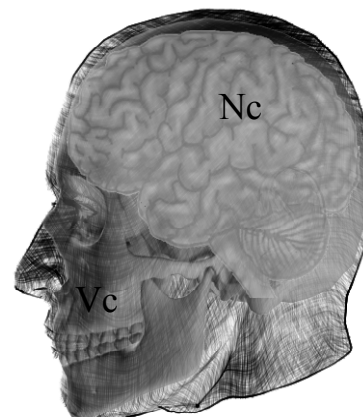


Fig. 2.3.: Neuro- and Viscerocranium  
The braincase (Neurocranium, Nc) and Viscerocranium (Vc). The neurocranial skull parts are transparent to make the position of brain visible. The brain does not fill the whole neurocranial cavity. There are spaces between the brain and the bony neurocranium, filled with meninges and the cerebrospinal fluid, which surround the brain.

## 2.2. Cranial Topography

In this chapter we will introduce the bones of skull and their topographic relations to each other.

With the exception of *Mandibula* (the lower jaw), each skull-bone is connected by tight immovable joints to the bones of the neighborhood. The areas of contact between two bones are called sutures (*Suturae*), which represent thin junctions between the irregular interlocking edges of adjacent skull bones. In adults *Suturae* consist of tight connective tissue.

We will use many different views in this chapter to show all skull structures. To understand the views it is important to know, which position or orientation is defined as the standard. To set up a standard nomenclature for orientations of skulls in anatomy a horizontal plane was defined in Frankfort more than hundred years ago. The *Frankfort Horizontal plane* is defined by three points: the bottom margin of the left eye cavity and the top margins of the external auditory porus (see chapter 2.6. *Os temporale*) on both sides.

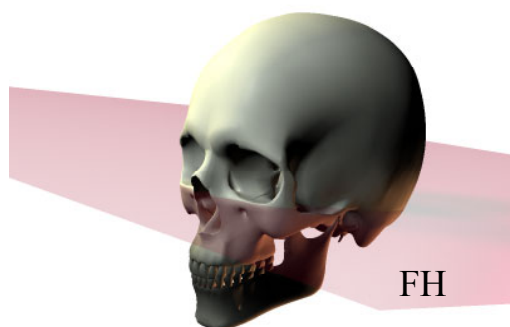


Fig. 2.4.: Frankfort horizontal plane

The standard anatomic perspectives are parallel or perpendicular to this (Frankfort Horizontal) plane.

Perspective	Explanation
Norma frontalis	View at the frontal outer surface of skull
Norma occipitalis	View at the back (posterior) outer surface of skull
Norma lateralis	View at the left or right outer surface of skull from side
Norma verticalis	View at the top outer surface of skull
Norma basalis	View at the inferior outer surface of skull

Fig. 2.5.: Standard perspectives

To describe all skull structures, it is also important to make some cuts through the skull and make the inner parts visible. In this chapter we will use the standard perspectives and additional views to show most skull structures. We will focus on major and important structures to show their topographic relations to each other. Following the *Suturae* as borders and using the knowledge of this chapter's topography it should be easy for you to learn and to describe all bones of skull. For more detailed descriptions see the following chapters which deal with separate skull bones.

Front view (*Norma frontalis*) of the skull shows the bones of the facial skull (*Viscerocranium*) and the frontal bone (*Os frontale*), which already belongs to the *Neurocranium*, at the top:

The most prominent structures in this view are the frontal bone (*Os frontale*) at the top, the zygomatic arches laterally, the mandible (the lower jaw, *Mandibula*) at the bottom, both orbital excavations (*Orbitae*) below the frontal bone, the anterior nasal aperture (*Apertura nasalis anterior*, *Apertura piriformis*) located in the middle line between both orbital cavities, and the dentition, which belongs to the upper (*Maxilla*) and the lower jaw (*Mandibula*).

The frontal bone (*Os frontale*) articulates downwards (on both sides) with the nasal bones (*Ossa nasalia*, sing. *Os nasale*), more lateral with *Maxillae*, the lacrimal bones (*Ossa lacrimalia*, sing. *Os lacrimale*) and with the zygomatic bones (*Ossa zygomatica*, sing. *Os zygomaticum*).

*Os frontale* and *Ossa nasalia* are joined to one another by the almost horizontal frontonasal suture (*Sutura frontonasalis*). The frontomaxillar suture (*Sutura frontomaxillaris*) unites the upper jaw (*Maxilla*) with the frontal bone on both sides of the frontonasal connection (suture).

The lateral arched parts of *Os frontale* have contact to *Os zygomaticum*. Both bones form together with the upper parts of *Maxilla* the exterior margins of the eye cavity (orbital cavity or *Orbita*) on both sides (see Fig.2.7.: *Orbita*).

To avoid an information overload we will describe the orbital structures later in separate illustrations. At this moment it is only important to note, that the above mentioned bones extend into the orbital interior, where they form in complex connections with four other bones (*Os lacrimale*, *Os*

*ethmoidale*, *Os sphenoidale*, *Os palatinum*) the pyramidal orbital cavities.

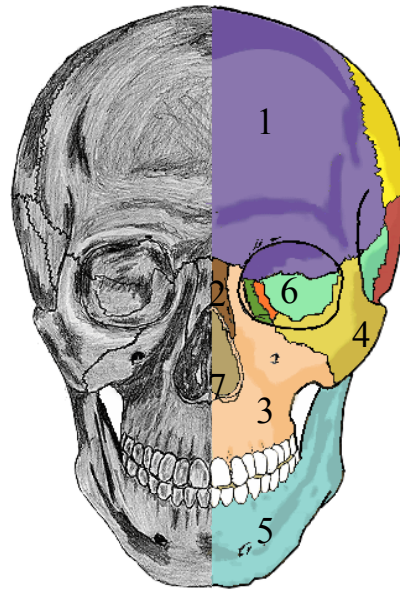


Fig. 2.6.: *Norma frontalis* of skull  
*Os frontale* (1), *Os nasale* (2), *Maxilla* (3), *Os zygomaticum* (4), *Mandibula* (5), *Orbita* (6), *Apertura nasalis ant.* (7)

The two nasal bones which form the bony bridge of the nose are united by the vertical internasal suture (*Sutura internasalis*) in the midline.

The anterior nasal aperture (*Apertura nasalis anterior* or *Apertura piriformis*) is located approximately in the middle of the facial cranium, below both nasal bones (*Ossa nasalia*) and between both *Maxillae*. Divided in the middle by the nasal septum it forms the entrance into the bony nasal cavity with visible nasal shells (*Conchae*) and nasal septum (*Septum nasi*) within.

The upper row of dentition (teeth) belongs to both *Maxillae*, which are separated by *Sutura intermaxillaris* under the nasal aperture. The lower row of dentition belongs to the lower jaw (*Mandibula*), which is the only movable bone of skull (if the small auditory ossicles of the middle-ear are not counted).

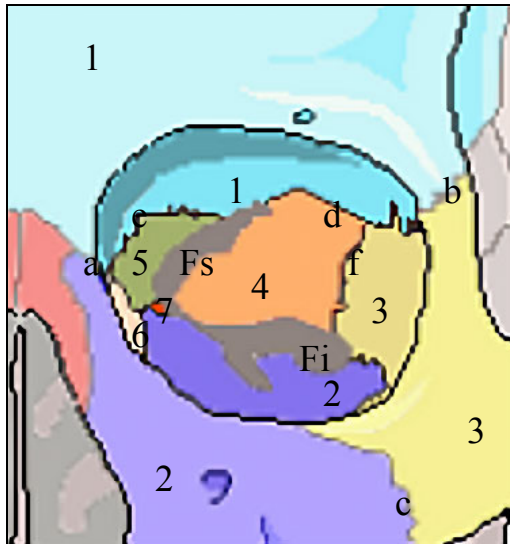


Fig. 2.7.: Left Orbita

Os frontale (1), Maxilla (2) and Os zygomaticum (3) form the exterior margins, with Sutura frontomaxillaris (a), frontozygomatica (b) and zygomaticomaxillaris (c) between them. Parts of Os sphenoidale (4), Os lacrimale (6), Os palatinum (7) and Os ethmoidale (5) form together with the already described bones the bottom of Orbita, separated by Sutura frontoethmoidalis (e), sphenofrontalis (d), sphenozygomatica (f), zygomaticomaxillaris (c), ethmoidomaxillaris, frontolacrimalis, palatomaxillaris and palatoethmoidalis. Two large apertures can be seen at the bottom of the orbital cavity: Fissura orbitalis superior (Fs) connects the orbital cavity with the internal cranial cavity, passed by Nervus ophthalmicus, oculomotorius, trochlearis, Nervus abducens and Vena ophthalmica superior. Fissura orbitalis inferior (Fi), located between Os sphenoidale and the upper orbital part of Maxilla is passed by Nervus zygomaticus, Nervus infraorbitalis and their corresponding vessels.

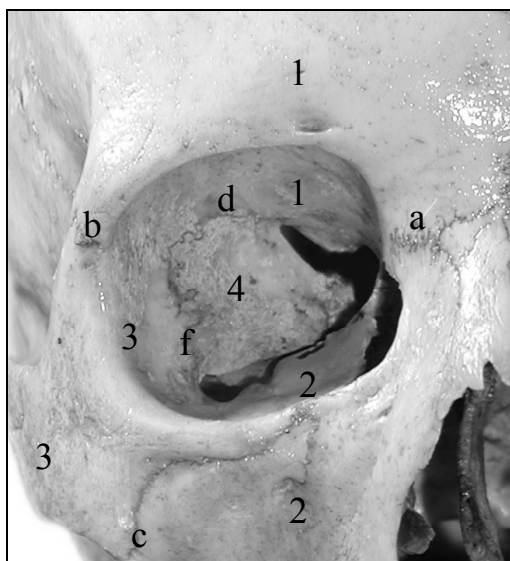


Fig. 2.8.: Right Orbita

Photography by Pekny P., ©2003

In this skull the lacrimal bone has been detached. Note the good visible Suturæ (S. frontomaxillaris- a, S. frontozygomatica- b, S. zygomaticomaxillaris- c, S. sphenofrontalis- d and S. sphenozygomatica- f). The bones are marked like in the previous figure (see Fig. 2.7.). Additional visible structures are the nasal bone, parts of the nasal aperture with septum, and parts of the temporal bone.

Some osseous structures displayed in the previous figure are not visible. Note that many skull bones can grow together during the reorganizations in the process of aging. Because of this also some sutures may almost “vanish” from a skull model (see next figures).

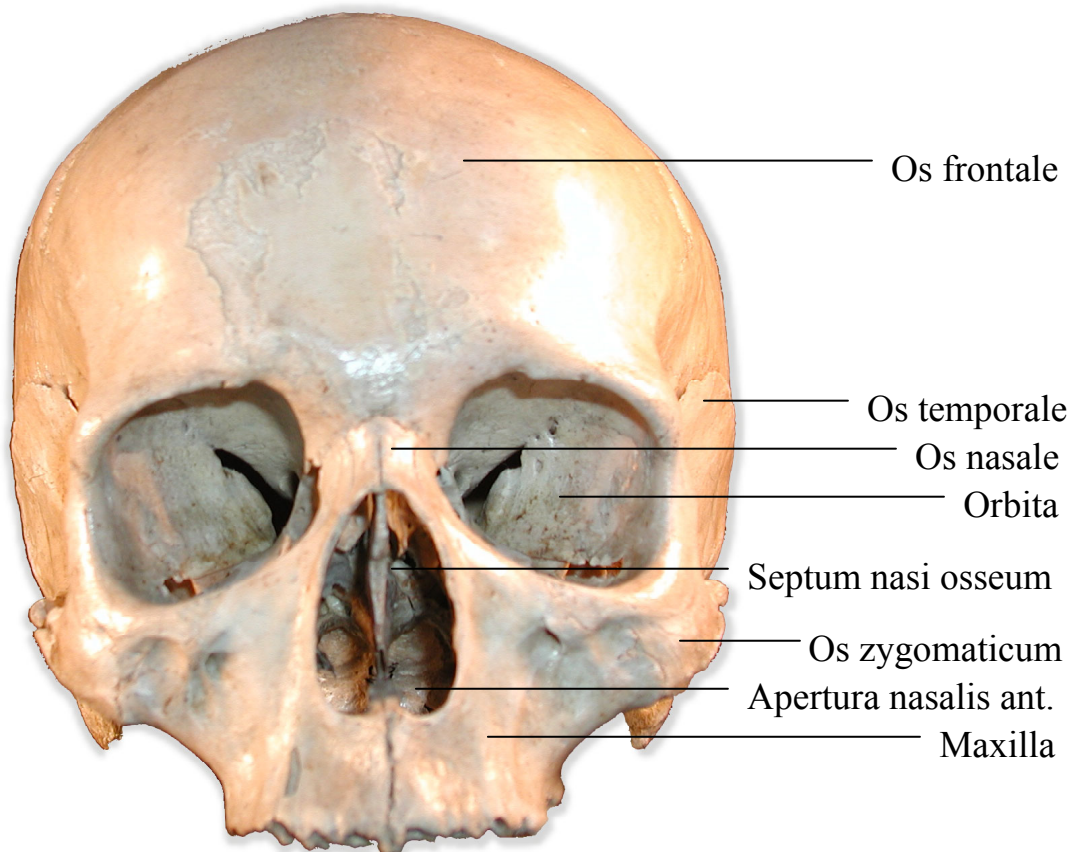


Fig. 2.9.: Aspectus anterior of skull

Photography by Pekny P., ©2003

View at all dense connected skull bones from the front. The Mandibula and the lacrimal bones were detached. Additional visible structures of this image are the parts of Os temporale on both sides.

Before we step to the next view, it is important to describe the nasal and the paranasal structures. Some of the structures we will describe may not be visible in the anterior view but are visible in the views described later in this chapter. In order to understand the structures in the next views better we will describe them at this point.

The entrance into the bony nasal cavity is formed by the maxillae, the frontal bone and the nasal bones, which form the almost triangular anterior nasal aperture (*Apertura nasalis anterior* or *Apertura piriformis*). Internally, the nasal cavity is divided by the nasal

septum (*Septum nasi*) into a left and right side. The septum can be straight (see the previous image) or deviated to one side (see the next images). Approximately 75% of nasal septa are deviated, what may lead to breathing problems and to an alteration of the mucociliary clearance. The nasal septum is composed of bony and cartilaginous parts: Anteriorly the quadrangular cartilage extends out of the bony nasal cavity and connects posteriorly to the bony part of septum, which consists posterosuperiorly of the perpendicular plate of ethmoid bone (*Lamina perpendicularis*) and postero-inferiorly of the *Vomer*.

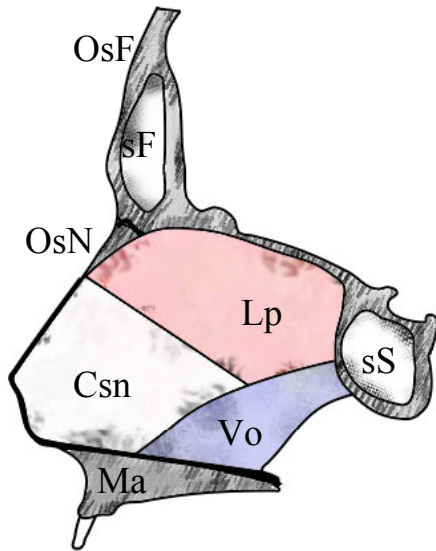


Fig. 2.10.: Septum nasi

Os frontale (OsF), Sinus frontalis (sF), Os nasale (OsN), Maxilla (Ma), Body of the sphenoid bone with Sinus sphenoidalis (sS), the nasal septum: Cartilago septi nasi (Csn), Lamina perpendicularis of the ethmoid (Lp) and the Vomer (Vo)

The floor of the nasal cavity is composed of both maxillae and palatine bones, which form the osseous palate.

The lateral nasal walls are composed of a conglomerate of osseous structures called the *ostiomeatal complex*. The function of this unit is to provide drainage and ventilation of the paranasal sinuses. The paranasal sinuses are air-filled cavities, located in the pneumatized bones of the adult skull. There are four paired sinuses, described by their corresponding bones:

#### *Sinus frontalis*

is the frontal sinus, located above the orbital cavities in the frontal bone. The posterior walls of the frontal sinuses are adjacent to the anterior cranial fossa. The volume of one frontal sinus is approximately 7ml. The frontal

sinuses develop about the second year of life.

#### *Sinus maxillaris*

is located in the cheekbones under the orbital cavities. It has the shape of a lying pyramid with the nasal walls as the base and the peak pointing toward the zygomatic process, taking a volume of approximately 15ml. The medial walls of the maxillary sinuses are part of the lateral walls of the nasal cavity. The inferior parts of the sinuses are located close to the dentition-bearing maxillary parts.

#### *Sinus ethmoidalis*

is located in the ethmoid bones, between the orbital and the nasal cavity. It is divided by a thin septum into posterior and anterior cells, taking together a volume of approximately 15ml on each side. The posterior cells are located close to the sphenoid sinus.

#### *Sinus sphenoidalis*

is located in the body of the sphenoid bone, posterosuperiorly of the *Nasopharynx*, and has a volume of approximately 8ml.

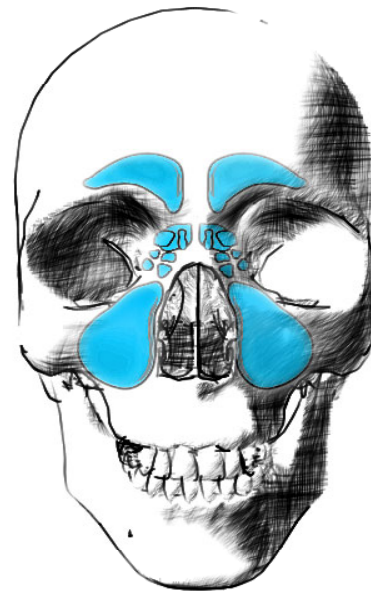


Fig. 2.11.: Paranasal sinuses

The image shows the locations of the paranasal sinuses in relation to the osseous surface of the skull.



The nasal drainage areas of the paranasal sinuses are located under the *superior, middle* and *inferior Conchae*, which form the corresponding *Meatus nasalis*. The frontal sinus drains via *Recessus frontalis* into the *Meatus nasalis medius*, located under the *Concha nasalis media*, which belongs to the ethmoid bone. The maxillary sinus drains also into the middle nasal meatus. The opening is located at the upper part of the medial wall of the maxillary sinus, what can possibly cause problems of the sinus- drainage and ventilation, leading to mucostasis and infection. The drainage of the ethmoid cells depends on their location. The anterior cells drain like the frontal and the maxillary sinuses into the middle nasal meatus. The posterior ethmoid cells drain with the sphenoid sinus into the superior meatus, located under *Concha nasalis superior*, which is a part of the ethmoid bone. The inferior nasal concha (*Concha nasalis inferior*) is a separate bone which protects the inferior meatus, which provides the drainage of the nasolacrimal duct (*Ductus nasolacrimalis*).

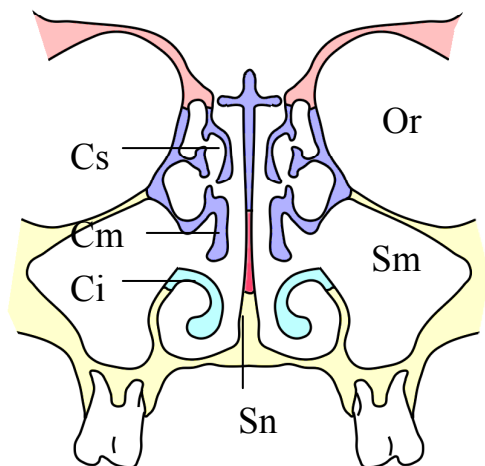


Fig. 2.12.: Coronal cut of the sinus area and the ostiomeatal complex  
Nasal septum (Sn), Sinus maxillaris (Sm), Orbita (Or), Nasal Conchae (superior- Cs, media- Cm, inferior- Ci)

The nasal cavity communicates posteriorly with the nasopharynx thru the *Meatus nasopharyngeus* and the *Choanae*. The *Choanae* are the posterior openings of the nasal cavity into the nasopharyngeal room. The osseous framework of the *Choanae* consists of the horizontal plates of the palatine bones, the body and the medial pterygoid plates of the sphenoid bone. They are divided in two openings by the Vomer, each opening measuring approximately 3x1cm.

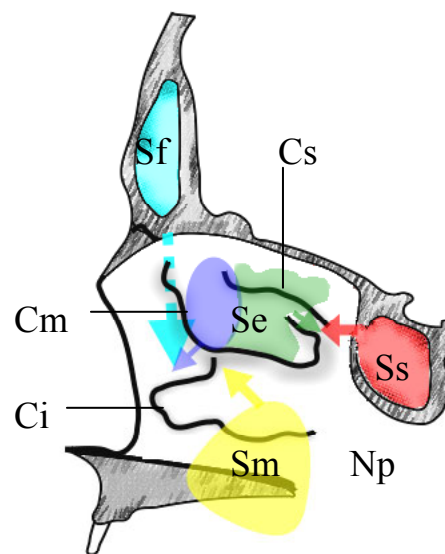


Fig. 2.13.: Parasagittal cut of the nose  
The lateral walls of the osseous nasal cavity, presenting the points of drainage of the paranasal sinuses:  
Sinus frontalis (Sf), Sinus maxillaris (Sm), and the anterior cells of Sinus ethmoidalis (Se) drain under the middle nasal Concha (Concha nasalis media, Cm). The posterior ethmoidal cells drain together with Sinus sphenoidalis (Ss) under the superior nasal Concha (Concha nasalis superior, Cs). Under the inferior nasal Concha (Concha nasalis inferior, Ci) is the point of drainage for the nasolacrimal ductus. The back of the nasal cavity communicates with the nasopharyngeal room (Np).

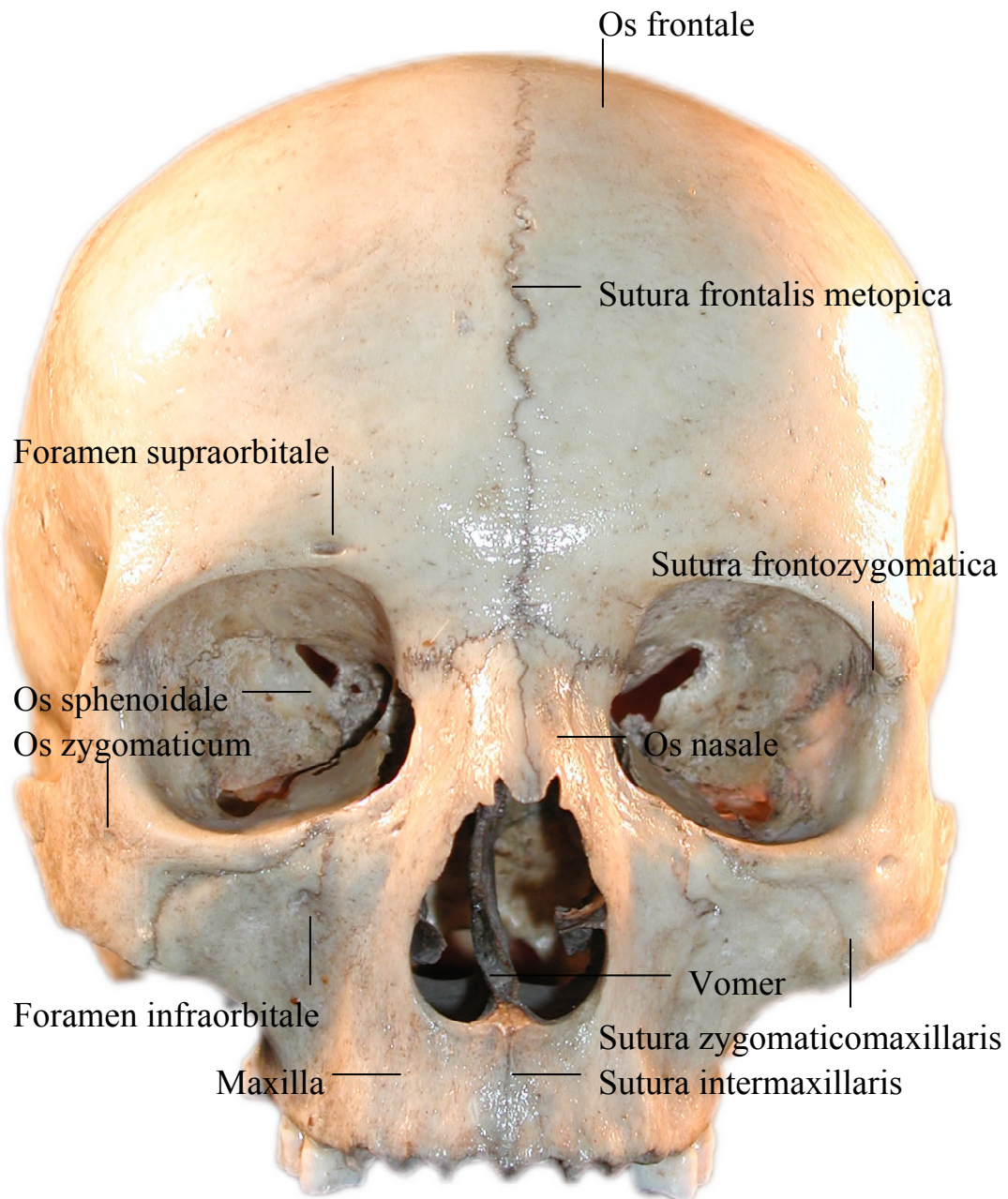


Fig. 2.14.: Aspectus anterior of skull (good visible Suturae)

Photography by Pekny P., ©2003

Note the good visible Suturae. The Mandibula was detached. An additional Sutura frontalis (metopica) was found in this model.

The side view (*Aspectus* or *Norma lateralis*) of skull presents the whole oval *neurocranium* and major *viscero-cranial* components.



Fig. 2.15.: Aspectus lateralis of skull

Starting again with the frontal bone (*Os frontale*) and following the oval contour of the *neurocranium* the lateral aspect shows the parietal bone (*Os parietale*), divided from *Os frontale* by the coronal suture (*Sutura coronalis*) on both sides of skull. Both parietal bones are in contact at the top of skull, separated by *Sutura sagittalis*. The occipital bone (*Os occipitale*) forms the back of the oval neurocranial part of skull. It is separated from the parietal bone (*Os parietale*) by *Sutura lambdoidea*. The temporal bone (*Os temporale*) is located at the base of the oval *neurocranium*, in the lateral aspect articulating with *Os occipitale* at the back, with *Os parietale* at the top, and with *Os sphenoidale* and *Os zygomaticum* at the front. The bony facial components of skull are only limited visible in the lateral view. The neurocranial *Os frontale* is at the face followed downwards by the nasal bones (*Os nasale*), the upper jaw (*Maxilla*) and the zygomatic bone (*Os zygomaticum*), which is articulating with *Os frontale*, *Maxilla* and the temporal bone (*Os temporale*), forming

together the bony zygomatic arch (*Arcus zygomaticus*).

Depending on the view also some orbital structures may be visible (frontolateral view): The lacrimal bone between *Maxilla* in front and bottom, *Os ethmoidale* in the interior and *Os frontale* at the top or the ethmoid bone (*Os ethmoidale*) in the interior medial part of *Orbita*.

The distal located *Mandibula* is the only movable bone of skull because it is not connected to other skull bones by tight immovable joints but by *ginglymoarthroidal* joints on both sides of the skull, which allow mastication movements in one axis and small gliding movements to sides. It is attached to the skull base and provides mastication, and facial movements.

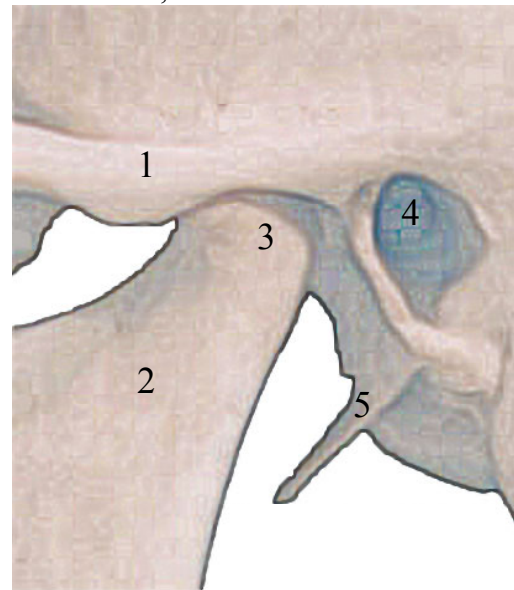


Fig. 2.16.: Aspectus lateralis of the Articulatio temporomandibularis

Processus zygomaticus (1) belongs to *Os temporale*, Collum (2) and Caput mandibulae (3) belong to the lower jaw, Porus and Meatus acusticus externus (4) and Processus styloideus (5) belong to the temporal bone.

The side- gliding movement is provided by a *Discus articularis*.

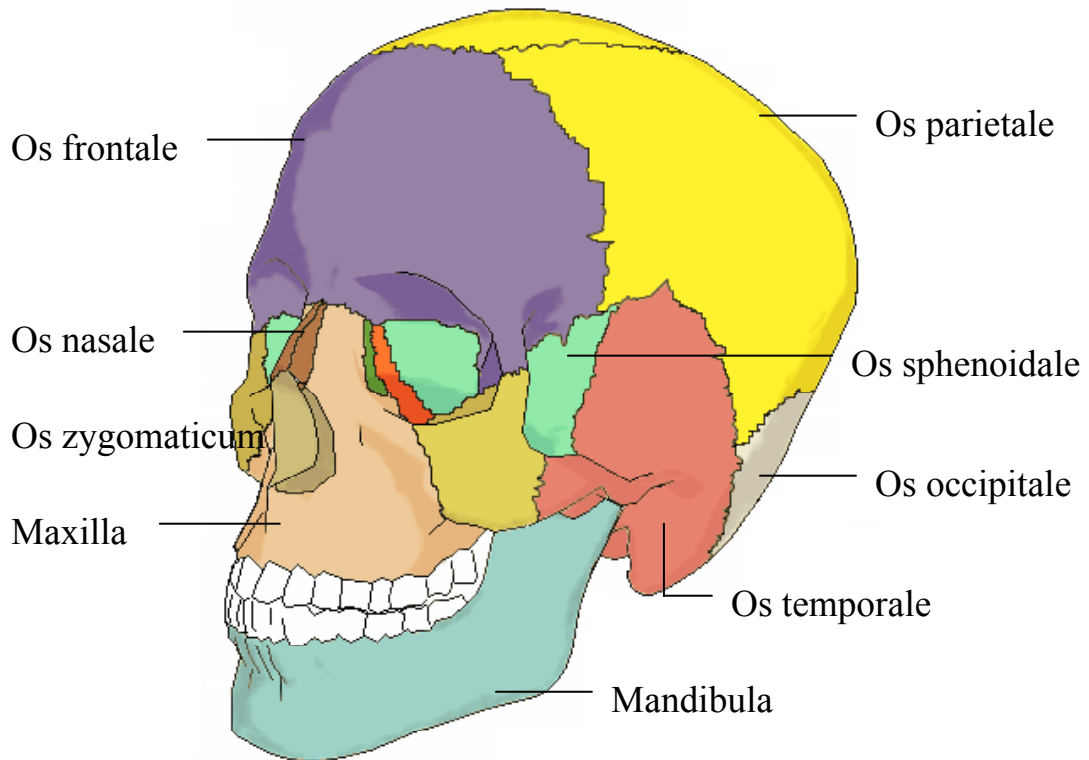


Fig. 2.17.: Aspectus anterolateralis of skull (bones)

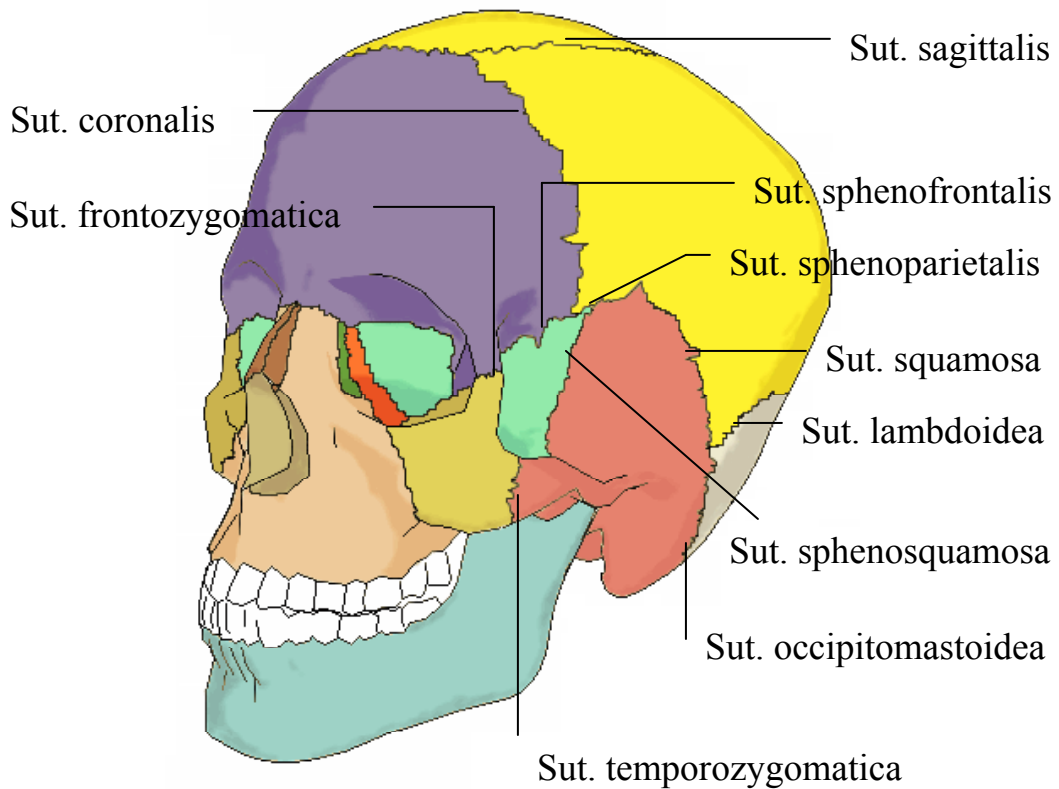


Fig. 2.18.: Aspectus anterolateralis of skull (sutures)

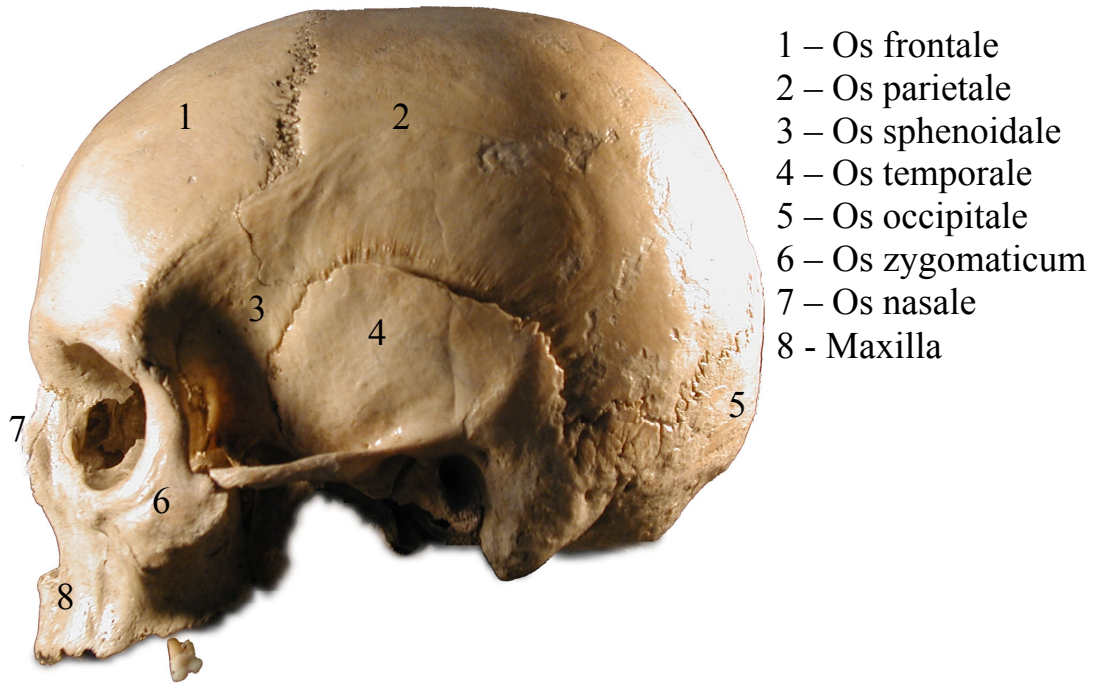


Fig. 2.19.: Aspectus lateralis of the skull (Mandibula detached)  
 Photography by Pekny P., ©2003

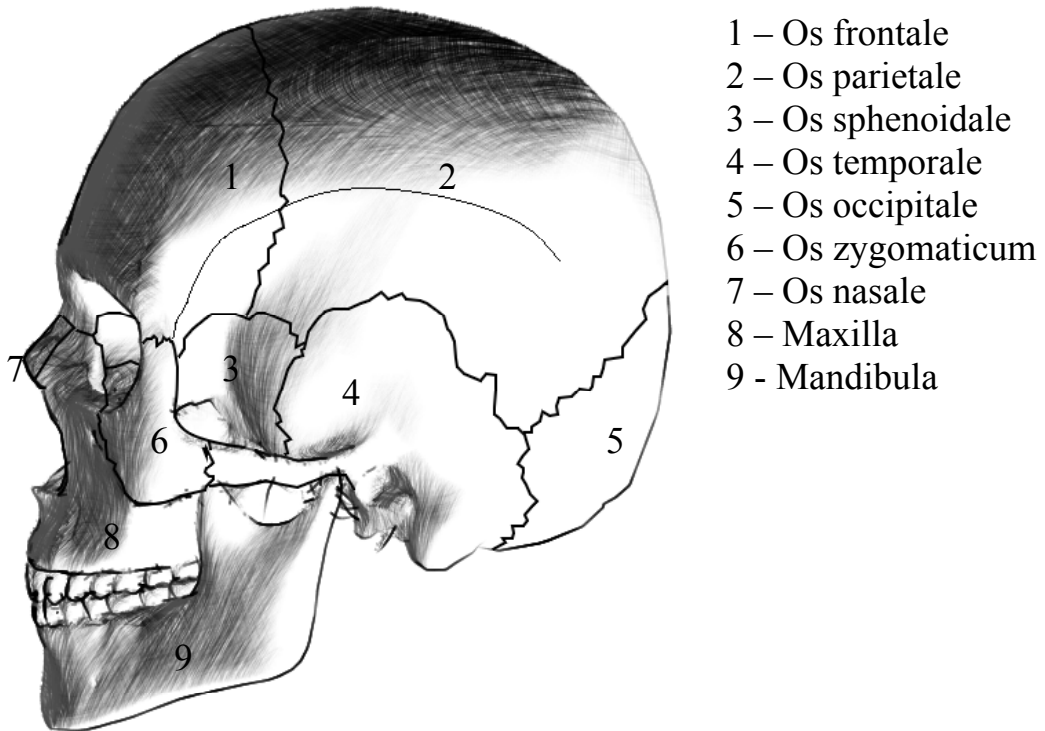


Fig. 2.20.: Aspectus lateralis of the skull

The superior view (*Aspectus superior* or *Norma verticalis*) presents the oval braincase called *Calvaria*. Four neurocranial bones are visible in this view: The two parietal bones (one *Os parietale* on each side) separated on the top of the skull by the sagittal suture (*Sutura sagittalis*), the frontal bone (*Os frontale*), separated from both parietal bones by the coronal suture (*Sutura coronalis*) and the occipital bone (*Os occipitale*), separated from both parietal bones by the lambdoidal suture (*Sutura lambdoidea*).

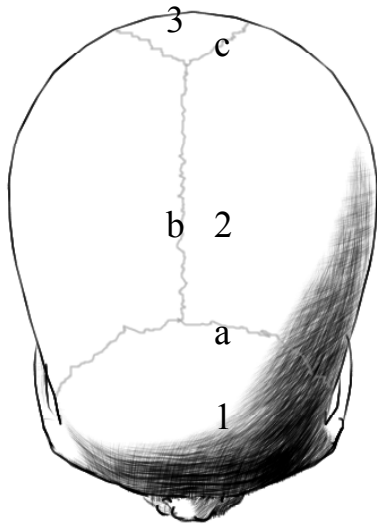


Fig. 2.21.: Norma verticalis of the skull. Visible structures are the upper parts of *Os frontale* (1), both *Ossa parietalia* (2) and *Os occipitale* (3). *Sutura sagittalis* (b) divides the skull into a left and a right part and separates both parietal bones (2) at the top of skull. *Sutura coronalis* (a) separates *Os frontale* (1) and both *Ossa parietalia* (2). *Sutura lambdoidea* (c) separates the occipital bone (3) and both *Ossa parietalia* (2) at the back of skull.

Note that also parts of the zygomatic arch (*Arcus zygomaticus*) or other facial bones (e.g. *Ossa nasalia*) may be visible in this view.

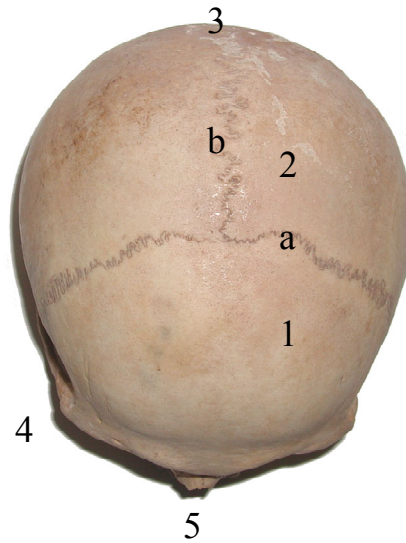


Fig. 2.22.: Norma verticalis of the skull. *Os frontale* (1), *Os parietale* (2), *Os occipitale* (3), *Os zygomaticum* (4), *Os nasale* (5), *Sutura coronalis* (a), *Sutura sagittalis* (b)

The posterior view (*Aspectus posterior*, *Norma occipitalis*) presents the occipital bone, both parietal bones, parts of the temporal bones, and the interior surface of the *Mandibula* (detached in the following image). The parietal bones are connected by *Sutura sagittalis* to each other, and by *Sutura lambdoidea* to the occipital bone.

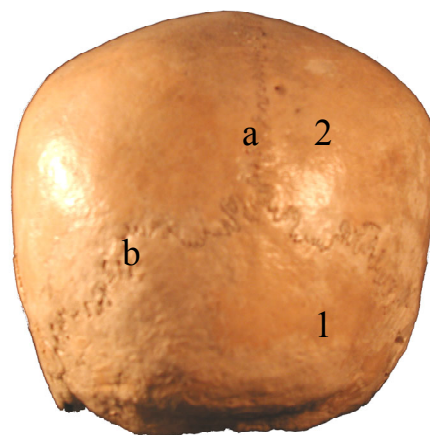


Fig. 2.23.: Norma occipitalis. *Os occipitale* (1), *Os parietale* (2), *Sut. sagittalis* (a), *Sut. lambdoidea* (b)

After detaching the lower jaw the inferior view at the skull (*Norma basalis*) presents the external skull base (*Basis cranii externa*), which consists of the occipital bone, the temporal, zygomatic, and the palatine bones, the vomer, the sphenoid bone and the *Maxillae*.

The outline of the skull base is made by the following structures: Both *Maxillae* are located at the front, followed laterally by the zygomatic bones and the temporal bones backwards, which are connected to the occipital bone, located at the back of the skull base.

The upper part of the occipital bone, termed the *Squama occipitalis* presents the almost horizontal inferior nuchal line (*Linea nuchalis inferior*) on both sides, and the vertical *Crista occipitalis externa*. These rough structures provide attachment for ligaments and muscles (See chapter: Os occipitale). *Crista occipitalis externa* extends downwards to the posterior margin of *Foramen magnum*. This point is termed the *Opisthion*.

The inferior part of the occipital bone has a large aperture (*Foramen magnum*), where the spinal cord leaves the skull cavity to enter into the spinal channel (*Canalis vertebralis*) of the vertebral column, formed by the *Vertebrae*. The first vertebra is connected to the skull base at the *Condylus occipitalis*, located on both sides of *Foramen magnum*, forming a movable sliding joint. This connection provides the movement of the head and the neck at one hand, and a flowing transmission of the spinal cord from one protecting cavity (skull) into the other (vertebral column) at the other hand. The rough medial portions of *Foramen magnum* give attachment for the alar ligaments (*Ligamenta alaria*) which connect the *Dens axis* (second vertebra) to the occipital bone and

additionally stabilize the joints of the head and the neck.

Behind each *Condylus occipitalis* is a condyloid fossa with a channel (*Canalis condylaris*). Lateral to each *Condylus occipitalis* is the jugular foramen (*Foramen jugulare*) for the transmission of the *Vena jugularis interna*, *Nervus glossopharyngeus*, *Nervus vagus* and *Nervus accessorius*, located between the *Pars petrosa ossis temporalis* and the *Pars lateralis ossis occipitalis*, followed by the jugular process (*Processus jugularis*) which gives attachment to the atlantooccipital ligaments.

The middle of the anterior margin of *Foramen magnum* is termed the *Basion*. In front of the *Foramen magnum* an almost plane part of the occipital bone called *Pars basilaris* forms a dense osseous connection with the body of the sphenoid bone. *Pars basilaris* presents near its center the pharyngeal tubercle (*Tuberculum pharyngeum*) for the attachment of the fibrous raphe of the pharynx (*Raphe pharyngis*). The oval aperture (*Foramen ovale*) of the sphenoid bone is located on both sides of the plane *Pars basilaris ossis occipitalis*, transmitting the mandibular nerve (*Nervus mandibularis*, N. V.) and accessory meningeal artery.

The *Sutura occipitomastoidea* connects the lateral parts of the occipital bone to the mastoid processes (*Processus mastoidei*) of the temporal bones on both sides. Medially, the sharp styloid processes (*Processus styloideus*, Pl.: *styloidei*) of the temporal bones extend downward. The temporal bones extend on both sides of the skull base to the front, where they articulate medially with the major wings of the sphenoid bone and laterally with the zygomatic bones. The zygomatic bones form together with the zygomatic process (*Processus zygomaticus*) of each temporal bone the zygomatic arch

(*Arcus zygomaticus*). The zygomatic bones are also connected to the *Maxillae*.

The mandibular joint is located behind the zygomatic arch. The location is visible at the skull base (after the lower jaw was detached) only as an excavation (*Fossa mandibularis*) of the temporal bone, between the zygomatic arch and the external acoustic porus (*Porus acusticus externus*), which is the aperture of the osseous hearing channel.

The *Maxillae*, which keep the upper row of dentition, are connected in the

midline by the sagittal *Sutura palatina mediana* to each other, and by the *Sutura palatina transversa* to the horizontal plates of the palatine bones. This connection (both maxillae with both palatine bones) forms the hard (osseous) palate, called *Palatum osseum*, which is encircled by the upper dentition. The incisive foramen (*Foramen incisivum*) is situated at the osseous palate behind the incisor teeth. It contains the incisive canals, which transmit palatine vessels and nerves.

The *Choanae* are located behind and above the osseous palate.

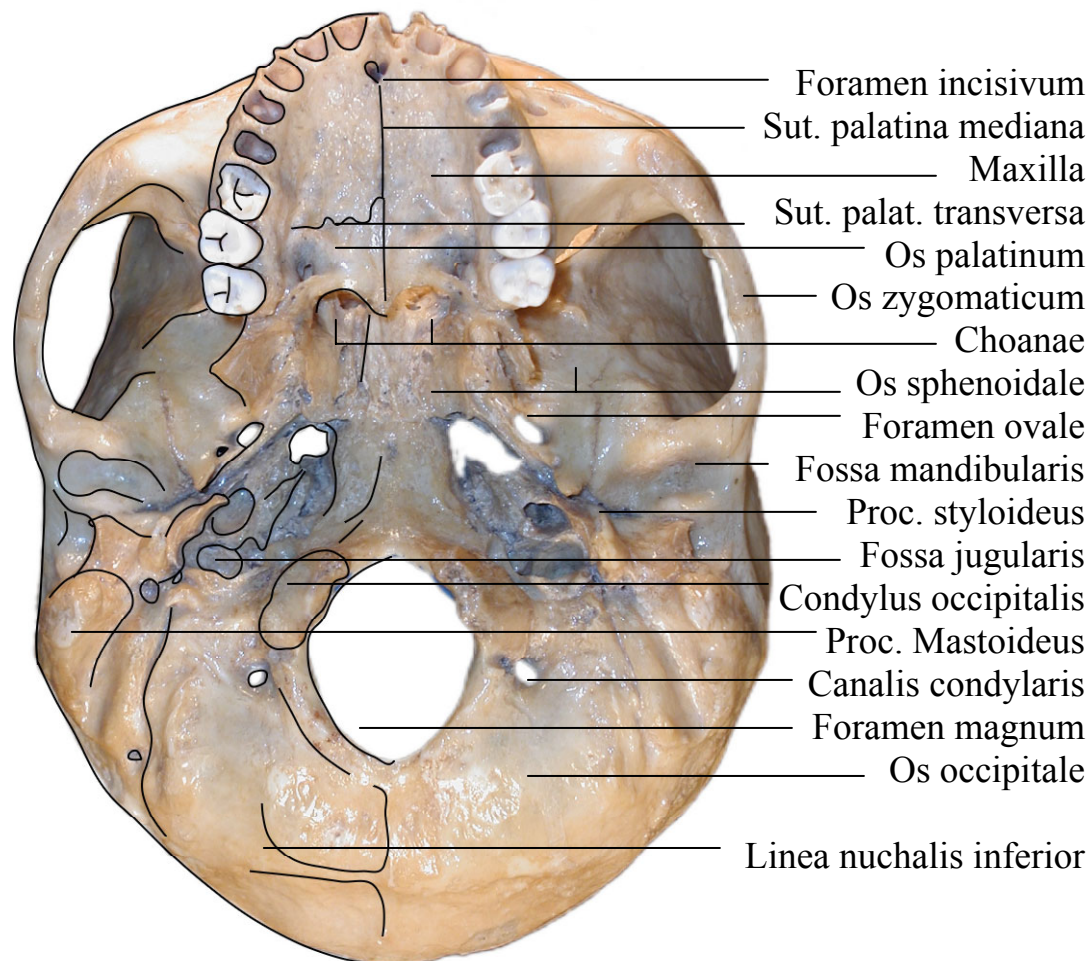


Fig. 2.24.: Norma basalis of the skull  
Photography by Pekny P., ©2003



*Choanae* consist of the horizontal plates of the palatine bones, the body and the medial pterygoid plates of the sphenoid bone (*Lamina medialis processus pterygoidei*) and the *Vomer*. They form the connection of the nasal cavity to the nasopharyngeal room.

The lateral pterygoid plates of the sphenoid bone are situated laterally. The major wings of the sphenoid bone are visible on both sides. They are connected laterally to the temporal and the zygomatic bones, forming the base under the zygomatic arches.

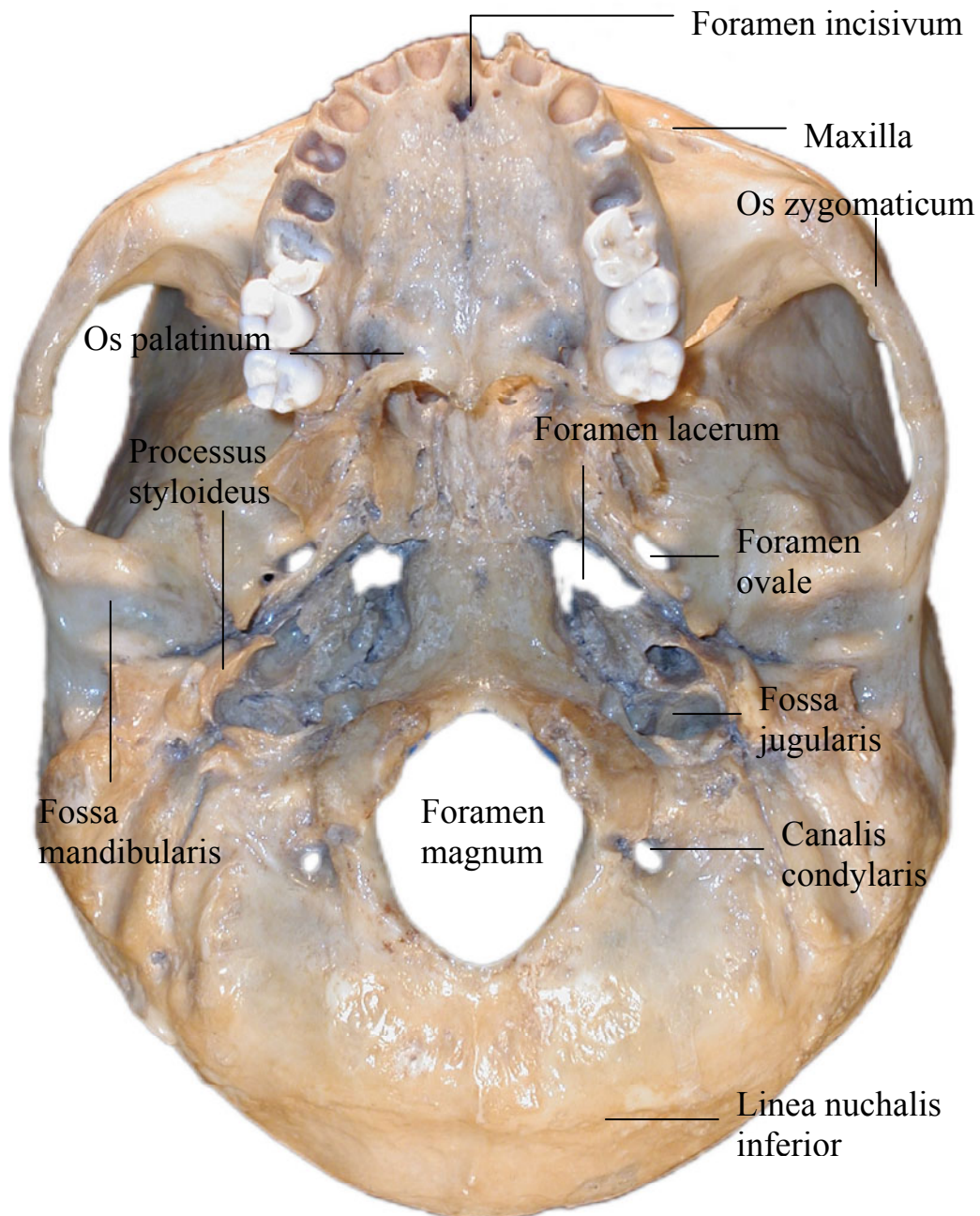


Fig. 2.25.: Norma basalis of the skull  
Photography by Pekny P., ©2003

The interior of skull gets visible after detaching the skull- cap (*Calvaria*) by a horizontal cut, which divides the skull into the *Calvaria* and the skull base (*Basis cranii*).

The *Calvaria* is made up of the frontal, parietal, temporal and occipital bones. The bones of *Calvaria* consist of outer and inner tables (*Tabula interna* and *externa*) of compact bone, separated by a cancellous bone tissue called the *Diploe*. The *Diploe* is rich vascularized. The veins are connected to the intracranial dural venous sinuses,

meningeal veins and to the veins of the scalp. The interior surface of *Calvaria* is concave and presents poorly defined depressions called *Impressiones digitatae* or *Impressiones gyrorum*, caused by the corresponding gyri of the brain and grooves of the venous sinuses. The most prominent groove is the *Sulcus sinus sagittalis superioris* for the superior sagittal sinus which extends sagittal along the midline. The sutures (coronal, sagittal and lambdoidal) are the same like in the exterior views (see Norma superior).

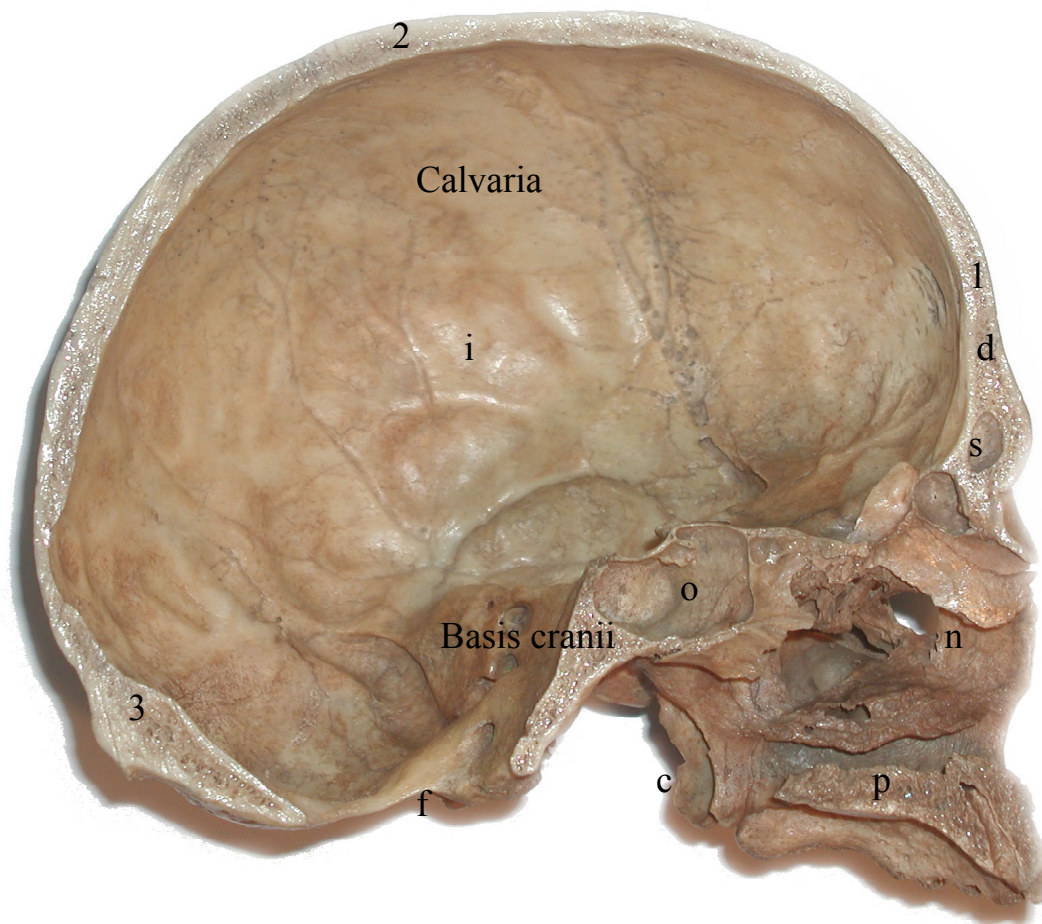


Fig. 2.26.: Interior of the skull (sagittal cut)

Photography by Pekny P., ©2003

Frontal bone (1) with frontal sinus (s), parietal bone (2), occipital bone (3) with Foramen magnum (f), Diploe (d), Impressiones gyrorum (i), nasal cavity (n), Choanae (c), osseous palate (p), sphenoid sinus (o) of the sphenoid bone

The interior of the skull base (*Basis cranii interna*) presents the upper surface which consists of three large depressions (*Fossae*):

The anterior fossa (*Fossa cranii anterior*) consists of the orbital parts of the frontal bone, the cribriform plate (*Lamina cribriformis*) of the ethmoid bone, and of the front parts of the sphenoid bone. It supports the frontal lobe of the brain, protects the intracranial parts of some cranial nerves (*N. olfactorii*, *N. ethmoidalis ant.*), vessels (*A. ethmoidalis ant.*), and provides attachment of the meninges.

The middle fossa (*Fossa cranii media*) is formed by the temporal bones and parts of the sphenoid bone. It extends from the posterior margins of the small wings of the sphenoid bone (*Alae minor ossis sphenoidalis*) and the anterior clinoid processes to the superior angles of the petrous parts of the temporal bones and the back of *Sella turcica* (*Dorsum sellae*). The middle cranial fossa provides protection for parts of the temporal lobe, the Hypophysis, Hypothalamus, for the intracranial parts of the nerves *N. opticus* (II), *oculomotorius* (III), *trochlearis* (IV), *trigemini* (V), *abducens* (VI), major vessels like the *A. carotis interna*, *A. ophthalmica* and the venous *Sinus cavernosus*.

The posterior fossa (*Fossa cranii posterior*) extends from the back of the petrosal parts of the temporal bones to the occipital bone. It protects the brainstem, the cerebellum, parts of the occipital lobe of the brain, the intracranial parts of the nerves *N. intermediofacialis* (VII), *vestibulo-cochlearis* (VIII), *glossopharyngeus* (IX), *vagus* (X), *accessorius* (XI), *hypoglossus* (XII), and major vessels like the internal jugular vein (*Vena jugularis interna*) and *A. basilaris*.

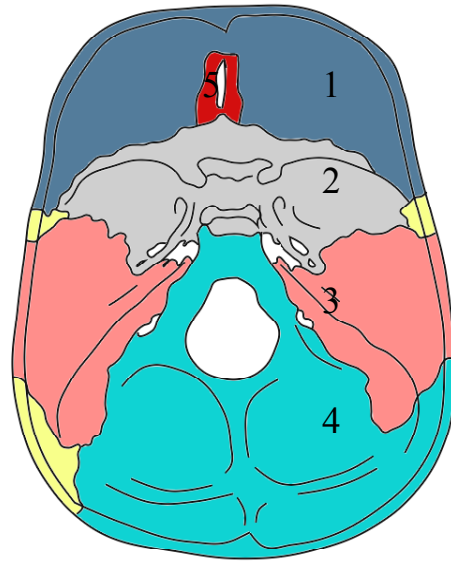


Fig. 2.27.: Basis cranii interna  
Os frontale (1), Os sphenoidale (2), Os temporale (3), Os occipitale (4), Os ethmoidale (5)

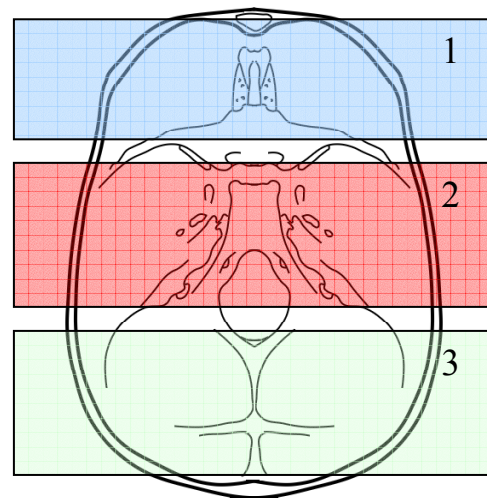
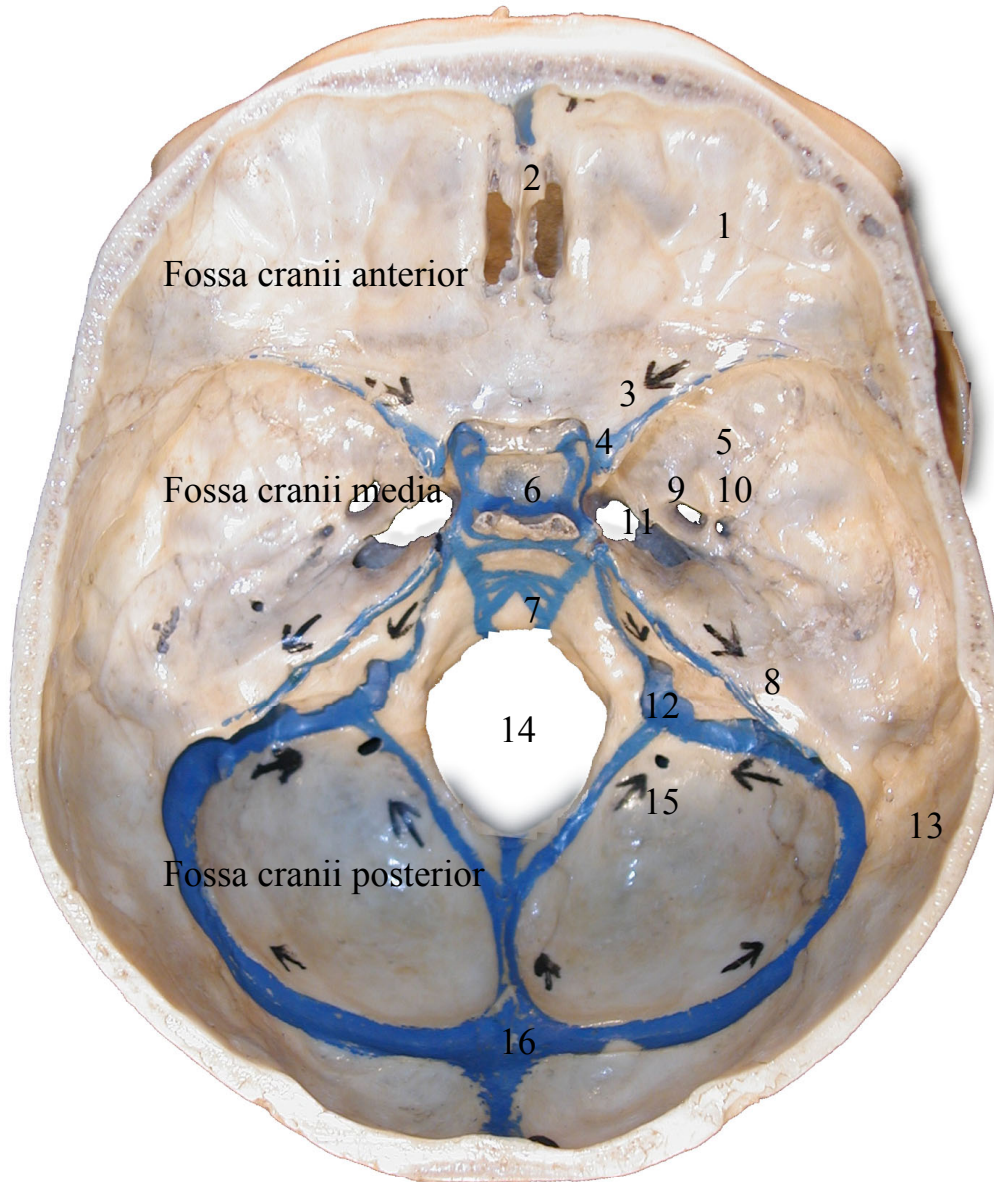


Fig. 2.28.: Basis cranii interna  
Fossa cranii anterior (1),  
Fossa cranii media (2),  
Fossa cranii posterior (3)

The following figures show an overview of the anatomic structures found in this view:



- |                                   |                           |
|-----------------------------------|---------------------------|
| 1- Os frontale (Pars orbitalis)   | 9- Foramen ovale          |
| 2- Crista galli (                 | 10- Foramen spinosum      |
| 3- Ala minor ossis sphenoidalis   | 11- Foramen lacerum       |
| 4- Processus clinoides anterior   | 12- Foramen jugulare      |
| 5- Ala major ossis sphenoidalis   | 13- Part of Os parietale  |
| 6- Sella turcica (Fossa hypoph.)  | 14- Foramen magnum        |
| 7- Os occipitale (Pars basilaris) | 15- Canalis condylaris    |
| 8- Os temporale (Pars petrosa)    | 16- Eminentia cruciformis |

Fig. 2.29.: Basis cranii interna with marked positions of the venous sinuses  
Photography by Pekny P., ©2003

STRUCTURE	LOCATION	STRUCTURES/ FUNCTION
<b>Fossa cranii anterior</b>		
Lamina cribrosa	Os ethmoidale	Connection to nasal cavity, N. olfactorius (I) N. ethmoidalis anterior A. ethmoidalis anterior
Crista galli	Os ethmoidale, middle sagittal	Attachment of Falx cerebri
Foramina ethmoidalia	Os ethmoidale, margin between Os ethmoidale and Os frontale	Connection to orbital cavity, A. ethmoidalis V. ethmoidalis N. ethmoidalis
Crista frontalis	Os frontale, middle sagittal	Attachment of Falx cerebri
Foramen caecum	Os frontale, under Crista frontalis middle sagittal	1% connection to nasal cavity, 99% blind ending, V. emissaria for. caeci
Impressiones digitatae	Os frontale, Squama frontalis	Cerebral impressions
<b>Fossa cranii media</b>		
Canalis opticus	Os sphenoidale	Connection to orbital cavity, N. opticus (II) A. ophthalmica
Fissura orbitalis superior	Os sphenoidale, between Ala major and minor	Connection to orbital cavity, N. oculomotorius (III) N. trochlearis (IV) N. ophthalmicus (V) N. abducens (VI) V. ophthalmica superior
Foramen rotundum	Os sphenoidale, Ala major	Connection to Fossa pterygopalatina, N. maxillaris (V)
Foramen ovale	Os sphenoidale, Ala major	Connection to Fossa infratemporalis, N. mandibularis (V)
Foramen spinosum	Os sphenoidale, Ala major	Connection to Fossa infratemporalis, A. meningea media R. meningeus n. V
Foramen lacerum	Os sphenoidale, Between Ala major and Pars petrosa of Os temporale	Connection to Basis cranii externa, A. carotis interna Plexus caroticus
Fossa hypophysialis	Os sphenoidale, Corpus, Sella turcica	Hypophysis

STRUCTURE	LOCATION	STRUCTURES/ FUNCTION
<b>Fossa cranii posterior</b>		
Foramen magnum	Os occipitale, middle sagittal	Connection to Basis cranii externa (Canalis vertebralis), Medulla oblongata R. spinalis N. accessorii (XI) A. vertebralis A. spinalis anterior A. spinalis posterior R. meningeus A. vertebralis
Foramen jugulare	Between Pars petrosa ossis temporalis and Pars lateralis ossis occipitalis	Connection to Basis cranii externa (Fossa jugularis), V. jugularis interna N. glossopharyngeus (IX) N. vagus (X) N. accessorius (XI)
Canalis nervi hypoglossi	Os occipitale, on both sides of Foramen magnum	Connection to Basis cranii externa, N. hypoglossus (XII)
Eminentia cruciformis	Os occipitale, middle sagittal Squama occipitalis	Support of the post. cerebral Hemispheres cerebellar Hemispheres Falx cerebri Tentorium cerebelli venous sinuses
Meatus acusticus internus	Os temporale, above the jugular foramen	Connection to middle and inner ear, N. intermediofacialis (VII) N. vestibulocochlearis (VIII)

Fig. 2.30.: Table of most important structures visible at the interior of the skull base

After this short introduction of the views at the skull it is important to note, that there are much more structures which can be seen and described in the separate views at the human skull. These structures and their function will be described in the specific chapters about separate bones in detail.

It is generally recommended to return to this chapter when reading the following chapters to achieve a better

overview about the specific structure's position in the whole skull. We will demonstrate the importance of the knowledge of skull anatomy in the last chapter (Clinical aspects) on diagnostic images and descriptions.

Before we step right into the specific descriptions of bones, we will focus on the difference between adult and newborn skulls in the following chapter.

### 2.3. Adult vs. Newborn Skull

Because the knowledge of newborn skull-structures is very important in the pediatrics and neonatology, we will focus in this chapter on the most important anatomic differences between the newborn and the adult skulls.

The skull (form and structures) of adult individuals, as described in the previous chapters is different than the skull of a newborn:

The skull of a newborn has other proportions than the adult skull. Because of the fast development of the brain and the slow development of mastication apparatus the *Neurocranium* is much larger than the *Viscerocranium*. The newborn skull has no teeth erupted and the jawbones and palate form a smaller percentage of the overall skull size than in adult skulls. The chin is also incompletely formed. The forehead is upright and bulbous.

As the result of the faster cerebral growth process is the skull of a newborn as a whole also much larger in relation to other skeletal parts and comprises much more of the percentage of the body than in the adult human.

The fast growth and development of the fetal brain would stop at an early level if there was not one more different parameter to adult skulls- the *Fontanelles*: Some skull bones of the newborn do not completely cover the brain but are connected by large fibrocartilaginous membranes, called the *Fontanelles (Fonticuli cranii)*.

Six *Fontanelles* are present in the newborn skull. The most prominent anterior and posterior *Fontanelles* are situated in the middle sagittal line. The *anterior Fontanelle (Fonticulus anterior)* is the junction where both frontal and both parietal bones meet (at

the junction of *Sutura frontalis, sagittalis* and *coronalis*). It is diamond-shaped, measures about 4x3cm and is the largest of all *Fontanelles*. It remains soft until about 2 years of age.



Fig. 2.31.: The anterior fontanelle  
Photography by Pekny P., ©2003

This image presents Norma verticalis of the skull of a newborn: the frontal bone is divided in two, connected to both parietal bones by the sagittal and the coronal suture and by the anterior fontanelle. Parts of the *Viscerocranium* are visible under the large, bulbous *Neurocranium*.

The *posterior Fontanelle (Fonticulus posterior)* is the junction where the occipital bone and both parietal bones meet (at the junction of *Sutura sagittalis* and *lambdoidea*). It is triangular-shaped and closes during the first months of an infant's life. The lateral *Fontanelles*, termed *sphenoidal* and *mastoid Fontanelles*, do not have any regular shape. The *sphenoidal Fontanelles (Fonticuli sphenoidales)* are situated between the frontal,

parietal, zygomatic, the squamous part of the temporal, and the major wing of the sphenoid bones. The *mastoid Fontanelles (Fonticuli mastoidei)* are situated between the occipital bone, the parietal, and the petrous parts of the temporal bones. They also close during the first months of life.

Although the *Fontanelles* make the baby's head vulnerable for physical impacts, they provide two important functions. First, they provide space between the bones and make the newborn skull flexible during the

childbirth. Second, they support the fast growth of the brain by their expansion.

Some skull bones of the newborn are pneumatized similar to the corresponding bones of adult skulls, but not all paranasal sinuses are developed in newborn skulls at birth. The ethmoid and the maxillary sinuses are present at birth. The frontal and the sphenoid sinus begin to appear at the age of two or three. Their development is associated with the facial growth.



Fig. 2.32.: Aspectus lateralis of the newborn skull

Photography by Pekny P., ©2003

This view presents the Fonticulus mastoideus (2) and sphenoidalis (1).