

Exterior of Skull

Competencies

AN26.1: Demonstrate anatomical position of skull, and identify and locate the individual skull bones in skull.

AN26.2: Describe the features of norma frontalis, verticalis, occipitalis, lateralis, and basalis.

AN26.3: Describe cranial cavity, its subdivisions, foramina, and structures passing through them.

SKULL (Skull = Cranium + Mandible)

For details of individual skull bones, see Chapter 40.

- *Skull* is the bony skeleton of the head. It consists of 22 bones and 6 ear ossicles.
- *Cranium* is the bony structure formed by skull bone except mandible (*cranium* = skull in Greek).
- *Mandible* or lower jawbone is the only mobile bone in the skull.

Parts of Skull

- The skull is subdivided into two parts:
 1. *Calvaria* (brain box or neurocranium): It is the upper part of the cranium which encloses the brain. It consists of
 - a. Skull cap or vault – upper part
 - b. Base of the skull – lower part.
 2. *Viscerocranium* (facial skeleton): It forms the rest of the skull including mandible.

Functions of Skull

1. *Protection*: It protects the brain and meninges.
2. *Space*: It provides confined space for brain, meninges, and CSF.
3. *Cavities for viscera*: It provides cavities for special organs such as eye, middle and internal ear, olfactory epithelium, and tongue.
4. *Patent passage*: It provides patent (open) passage for air (nose, nostrils) and food (oral cavity).

5. *Muscular attachments*: It provides attachments to the muscles of mastication and facial expression.

Bones of the Skull

- The skull consists of 22 bones and 6 ear ossicles which are subdivided as (Fig. 1.1)
 - A. *Cranial skeleton or calvaria*: It includes 8 bones and 6 ear ossicles as follow:
 1. Paired bones: Parietal and temporal
 2. Unpaired bones: Frontal, occipital, sphenoid, ethmoid
 3. Paired ear ossicles: Incus, malleus, and stapes.
 - B. *Facial skeleton*: It consists of 14 bones as follows:
 1. Paired bones: Maxilla, zygomatic, nasal, lacrimal, palatine, inferior nasal concha
 2. Unpaired bones: Mandible and vomer.

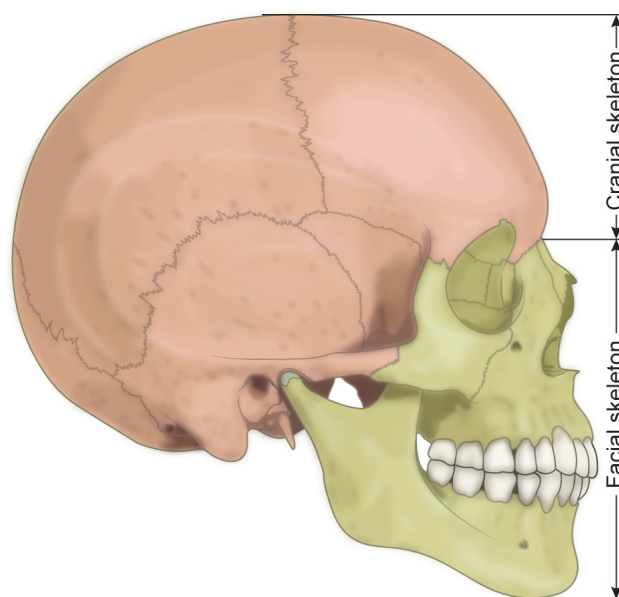


Fig. 1.1: Skull showing cranial skeleton (pink color) and facial skeleton (green color) (lateral view)

Joint of Skull

- The bones of skull are connected with each other by immovable fibrous joints called *sutures* (cranial sutures).
- These are *synarthrosis*, that is, in normal condition, there is no movement.
- Other than suture, the skull has the following joints:
 1. Two pairs of synovial joints between ear ossicles.
 2. One pair of temporomandibular joints.
- The sutures can be classified into
 1. *Plane suture* – edges of bone are flat, for example, internasal suture.
 2. *Serrate suture*, for example, coronal suture.
 3. *Denticulate suture*, for example, lambdoid suture.
 4. *Squamous suture*, for example, parietotemporal suture.
 5. *Schindylesis*, for example, palatomaxillary suture.

Anatomical Position of Skull

Hold the skull in both the hands so that (Fig. 1.2):^{Practical guide}

1. The orbital cavities are directed forward
2. The lower margin of the orbit and upper margin of the external acoustic meatus lie in the same horizontal plane (called *Frankfurt's plane*).



Some Interesting Facts

- *Reid's baseline* is a horizontal line passing through the lower margin of the orbit and the center of external acoustic meatus (Fig. 1.2).

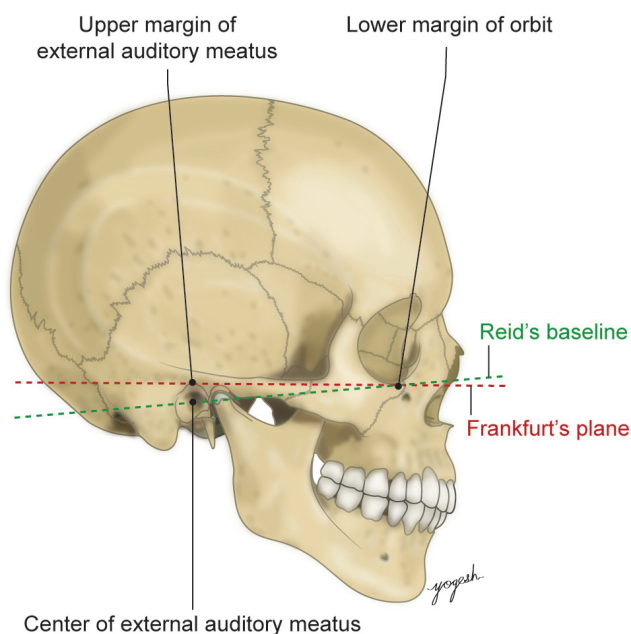


Fig. 1.2: Anatomical position of the skull

Norma (Views) of the Skull

- The skull is studied externally in the following views:
 1. *Norma verticalis*: Superior view
 2. *Norma frontalis*: Anterior view
 3. *Norma occipitalis*: Posterior view
 4. *Norma lateralis*: Lateral view
 5. *Norma basalis*: Inferior view.
- The skull is also studied as individual skull bone and interior of the skull.

NORMA VERTICALIS

- The top view of the skull is called *norma verticalis*.
- *Shape*: Oval (wider posteriorly than anteriorly).

Bones and Sutures of Norma Verticalis

Bones (Figs 1.3, 1.4)

1. Frontal bone
2. Parietal bones
3. Occipital bone.

Sutures

1. Coronal
2. Sagittal
3. Lambdoid
4. Metopic (occasional).

Features of Norma Verticalis

Bony features (Figs 1.3, 1.4, Flowchart 1.1)

- Frontal bone forms the anterior part. The occipital bone forms the posterior part and the parietal bone (paired) forms the lateral part.
- *Sutures*
 1. *Coronal suture* (*coronal* = crown in Latin) lies between frontal and two parietal bones.^{Viva}
 2. *Sagittal suture* lies in the median plane between two parietal bones.^{Viva}
 3. *Lambdoid suture* lies posteriorly between occipital and two parietal bones. It is lambda-shaped.^{Viva}
 4. *Metopic suture* is present occasionally (in 3 to 8% individuals). It lies in the median plane and divides the frontal bone into two halves.^{Viva} Usually, it ossifies (fuses) by 6 years of age.^{MCQ}
- *Reference point*
 1. *Vertex*: It is the highest point on the skull. It lies on the sagittal suture.^{Viva}
 2. *Bregma*: It is the meeting point between coronal and sagittal sutures.^{Viva} It is the site of *anterior fontanelle* (closure time: 18–24 months).

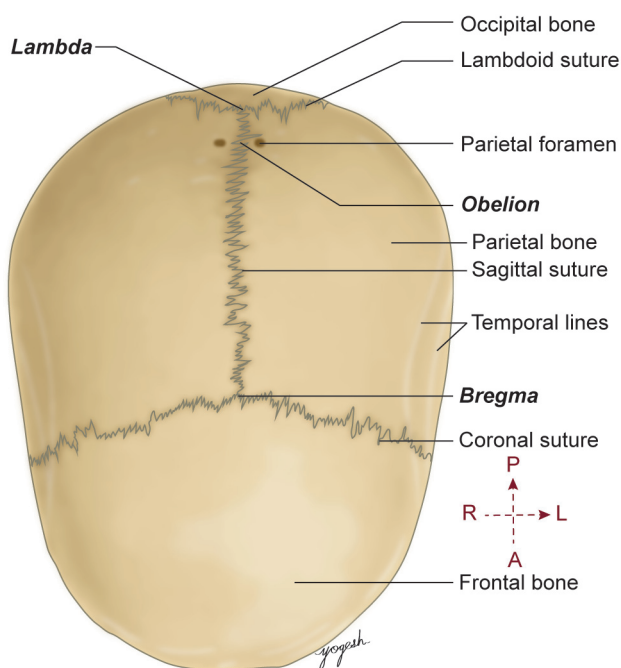


Fig. 1.3: Norma verticalis

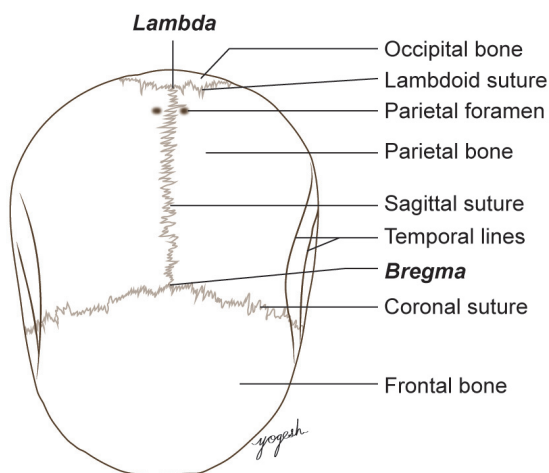
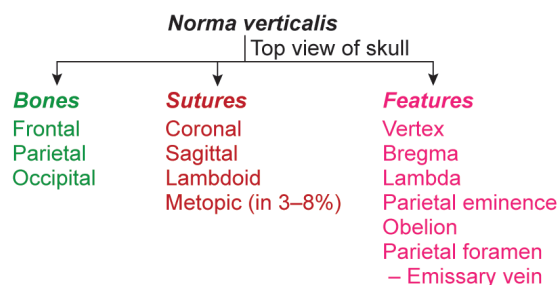


Fig. 1.4: Practice figure: Norma verticalis

Flowchart 1.1: Features of norma verticalis



3. **Lambda:** It is the meeting point of the lambdoid and sagittal sutures. It is the site of posterior fontanelle (closure time: 2–3 months). ^{Viva}
4. **Parietal eminence (tuber)** is an area of maximum convexity of the parietal bone. It is a common site of skull fractures.

5. **Obelion** is a point on sagittal suture between two parietal foramina.
 6. **Temporal lines** (For details, refer norma lateralis).
- **Other features**
 1. **Parietal foramen** (one on each side) is a small foramen in parietal bone. It lies near the sagittal suture, about 2.5–4 cm in front of the lambda.
Structures passing through: Emissary vein connecting veins of scalp and superior sagittal sinus passes through the parietal foramen.

NORMA OCCIPITALIS

- The posterior view of the skull is called *norma occipitalis*.
- **Shape:** It is convex upward and on side, fattened below.

Bones and Sutures of Norma Occipitalis

Bones (Figs 1.5, 1.6)

1. Parietal bones
2. Occipital bone
3. Mastoid part of temporal bone.

Sutures

1. Lambdoid suture
2. Occipitomastoid suture
3. Parietomastoid suture.

Features of Norma Occipitalis (Figs 1.5, 1.6, Flowchart 1.2)

Bony features

1. Parietal bones form upper part
2. Occipital bone forms lower part
3. Mastoid part of the temporal bone forms inferolateral part.

Sutures of norma occipitalis

- The bones of norma occipitalis articulate at the following sutures:
 1. **Lambdoid suture** lies between occipital and two parietal bones. It is lambda-shaped. *Wormian or suture bones* are commonly seen along the lambdoid suture. ^{MCQ}
 2. **Occipitomastoid suture** lies between occipital bone and mastoid part of temporal bone.
 3. **Parietomastoid suture** lies between parietal bone and mastoid part – temporal bone.
 4. **Sagittal suture:** The posteriormost part of sagittal suture is also seen in norma occipitalis.

Reference points

1. **Lambda:** It is the meeting point of the lambdoid and sagittal sutures.

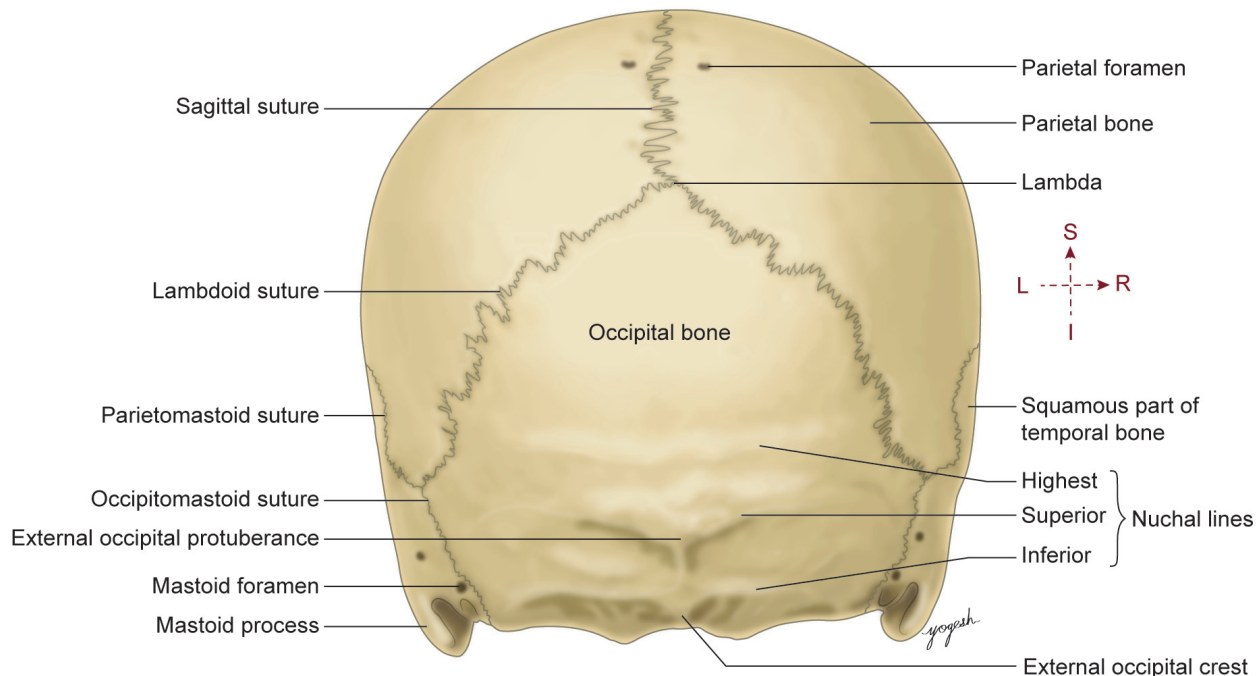


Fig. 1.5: Norma occipitalis

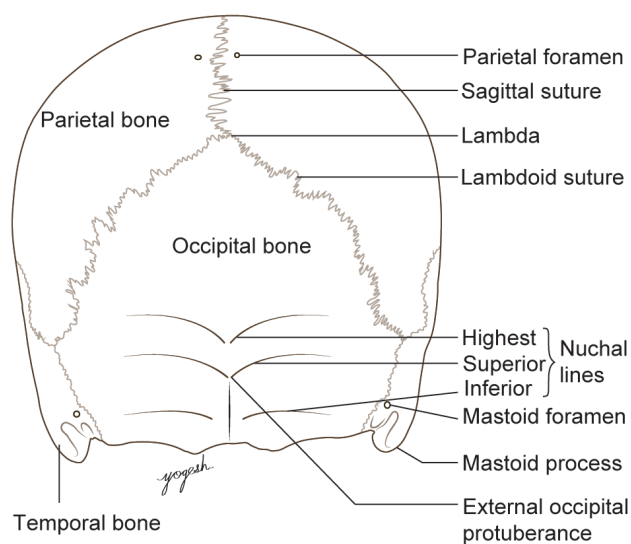
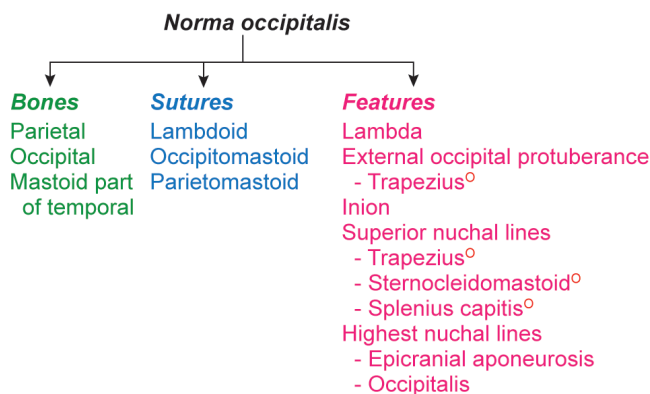


Fig. 1.6: Practice figure: Norma occipitalis

Flowchart 1.2: Features of norma occipitalis



Mastoid foramen: Emissary vein, meningeal branch of occipital artery

2. *External occipital protuberance*: It is a median bony projection of the outer surface of occipital bone. It demarcates the junction of neck and head.

Attachments: **Trapezius** (origin), upper end of ligamentum nuchae

3. *Inion*: It is the most prominent point of the external occipital protuberance. It can be palpated easily. ^{Viva}

4. *Superior nuchal line*: It is an arched line, extending laterally from the external occipital protuberance.

Attachments

- **Trapezius** originates from medial one-third of superior nuchal line.
- **Sternocleidomastoid** (above) and **splenius capitis** (below) are inserted in lateral one-third of superior nuchal line.

5. *Highest nuchal line*: It is a less distinctly curved line, extending laterally from the external occipital protuberance. It lies about 1 cm above the superior nuchal line.

Attachments

- Medial part: Epicranial aponeurosis
- Lateral part: **Occipitalis** or occipital belly of occipitofrontalis muscle (origin)

Note: If the highest nuchal line is absent, then epicranial aponeurosis and occipitalis are attached to the superior nuchal line.

6. *Mastoid foramen*: It is present on the mastoid part of temporal bone at or near occipitomastoid suture.

Structures passing through:

1. Emissary vein (connecting veins scalp with sigmoid sinus)
2. Meningeal branch of occipital artery.



Some Interesting Facts

Inca bone: It is occasionally occurring interparietal bone. It is a triangular bone located at the apex of squamous (membranous) part of occipital bone. It represents separated membrane part of occipital bone.

Note: It is not a suture bone.

NORMA FRONTALIS

- The front view of the skull is called *norma frontalis*.
- **Shape:** It is oval in outline (broader above than below).

Bones and Sutures of Norma Frontalis

Bones (Fig. 1.7)

1. Frontal
2. Nasal (pair)
3. Maxilla (pair)
4. Zygomatic bones
5. Mandible
6. Bony orbit.

Sutures

1. Internasal
2. Frontonasal
3. Frontozygomatic
4. Frontomaxillary
5. Zygomaticomaxillary.

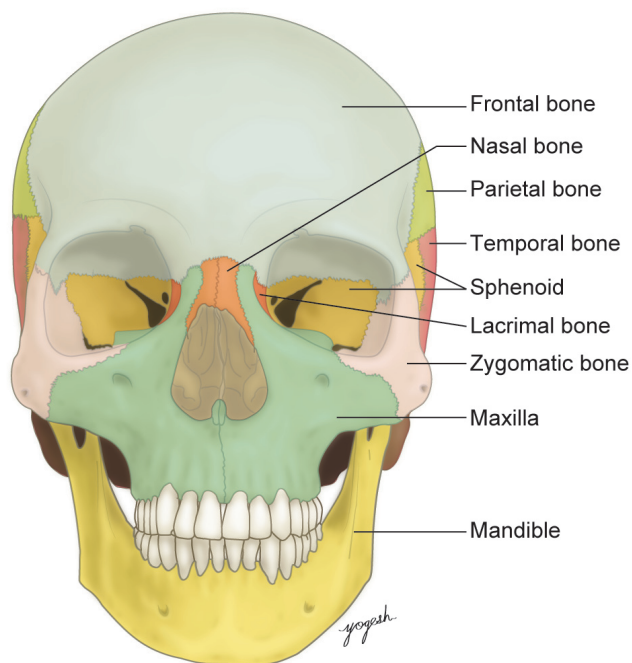


Fig. 1.7: Bones of norma frontalis

Features of Norma Frontalis

Bony formation (Figs 1.8, 1.9)

1. *Frontal bone* forms the frontal region or forehead.
2. *Maxillae* (right and left) form the upper jaw.
3. *Nasal bones* (right and left) form the bridge of the nose.
4. *Zygomatic bones* (right and left) form the bony prominence of the cheek.
5. *Mandible* forms lower jaw (for details, see Chapter 4).

Sutures

1. *Internasal suture* lies in the midline between right and left nasal bones.
2. *Frontonasal suture* lies between frontal bone and nasal bones.
3. *Frontomaxillary suture* lies between the frontal bone and the maxilla.
4. *Frontozygomatic suture* lies between zygomatic process of frontal bone and frontal process of zygomatic bone.
5. *Nasomaxillary suture* lies between nasal bone and maxilla.
6. *Intermaxillary suture* lies at right and left maxillae.
7. *Zygomaticomaxillary suture* lies between zygomatic bone and maxillae.

Descriptive Divisions

- For the descriptive purposes, the norma frontalis is divided into four parts as follows (Flowchart 1.3):
 1. Frontal region
 2. Orbital openings
 3. Anterior nasal aperture
 4. Lower part of the face.

Frontal region of norma frontalis

Bones (Figs 1.8, 1.9)

- The frontal region is formed by the squamous part of the frontal bone. It shows the following features:
 1. *Superciliary arches* are rounded, curved elevation (one on each side), situated just above the medial part of each orbit.
 2. *Glabella* is a smooth elevated area in the median plane where the superciliary arches meet.
 3. *Nasion* is a median point on the skull at the junction of internasal and frontonasal sutures.
 4. *Frontal eminence* is a smooth rounded elevation above the superciliary arch.



Some Interesting Facts

- The superciliary arches are more marked in males and frontal eminences are more prominent in females.

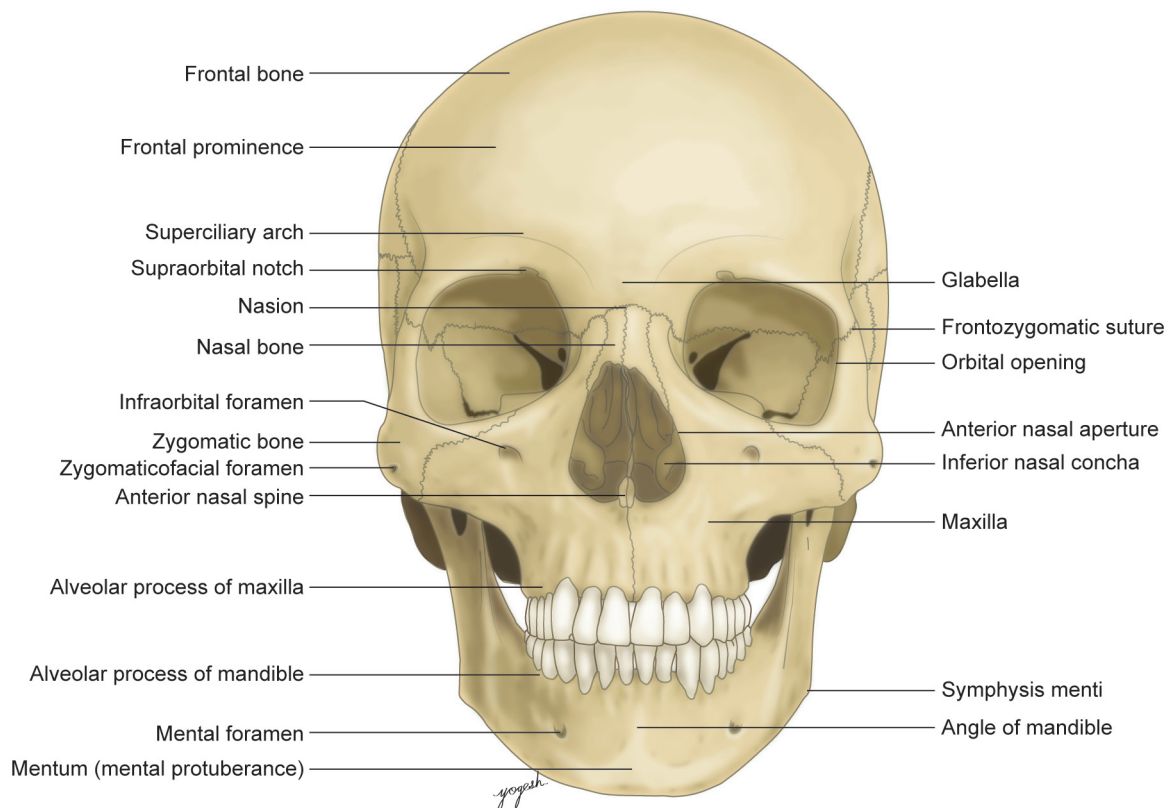


Fig. 1.8: Norma frontalis

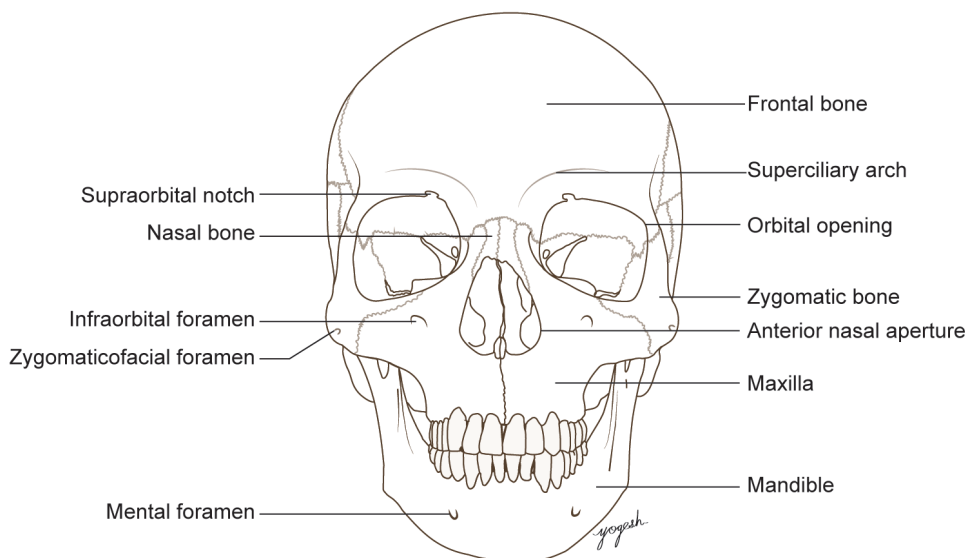
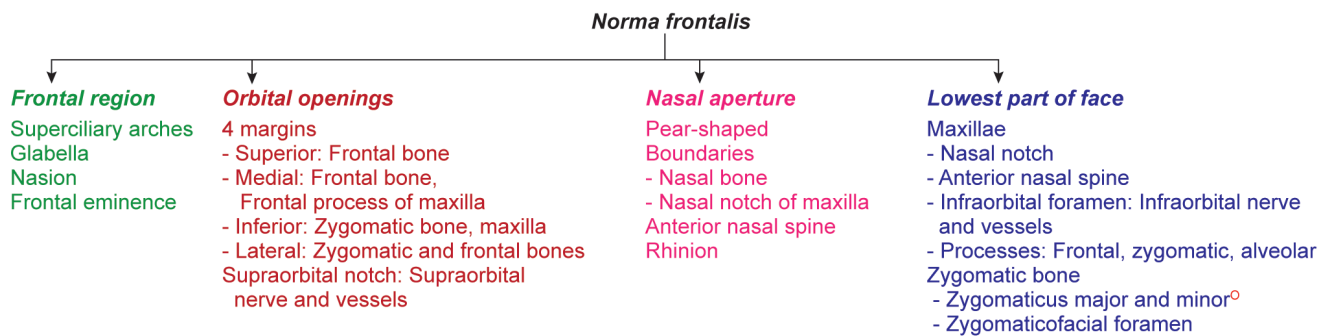


Fig. 1.9: Practice figure: Norma frontalis

Flowchart 1.3: Features of norma frontalis



Orbital openings

- Each orbital opening is a quadrangular opening of the bony orbit. It has four margins as follows (Figs 1.8 and 1.9):

1. *Superior orbital margin* is formed by frontal bone.
2. *Medial orbital margin* is formed by frontal bone above and lacrimal crest of the frontal processes of the maxilla below.
3. *Inferior orbital margin* is formed by the zygomatic bone laterally and maxilla medially.
4. *Lateral orbital margin* is formed by the frontal process of zygomatic bone below and zygomatic process of frontal bone above.

- Supraorbital notch* is the notch at the junction of lateral two-thirds and medial one-third of the supraorbital margin.

Structures passing through: Supraorbital nerve and vessels. *Viva*

Note: Sometimes, the supraorbital notch is present as *supraorbital foramen*.

Bony nasal aperture

- The external or anterior bony nasal aperture is a pear-shaped opening (Figs 1.8, 1.9).

Boundaries

- *Superiorly:* Nasal bone
- *On each side and inferiorly:* Nasal notch of maxilla

Features

- *Anterior nasal spine* is a sharp median bony projection at inferior boundary of anterior bony nasal aperture. It is present at the meeting point of two maxillae.
- *Rhinion* is the lowest point of internasal suture.

Lower part of face

- The lower part of face presents the following features (Figs 1.8, 1.9):

Bones forming

1. Maxilla forms upper jaw.
2. Zygomatic bone forms malar prominences.
3. Mandible forms lower jaw.

Upper jaw or maxillae

- The upper jaw is formed by two maxillae. It presents the following features:

Nasal notch which forms inferolateral boundary of anterior bony nasal aperture.

Anterior nasal spine is a median sharp bony projection. *Infraorbital foramen* lies about 1 cm below the infra-orbital margin.

Structures passing through: Infraorbital nerve and vessels. *Viva*

- *Processes of maxilla*

1. *Frontal process* is directed upward.

Articulation: It articulates with frontal bone at *fronto-maxillary suture*, with nasal bone at *nasomaxillary*

suture and with lacrimal bone at *lacrimomaxillary suture*.

2. *Zygomatic process* of maxilla is short.

Articulation: It articulates with maxillary process of zygomatic bone.

3. *Alveolar process* is thick arched border with eight sockets for upper teeth. *Incisive fossa* lies above the incisor teeth. *Canine fossa* lies lateral to canine eminence.

Zygomatic bone

- It forms prominence of the cheek.

Articulation: On *norma frontalis*, articulation with frontal and maxilla is visible.

Attachments: *Zygomaticus major* and *minor* originate from zygomatic bone.

- *Zygomaticofacial foramen* is present on facial surface of zygomatic bone.

Structures passing through: Zygomaticofacial branches of zygomatic nerve (branch of maxillary division of trigeminal nerve). *Viva*

Mandible

- It is a lower jawbone (for details, see Chapter 4).

- It shows the following features:

1. Alveolar arch
2. Body of mandible
3. Symphysis menti
4. Mental protuberance
5. Gonion
6. Mental foramen
7. Mental nerves and vessels
8. Oblique line on the outer surface of mandible
9. Ramus of mandible

Attachments of Norma Frontalis (Fig. 1.10)

- *Corrugator supercilli* originates from the medial part of superciliary arch.

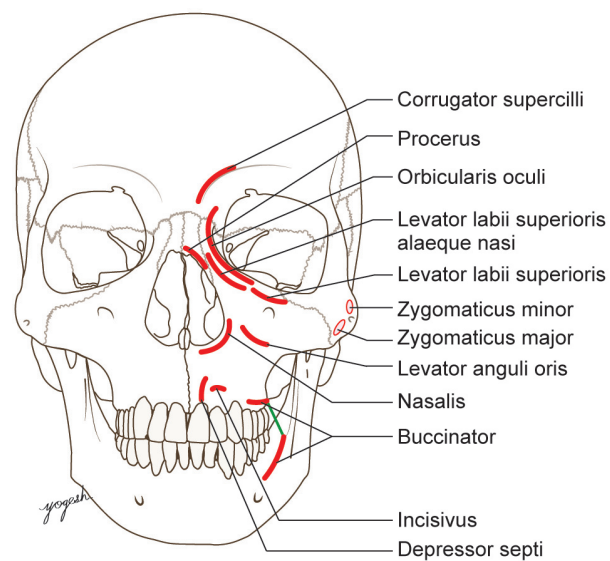


Fig. 1.10: Attachments of norma frontalis

- *Procerus* originates from the nasal bone near the median plane.
- *Orbicularis oculi* (orbital part) originates from the frontal process of maxilla and nasal process of the frontal bone.
- *Median palpebral ligament* is attached to the frontal process of maxilla.
- *Levator labii superioris alaeque nasi* originates from the frontal process of maxilla.
- *Levator labii superioris* originates from the maxilla between the infraorbital margin and the infraorbital foramen.
- *Levator anguli oris* originates from canine fossa.
- *Nasalis* and *depressor septi* originate from the maxilla, near the nasal notch.
- *Incisivus* (part of orbicularis oris) originates from maxilla just below the origin of depressor septi.

Clinical Integration

- Nasal bone is commonly fractured facial bone in boxers and cricketers. Mandible and parietal eminence are also commonly fractured.

NORMA LATERALIS

The lateral view of the skull is called norma lateralis.

Bones and Sutures of Norma Lateralis

Bones (Fig. 1.11)

1. Frontal
2. Parietal
3. Occipital
4. Temporal
5. Sphenoid

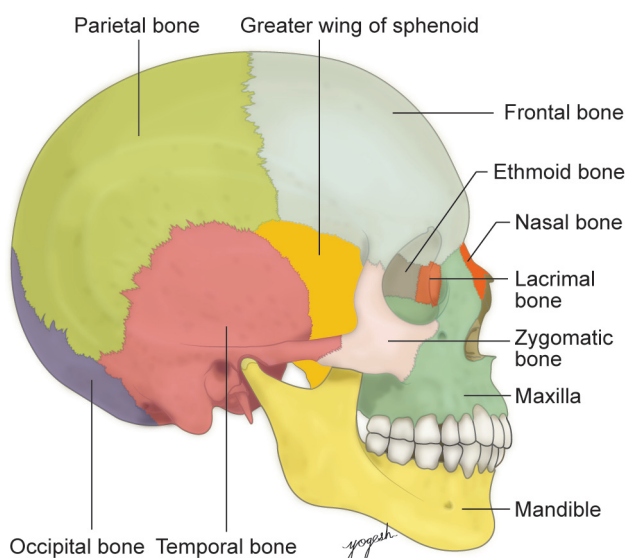


Fig. 1.11: Bones of norma lateralis

6. Zygomatic
7. Maxilla
8. Nasal
9. Mandible.

Sutures

1. Coronal
2. Parietosquamous
3. Lambdoid

Features of Norma Lateralis

The bones forming the norma lateralis present the following features (Figs 1.12 to 1.14, , Flowchart 1.4):

1. **Temporal lines:** These lines are arched lines projecting backward from zygomatic process of the frontal bone and then bifurcating into superior and inferior temporal lines.
 - *Superior temporal line* becomes indistinguishable, posteriorly. *Inferior temporal line* is more prominent and becomes continuous with the posterior root of zygomatic process of temporal bone.

Attachments

- *Temporal fascia* is attached to the superior temporal line.
 - *Temporalis* originates from temporal fossa.
2. **Supramastoid crest:** It is a curved part of interior temporal line that demarcates the mastoid part from the squamous part of temporal bone.
 3. **Zygomatic arch:** It is a horizontal bar of bone on each side of the head, in front of the ear.

Formation:

- Anterior one-third: Temporal process of the zygomatic bone
- Posterior two-thirds: Zygomatic process of temporal bone.

Zygomaticotemporal suture connects the above-mentioned processes. This suture is directed downward and backward.

Features: It presents two surfaces: Outer and inner, and two borders: Upper and lower.

Attachments

- *Masseter* originates from medial surface and lower border of zygomatic arch. *Viva*
 - *Lateral ligament of the temporomandibular joint* is attached to the tubercle of the root of zygomatic arch. *Viva*
4. Structures passing through the gap between zygomatic arch and the side of skull. *Practical guide*
 1. Tendon of temporalis
 2. Deep temporal nerves and vessels.

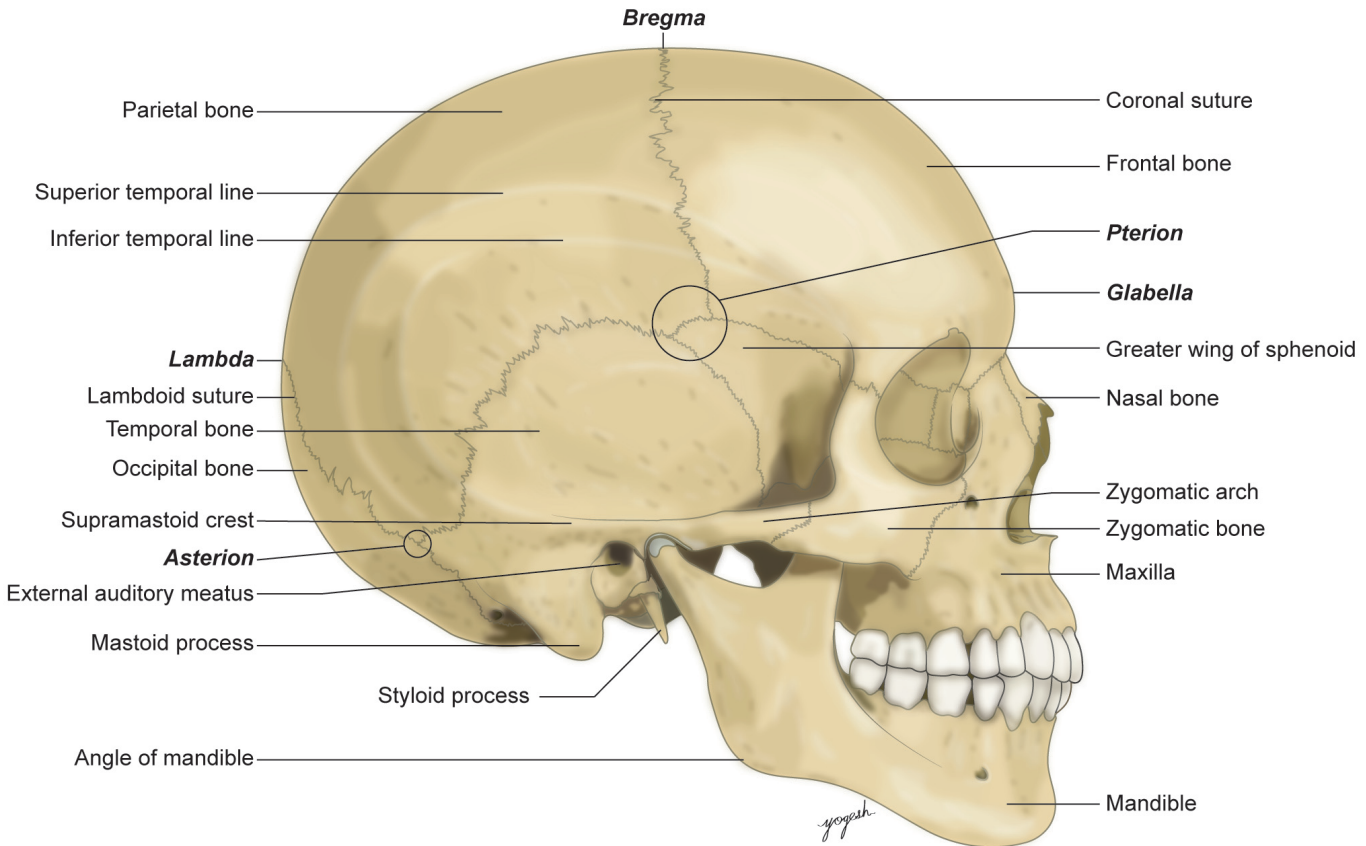


Fig. 1.12: Norma lateralis

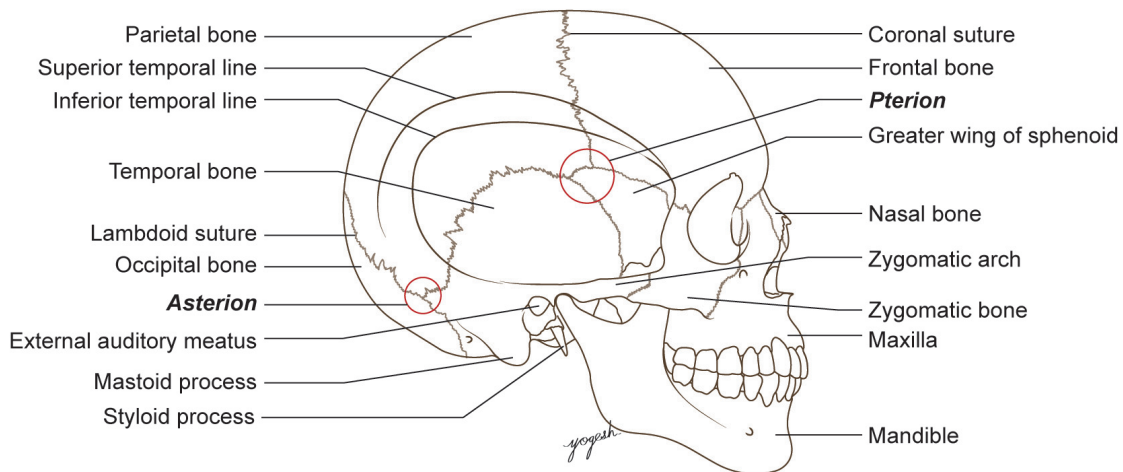
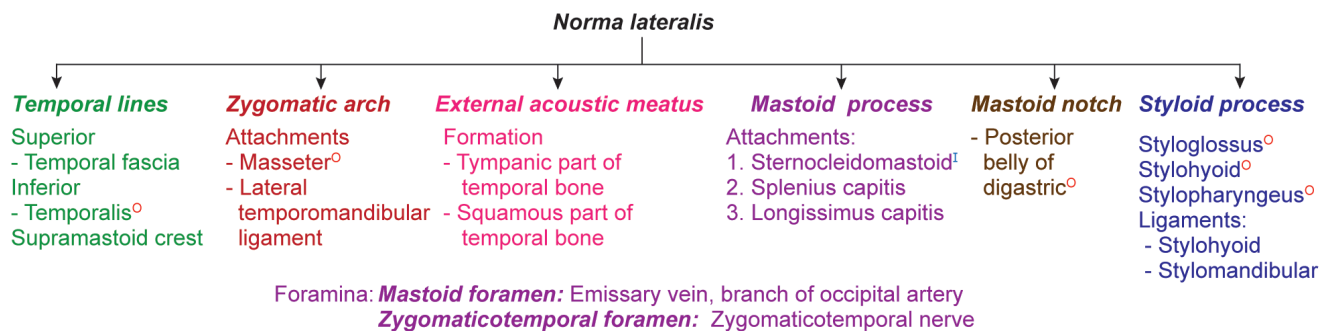


Fig. 1.13: Practice figure: Norma lateralis

Flowchart 1.4: Features of norma lateralis



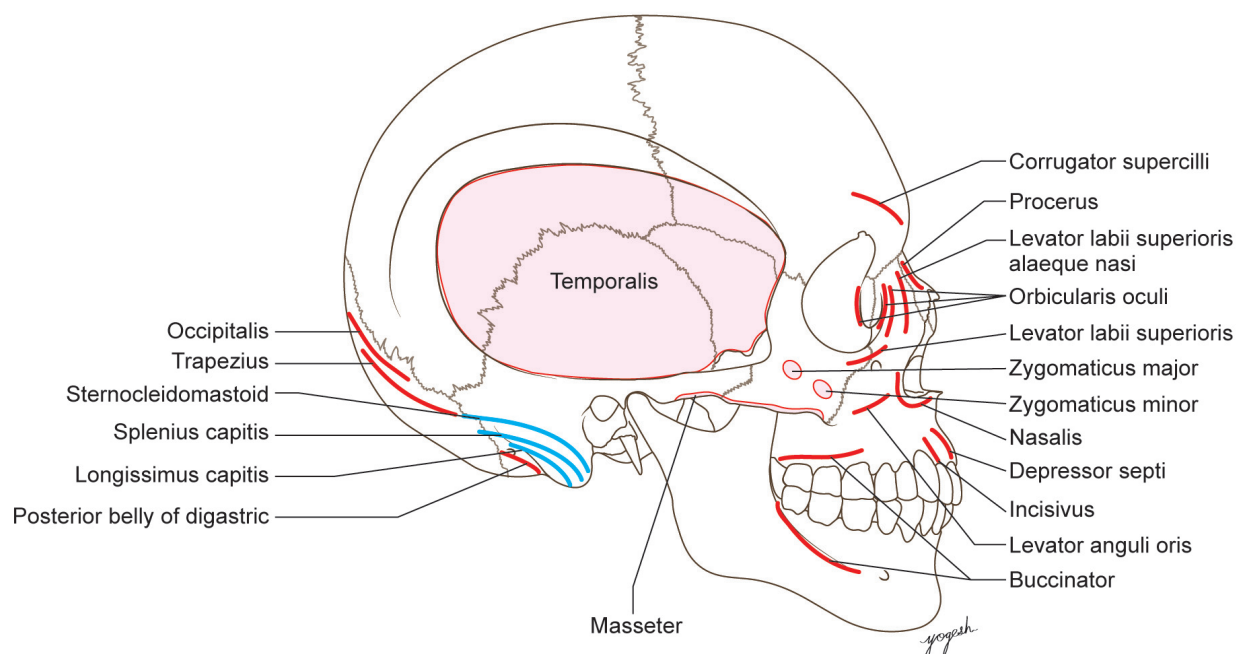


Fig. 1.14: Practice figure: Attachments of norma lateralis (attachments of styloid process and mandible are not shown)



Some Interesting Facts

- *Upper border of zygomatic arch* continues anteriorly with temporal line and posteriorly with the *supramastoid crest*.
- *Tubercle of root of zygoma*: It is a tubercle on the posterior end of zygomatic arch. It is also called *articular tubercle*.
- *Posterior end of zygomatic arch* is attached to the squamous part of temporal bone by anterior and posterior roots. *Anterior root* passes medially forming the anterior boundary of mandibular fossa. *Posterior root* forms lateral margin of mandibular fossa.
- *Postglenoid tubercle* is a small tubercle at the posterior end of posterior root.

5. *External acoustic meatus*: It is an opening just below the posterior root of zygomatic arch.

Formation

- *Tympanic part of the temporal bone* forms anterior and interior walls and lower part of posterior wall of external acoustic meatus.
- *Squamous part of the temporal bone* forms superior wall and upper part or posterior wall.



Box 1.1: Suprameatal triangle

Q. Write a short note on suprameatal triangle.

- It is also called *MacEwen's triangle* (Sir William MacEwen, Scottish surgeon, 1848–1924).
- It is a small depression posterosuperior to the external auditory meatus (Fig. 1.15, Flowchart 1.5).

- **Boundaries**
Superior: Supramastoid crest
Anterior: Posterosuperior margin of external acoustic meatus
Posterior: Vertical tangent to the posterior margin of the meatus.
- **Clinical aspects**
Mastoid antrum lies 1.25 cm deep to the suprameatal triangle.
This triangle is an important landmark in cortical mastoidectomy.

Flowchart 1.5: Suprameatal triangle

Suprameatal triangle (MacEwen's triangle)

Definition	Boundaries	Clinical integration
Small triangular depression Posterosuperior to external acoustic meatus	Superior: Supramastoid crest Anterior: External acoustic meatus Posterior: Vertical tangent to the posterior margin of external acoustic meatus	Mastoid antrum lies 1.25 cm deep Important in cortical mastoidectomy

6. *Mastoid part of temporal bone*: The mastoid part of the temporal bone occupies the posterior part of the temporal bone. The outer surface of mastoid part is convex.
Mastoid process is a conical projection from antero-inferior end of mastoid part of temporal bone.

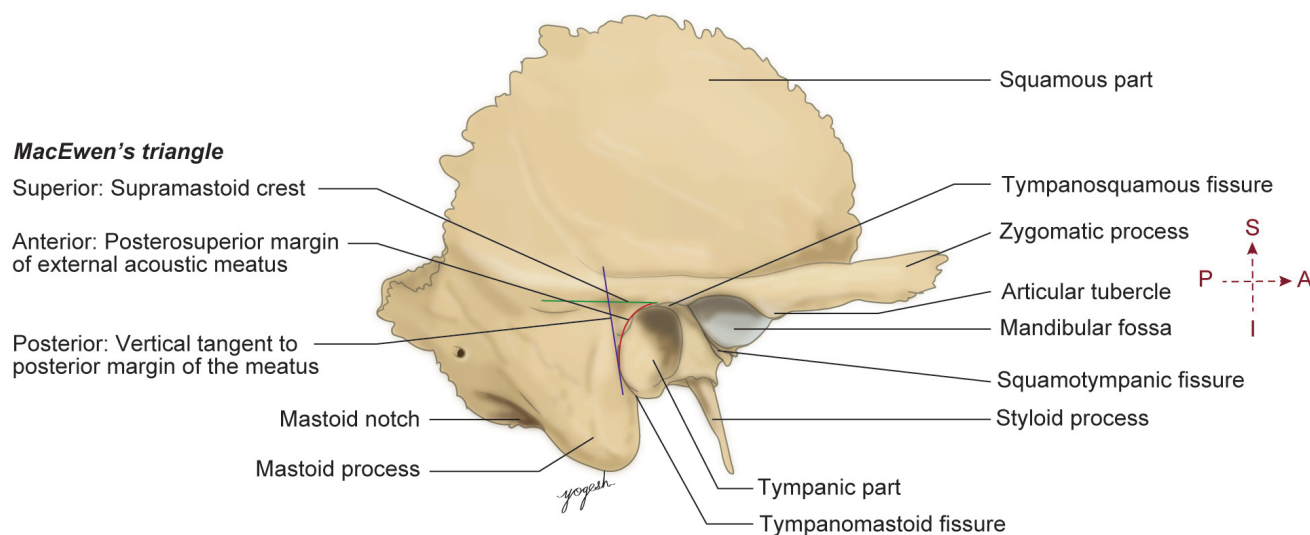


Fig. 1.15: Right temporal bone: External aspect

- **Attachments**

Sternocleidomastoid, *splenius capitis*, and *longissimus capitis* are inserted from before backward on the mastoid process.

7. *Parietomastoid suture*: Here, the mastoid part of temporal bone articulates with the parietal bone.
8. *Occipitomastoid suture*: Here, the mastoid part of temporal bone articulates with parietal bone.
9. *Asterion*: It is a meeting point of parietomastoid, occipitomastoid, and lambdoid sutures. ^{Viva} It is a site of posterolateral fontanelle which closes by 12th month of life.

10. *Mastoid notch*: It is a notch on the medial surface of the mastoid process.

Attachment: *Posterior belly of digastric* muscle originates from the mastoid notch.

Note: The groove behind the mastoid notch is due to occipital artery (a branch of external carotid artery).

11. *Tympanomastoid fissure* lies between tympanic part and mastoid process of the temporal bone.
12. *Mastoid foramen* lies below the groove for the occipital artery on the posterior border of mastoid process.

Structures passing through:

- Emissary vein connecting sigmoid sinus and posterior auricular vein. ^{Viva}
- Branch of occipital artery for dura mater.

13. *Styloid process*: It is a needle-like thin, long projection from the inferior aspect of the temporal bone (*stylus* = pen in Latin).

Location: It is located on norma basalis, antero-medial to mastoid process.

Direction: Downward, forward, and slightly medially.

It has base, body and apex (tip). Its base is partially ensheathed by tympanic plate.

Attachments

- Origin to styloid group of muscle: *Styloglossus*, *stylohyoid*, and *stylopharyngeus*.
- Two ligaments: *Stylohyoid* and *stylomandibular ligaments*.

14. *Zygomaticotemporal foramen* is located on the temporal surface of the zygomatic bone.

Structures passing through: Zygomaticotemporal nerve (branch of zygomatic branch of maxillary division of trigeminal nerve).



Some Interesting Facts

- Mastoid process is absent at birth. It appears by 2nd year of life. ^{Clinical fact}
- Stylohyoid ligament represents fibrous sheath of the 2nd pharyngeal arch cartilage. ^{MCQ}
- Stylomandibular ligament is thickening of deep cervical fascia. ^{Viva}
- Temporal fossa: Box 1.2.
- Infratemporal fossa: Refer Chapter 12.



Box 1.2: Temporal fossa

- Temporal fossa is a shallow depression on each side of the skull above the zygomatic arch.
- **Boundaries**
Superior: Superior temporal line
Inferior: Upper border zygomatic arch on lateral side
Inferomedially: It communicates with infratemporal fossa.
Anterior wall: Zygomatic bone, parts of frontal and sphenoid bones.
- **Floor:** Part of 4 bones: Frontal, temporal, parietal, and greater wing of sphenoid.



Box 1.3: Pterion

Q. Write a short note on pterion.

- It is a H-shaped suture present in the floor of temporal fossa. It is the meeting point of 4 bones: Frontal, temporal, parietal bones, and greater wing of sphenoid (Fig. 1.16, Flowchart 1.6).
- **Location:** 4 cm above the midpoint of the zygomatic arch and 2.5 cm behind the frontozygomatic suture
- **Deep relation:** Pterion lies over three structures:
 1. Middle meningeal vein.
 2. Anterior division of middle meningeal artery
 3. Stem of lateral sulcus of brain
- **Clinical integration:** Fracture of pterion may cause rupture of middle meningeal vein. It leads to formation of clot (extradural hematoma) that may compress the brain (Fig. 1.17). Emergency *trephination* or *craniotomy* is required to remove this clot. Hence, it is advised to use helmet while driving two-wheeler.

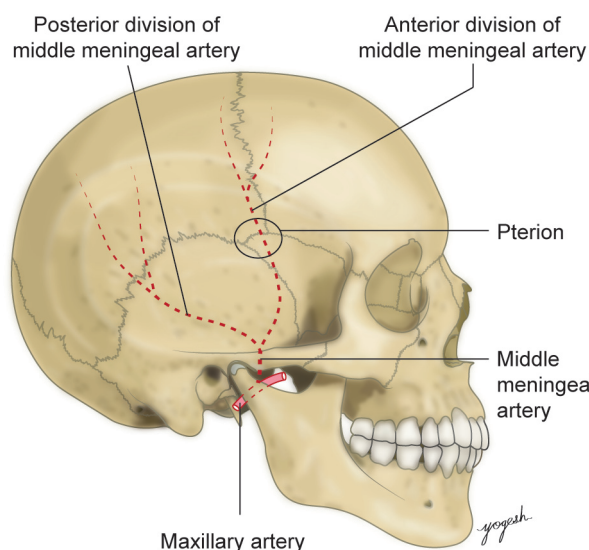


Fig. 1.16: Relationship of anterior division of middle meningeal artery to the pterion

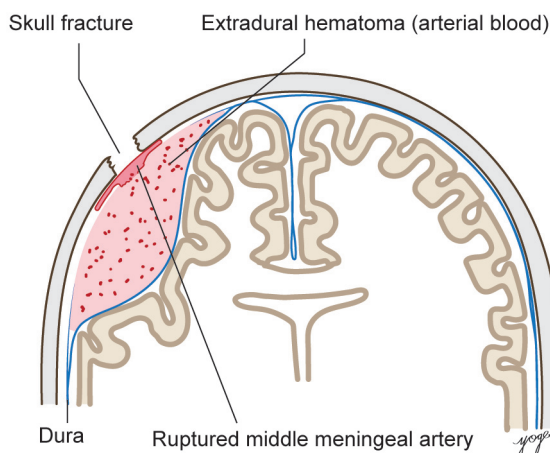
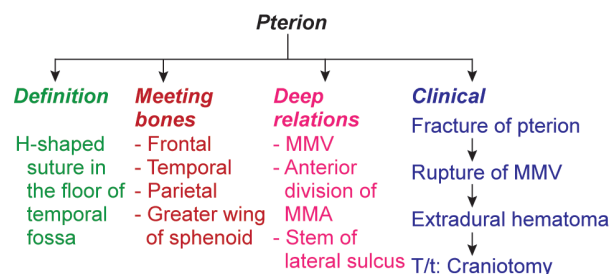


Fig. 1.17: Extradural hematoma (coronal section, anterior view)

Flowchart 1.6: Pterion (MAA: Middle meningeal artery, MMV: Middle meningeal vein, T/t: Treatment)



NORMA BASALIS

- The inferior view of the skull is *norma basalis*.
- For descriptive purpose, the norma basalis is divided into anterior, middle, and posterior parts by two imaginary transverse lines (Figs 1.18 to 1.20):
 1. **Anterior transverse line:** It passes along the posterior margin of the hard palate.
 2. **Posterior transverse line:** It passes along the anterior margin of the foramen magnum.

Anterior Part of Norma Basalis

- The anterior part of norma basalis consists of two parts (Figs 1.20, 1.21, Flowchart 1.7):
 1. Alveolar processes of maxillae
 2. Hard palate

Alveolar process

- The alveolar process forms a thick arched border with both side maxillae. It is called *alveolar arch* (Fig. 1.21). It shows *eight sockets* in which roots of eight teeth articulate.



Some Interesting Facts

- The sockets for incisors, canine, and second premolar are subdivided into two by a septum.
- The sockets for molar teeth are wide and divided into three smaller sockets by two small septa.

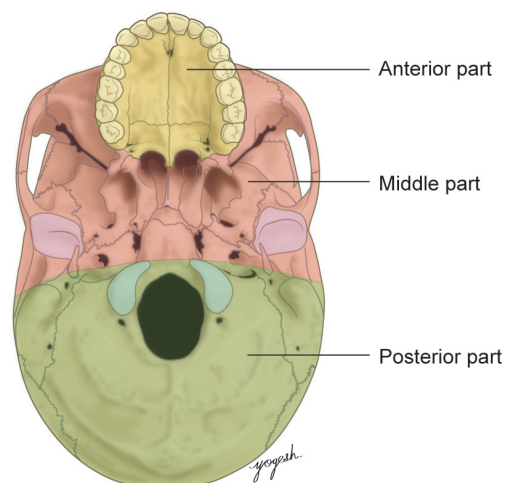


Fig. 1.18: Parts of norma basalis

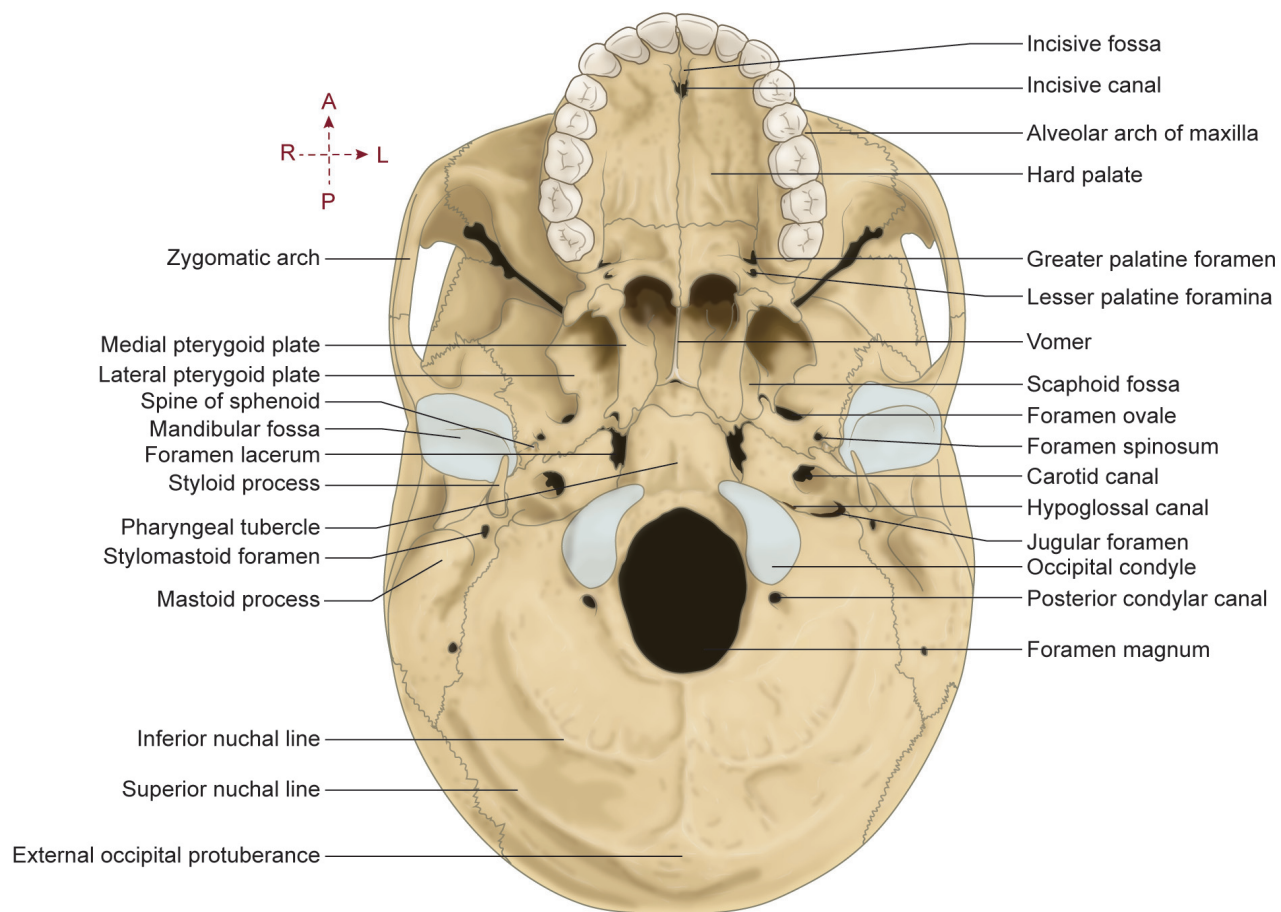


Fig. 1.19: Norma basalis

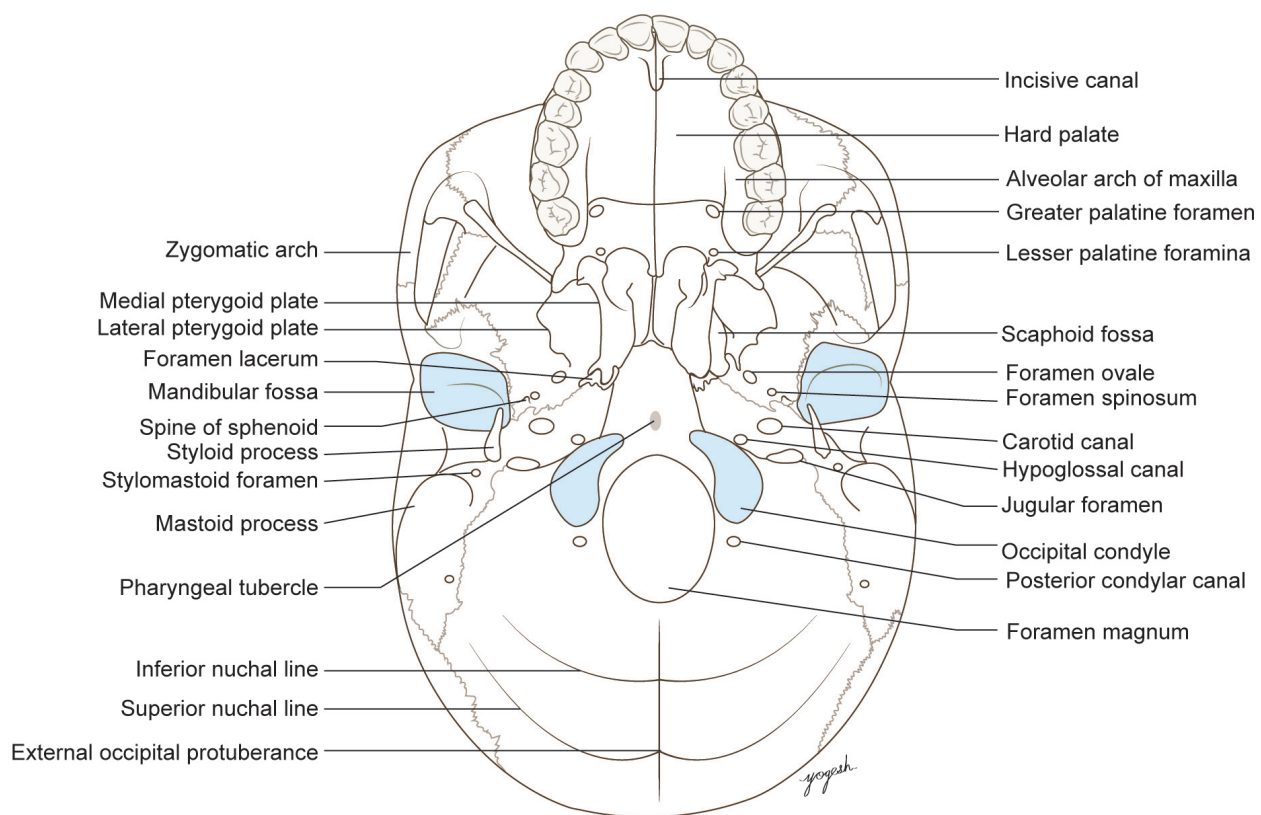
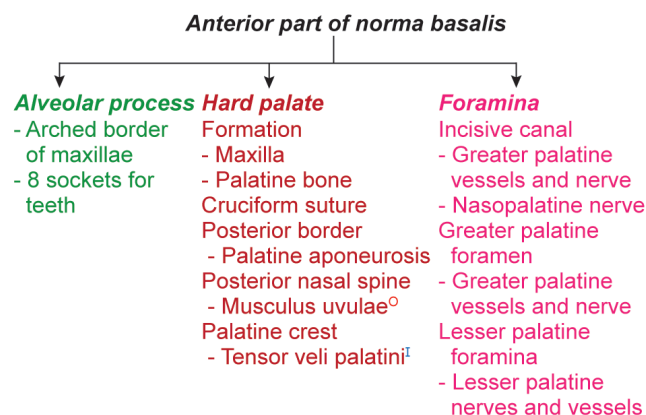


Fig. 1.20: Practice figure: Norma basalis

Flowchart 1.7: Features of anterior part of norma basalis**Hard palate**

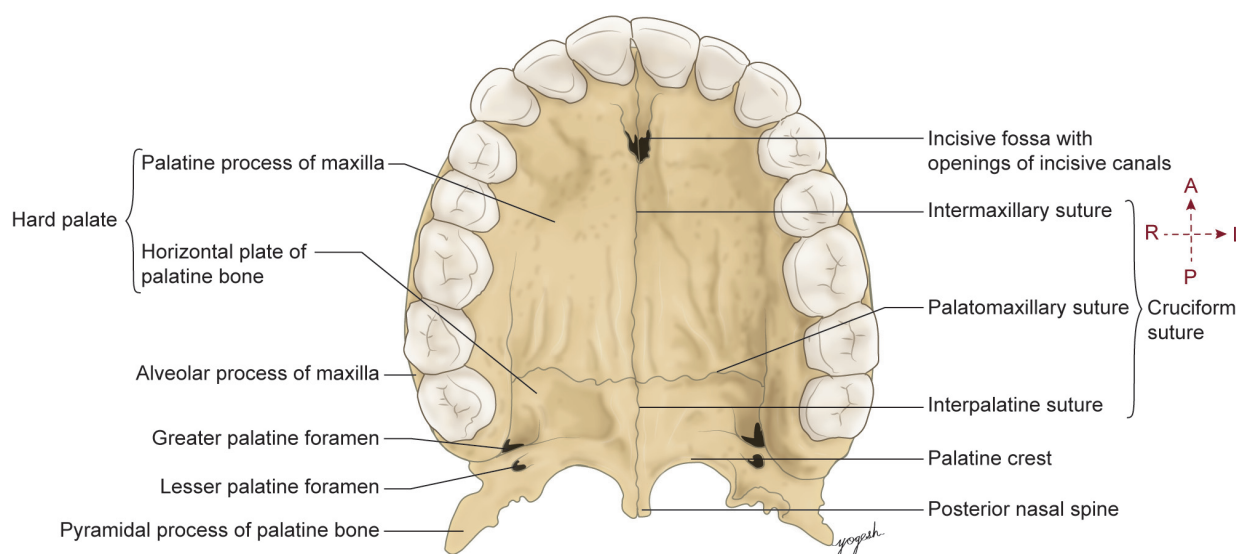
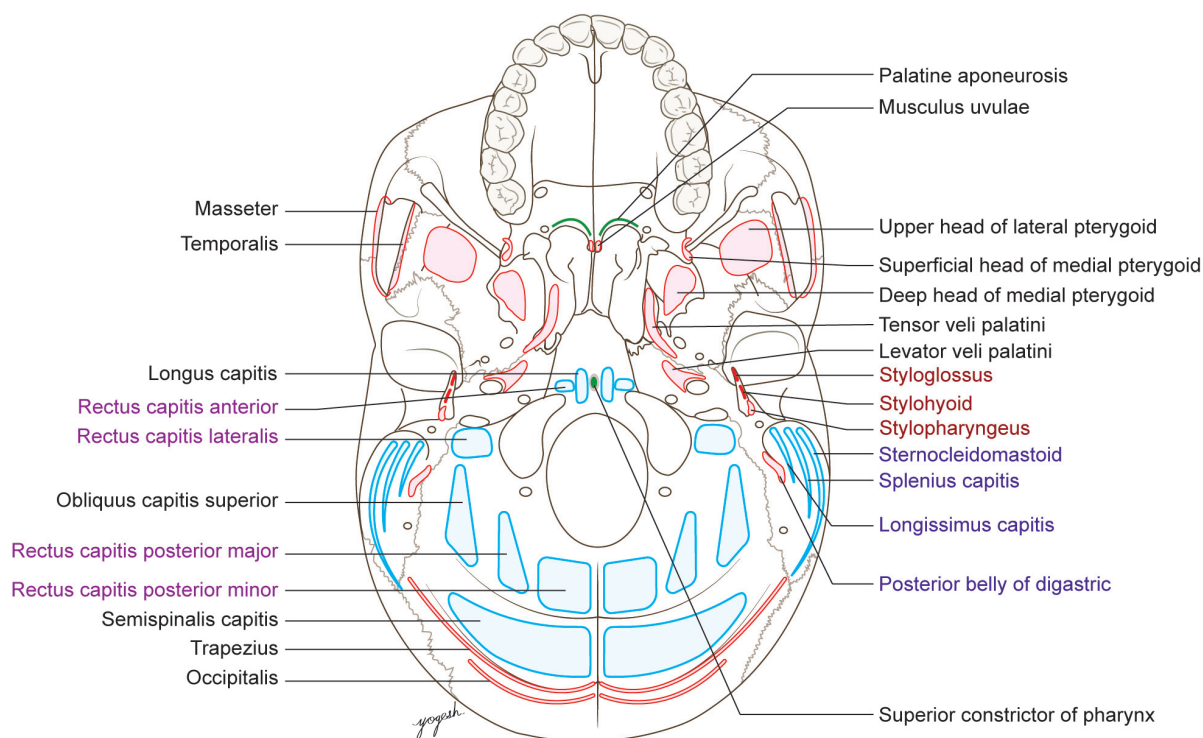
- The hard palate shows the following features (Figs 1.21 and 1.22):

Bony formation

- Anterior two-thirds by palatine processes of the maxillae
- Posterior one-third by horizontal plate of palatine bone.

- Sutures:** It shows *cruciform suture* that consists of intermaxillary, interpalatine, and palatomaxillary sutures.

- Shape:** It is arched in all directions. It is rough and shows pits for the lodgment of palatine glands.

**Fig. 1.21:** Anterior part of norma basalis**Fig. 1.22:** Practice figure: Attachments of norma basalis

- Posterior border of hard palate is free. It presents a midline projection called *posterior nasal spine*.
Attachments
 - *Palatine aponeurosis* is attached to the posterior border of the hard palate.
 - *Musculus uvulae* originates from the posterior nasal spine.
- *Palatine crest*: It is a curved ridge near the posterior border of hard palate.
Attachments: Insertion of *tensor veli palatini*.

Foramina

1. *Incisive foramen (fossa)*: Opposite the incisor teeth, there is a small depression which together with the follow of its opposite side forms the incisive fossa (Figs 1.19 to 1.21).
2. *Incisive canal*: At the bottom of the incisive fossa, there is an opening of incisive canal, one on each side.
Structures passing through: It transmits terminal parts of *greater palatine vessels* and *nerves* from the palate to the nose and terminal part of *nasopalatine nerve* from nose to the palate.
3. *Greater palatine foramen*: It lies one on each side, behind the lateral part of palatamaxillary suture.
Structures passing through: It gives passages to *greater palatine vessels* and *nerves*.
4. *Lesser palatine foramina*: They may be two or three in number on each side. They are situated behind the greater palatine foramen. They perforate the pyramidal process of the palatine bone.
Structures passing through: They transmit the *lesser palatine vessels* and *nerves*.

Middle Part of Norma Basalis

- The middle part of norma basalis extends from the posterior border of the hard palate to imaginary transverse line passing through the anterior border of the foramen magnum (Fig. 1.18).
- Middle part of the norma basalis is studied as median and lateral areas.

Median area of middle part of norma basalis

- It presents the following bony features (Figs 1.23, 1.24, Flowchart 1.8):
 1. Vomer (posterior border)
 2. Broad bar of bone.

Vomer

- The posterior border of vomer separates the *posterior nasal apertures*.
- Interior border of vomer articulates with the nasal crest formed by the two maxillae and two palatine bones.
- The superior border of vomer is broad and expanded. It splits into two projecting *alae* which articulate with the rostrum of sphenoid.

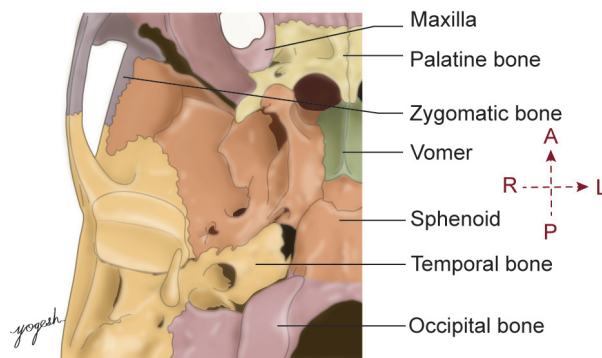
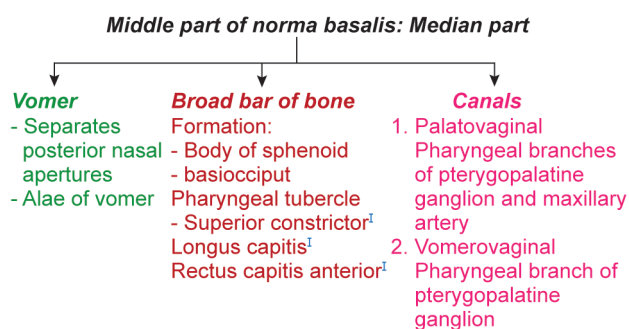


Fig. 1.23: Bones of middle part of norma basalis

Flowchart 1.8: Features of median area of middle part of norma basalis



Broad bar of bone

- It is formed by the fusion of (Fig. 1.24)
 1. Posterior part of the body of sphenoid
 2. Basilar part of occipital bone.
- *Pharyngeal tubercle*: It is a median tubercle on the broad bar of bone, just in front of foramen magnum.
Attachments^{Viva}
 1. Upper fibers of *superior constrictor* (median raphe) are inserted on the pharyngeal tubercle.
 2. Area or broader bar in front of pharyngeal tubercle forms the roof of the nasopharynx.
 3. *Longus capitis* is inserted lateral to the pharyngeal tubercle.
 4. *Rectus capitis anterior* is inserted lateral to pharyngeal tubercle anterior to foramen magnum on basiocciput.
- *Palatovaginal canal*: It lies between the sphenoid process of palatine bone and vaginal process of sphenoid bone (Fig. 1.25). Canal communicates posteriorly with the nasopharynx and anteriorly with the pterygopalatine fossa.
Structures passing through^{Viva}
 1. Pharyngeal branch of pterygopalatine ganglion
 2. Pharyngeal branch of maxillary artery.

Note: The pterygopalatine ganglion and 3rd part of maxillary artery lie in the pterygopalatine fossa.
- *Vomerovaginal canal*: It lies between ala of vomer and vaginal process of sphenoid bone (Fig. 1.25). It is also a communication channel between the pterygopalatine fossa and the nasopharynx.

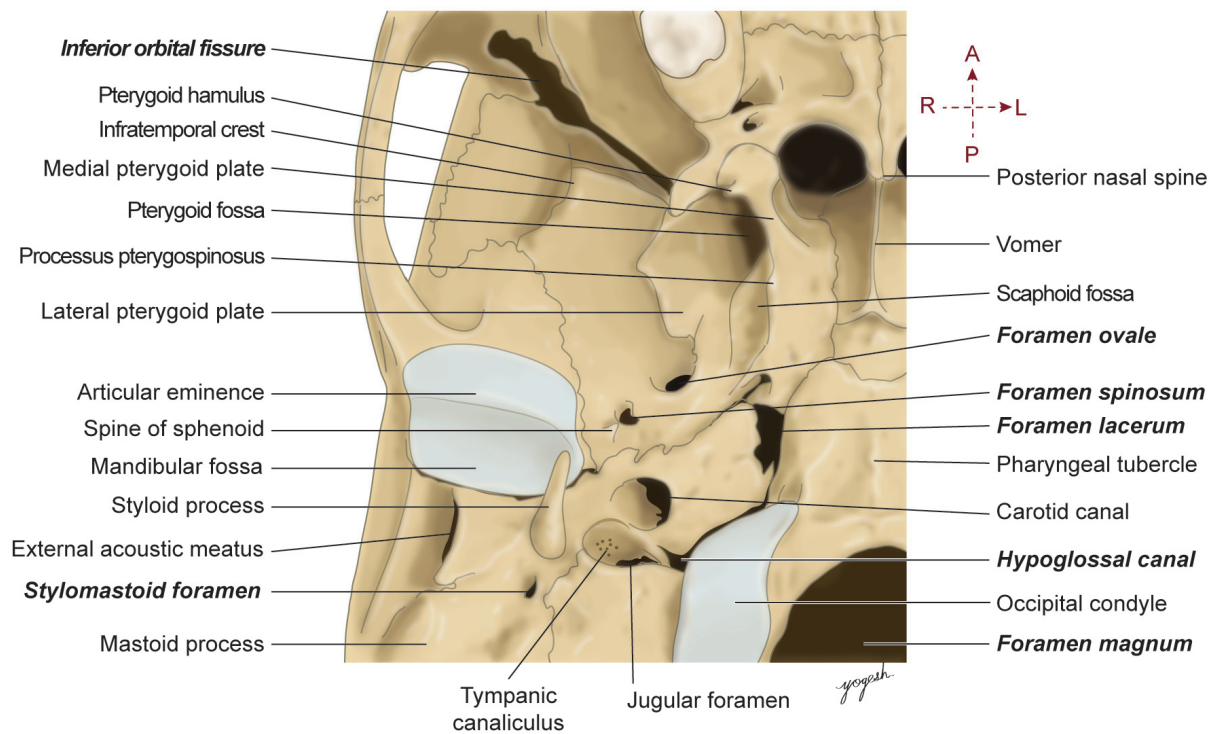


Fig. 1.24: Features of middle part of norma basalis

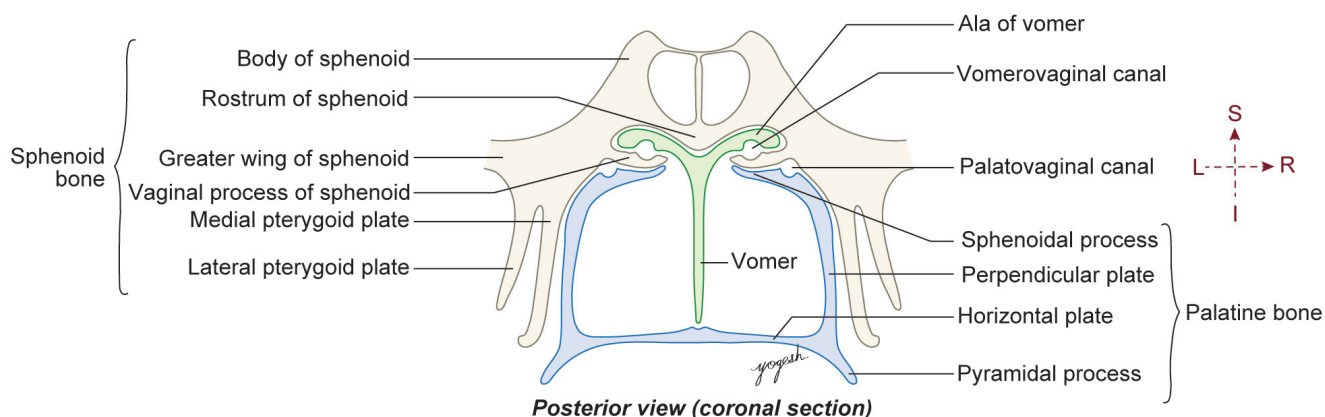


Fig. 1.25: Vomerovaginal and palatovaginal canals

Structures passing through: It transmits pharyngeal branch of pterygopalatine ganglion.

Lateral area of middle part of norma basalis

The lateral area of middle part of the norma basalis is formed by (Flowchart 1.9):

1. *Parts of sphenoid bone:* Pterygoid process, greater wing
2. *Parts of temporal bone:* Petrous temporal, tympanic plates, squamous temporal parts.
- This area presents the following features:
 1. *Pterygoid process:* Median and lateral pterygoid plates, scaphoid fossa, and pterygoid hamulus.
 2. *Infratemporal surface of greater wing of sphenoid:* Spine of sphenoid, foramen ovale, foramen spinosum, sulcus tubae
 3. *Petrous part of the temporal bone:* Carotid canal

4. Foramen lacerum
5. Tympanic parts of temporal bone
6. Squamous part of temporal bone.

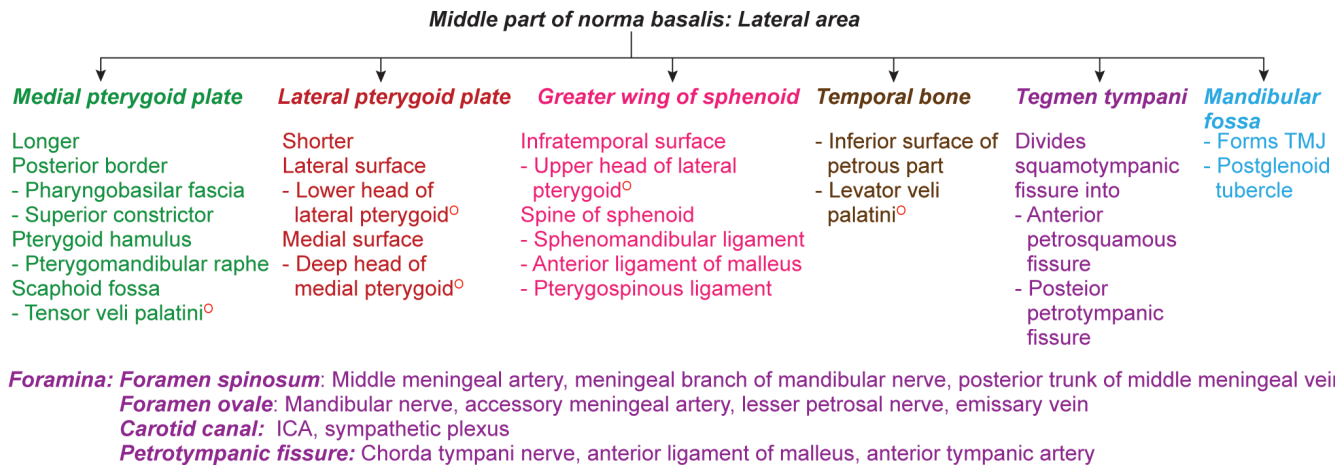
- *Pterygoid process:* It is a part of sphenoid bone. It descends downward from the junction of the body and greater wing. It consists of two plates of bones: Medial and lateral which are fused anteriorly and separated posteriorly by V-shaped *pterygoid fossa*.

- *Medial pterygoid plate:* It is longer than the lateral pterygoid plates. It has posterior border, medial and lateral surface, and pterygoid hamulus.

Pterygoid hamulus: The lower end of the posterior border curves laterally to form hook-shaped process called pterygoid hamulus.

Upper ends of posterior border divide to enclose *scaphoid fossa*.

Flowchart 1.9: Features of lateral area of middle part of norma basalis



Processus tuberos (civini process or processus pterygospinosus) is a spine-like triangular projection in the middle of the posterior border of the medial pterygoid plate.

Attachments of medial pterygoid plate (Fig. 1.22)^{Spotters}

1. **Pharyngobasilar fascia** is attached to the posterior border.
 2. **Superior constrictor** of pharynx originates from lower part of the posterior border and pterygoid hamulus.
 3. **Pterygomandibular raphe** extends between tip of pterygoid hamulus and mandible (behind the third molar tooth).
 4. **Tensor veli palatini** originates from the scaphoid fossa.
- **Lateral pterygoid plate:** It is shorter than the medial pterygoid plate. Its posterior border is sharp and free. Its lateral surface forms a part of infratemporal fossa. Its medial surface forms the lateral wall of the pterygoid fossa.

Attachment of lateral pterygoid plate (Fig. 1.22)^{Spotters}

1. The lower head of **lateral pterygoid** muscle originates from lateral surface of lateral pterygoid plate.
 2. Its medial surface gives origin to deep head **medial pterygoid** muscle.
- **Infratemporal surface of greater wing of sphenoid:** It is pentagonal in shape. It has the following margins (Fig. 1.23):
 1. Anterior margin forms the posterior border of *inferior orbital fissure*.
 2. Anterolateral margin forms *infratemporal crest*.
 3. Posterolateral margin articulates with squamous part of temporal bone.
 4. Posteromedial margin articulates with petrous part of temporal bone.
 5. Anteromedially, it is continuous with the pterygoid process and the body of sphenoid bone.

Attachments: Upper head of **lateral pterygoid muscle** originates from the infratemporal surface of the greater wing of sphenoid.

- **Spine of sphenoid:** It is a small, sharp bony projection posterolateral to the foramen spinosum.^{Spotters}

Q. Write a short note on spine of the sphenoid.

Attachments: It gives attachments to

1. Sphenomandibular ligament
 2. Anterior ligament of malleus
 3. Pterygospinous ligament^{MCQ}
 4. Few fibers of *tensor veli palatini* and *tensor tympani*
- Relations:* Spine of sphenoid is related laterally to the auriculotemporal nerve and medially to the chorda tympani nerve and auditory tube.^{MCQ}

- Four foramina (along the posteromedial margin)
 1. **Foramen spinosum:** It is a small, circular foramen. It is located between the foramen ovale and spine of sphenoid.^{Spotters}

Q. List the structures passing through foramen spinosum.

Structures passing through:

- i. Middle meningeal artery
 - ii. Meningeal branch of mandibular nerve or nervous spinosus
 - iii. Posterior trunk of middle meningeal vein
2. **Foramen ovale:** It is a large, oval-shaped foramen. It lies posterolateral to the upper end of the posterior border of lateral pterygoid plate.^{Spotters}

Q. List the structures passing through foramen ovale.

Structures passing through:^{Viva, MCQ}

(mnemonics = **MALE**)

- i. **Mandibular nerve**
 - ii. **Accessory meningeal artery**
 - iii. **Lesser petrosal nerve**
 - iv. **Emissary vein** (connecting the cavernous sinus with pterygoid plexus of vein)
3. **Emissary sphenoid foramen or foramen of Vesalius:** It is sometimes present between the foramen ovale and the scaphoid fossa.

Structures passing through: It transmits an emissary vein connecting the cavernous sinus with pterygoid plexus of veins.^{MCQ}

4. *Canaliculus innominatus*: It is a very small foramen situated between foramen ovale and foramen spinosum.

Structures passing through: If it is present, it transmits lesser petrosal nerve (usually, this nerve passes through foramen ovale).^{MCQ}

- *Sulcus tubae* (groove for auditory tube): It is a groove between posteromedial margin of the greater wing sphenoid and petrous temporal bone.

Relation: It lodges the cartilaginous part of auditory tube. Laterally, it continues as bony part of auditory tube that opens into the middle ear.

- *Inferior surface of petrous part of temporal bone*: It is triangular. Its apex is directed forward and medially. *Attachments*: *Levator veli palatini* originates from the inferior surfaces of petrous temporal bone.

- *Carotid canal*: It perforates the apex of the petrous part of temporal bone.

Structures passing through: It transmits the *internal carotid artery* and *sympathetic plexus* around the artery.^{Viva, Spotters}

- *Tegmen tympani* is a curved plate of bone in the middle cranial fossa (part of temporal bone). The lower border of this plate extends from carotid canal to styloid process and can be seen in the squamotympanic fissure. This plate divides the squamotympanic fissure into anterior petrosquamous and posterior petrotympanic fissures.

Structures passing through: The medial end of petrotympanic fissure transmits

- Chorda tympani nerve
- Anterior ligament of malleus
- Anterior tympanic artery

Box 1.4: Mandibular fossa

- The mandibular fossa of the temporal bone is formed partly by squamous part and partly by tympanic part as follows (Fig. 1.24):

Articular part is formed by squamous part of temporal bone.

Nonarticular part is formed by tympanic part of temporal bone.

- *Postglenoid tubercle* is a small tubercle that separates the articular and nonarticular parts laterally.

- *Squamotympanic fissure* separates the articular and nonarticular parts, medially.
- The mandibular fossa is deeply concave. It is anteriorly bounded by convex *articular tubercle* or eminence.

- *Articulation*: Mandibular fossa articulates with the head of mandible to form the temporomandibular joint.

- *Attachments*

The margin of the mandibular fossa gives attachment to the *capsule of temporomandibular joint*.

Upper end of *lateral temporomandibular ligament* is attached to the articular tubercle on the root of zygoma.

Box 1.5: Foramen lacerum

- It is a short, wide canal (1 cm long) (Fig. 1.26, Flowchart 1.10).

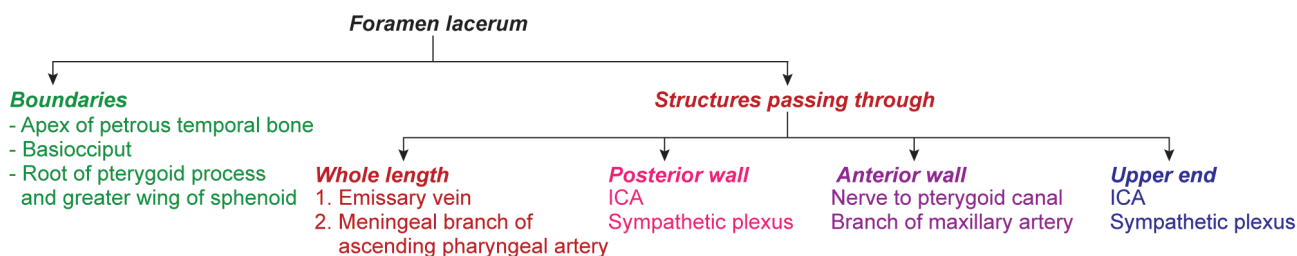
- *Boundaries*: Foramen lacerum is bounded

1. Posterolaterally: Apex of the petrous temporal bone
2. Medially: Basiocciput and body of sphenoid
3. Anteriorly: Root of pterygoid process and greater wing of sphenoid.

- *Structures passing through*:

1. Foramen lacerum is closed by a cartilage and no significant structure passes through the whole length of canal except *meningeal branch of ascending pharyngeal artery and emissary vein*.
2. Structures entering through posterior wall: Carotid canal brings *internal carotid artery* and *sympathetic plexus* around it. ICA traverses the upper part of foramen lacerum and enters the cranial cavity.
3. Structures through anterior wall: Pterygoid canal connects foramen lacerum with pterygopalatine fossa. *Nerve to pterygoid canal (vidian nerve)* leaves the foramen lacerum through its anterior wall. It receives artery pterygoid canal (branch of maxillary artery) through same canal.
4. Structures through upper end: *Internal carotid artery* leaves and the *greater petrosal nerve* enters through the upper end of foramen lacerum.

Flowchart 1.10: Foramen lacerum (ICA: Internal carotid artery)



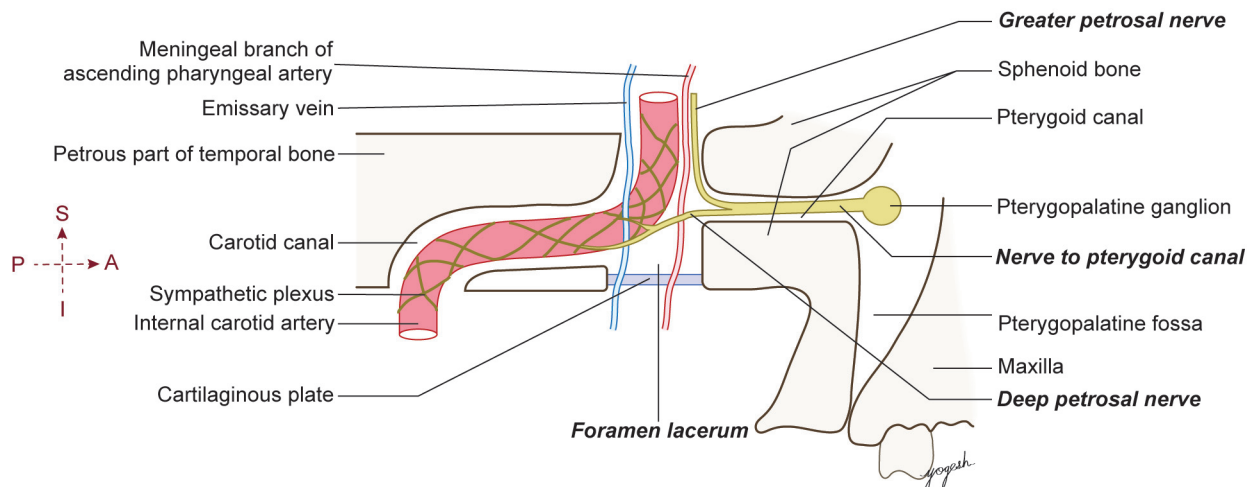


Fig. 1.26: Practice figure: Structures passing through the foramen lacerum (right lateral view)

Posterior Part of Norma Basalis

The posterior part of the norma basalis lies behind the imaginary transverse line passes through the anterior border of the foramen magnum (Figs 1.19, 1.20, and 1.22, Flowchart 1.11).

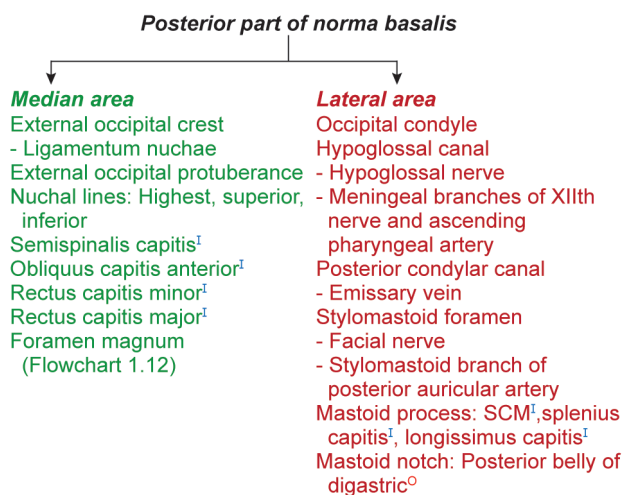
The posterior part of norma basalis is studied as median and lateral areas.

Median area of posterior part of norma basalis

It presents 4 features (before backward):

1. Foramen magnum
 2. External occipital protuberance
 3. External occipital crest
 4. Nuchal lines
- *External occipital crest*: It extends from posterior margin of foramen magnum to the external occipital protuberance.
- Attachments*: *Ligamentum nuchae* is attached to the external occipital crest and external occipital protuberance.
- *External occipital protuberance*: It is a bony projection at the posterior end of the external occipital crest. It

Flowchart 1.11: Features of posterior part of norma basalis



can be felt in the midline at the junction of scalp and neck.

- *Nuchal lines*: These are superior, inferior, and the highest. *Superior* and the *highest nuchal lines* curve outward from the external occipital protuberance. *Inferior nuchal lines* extend outward from middle of the external occipital crest.
- Attachments*: The squamous part of occipital bone gives attachments to the following muscles:
- Semispinalis capitis* inserts medially and *obliquus capitis superior* laterally on the area between superior and inferior nuchal lines.
- Rectus capitis minor* inserts medially and *rectus capitis major* inserts laterally on the area below the inferior nuchal line.

Box 1.6: Foramen magnum

- It is an oval aperture in the occipital bone. It is on each side by the condylar part of the occipital bone. It is wider behind than in front.
- *Alar ligament*, which is attached to the medial part of the occipital condyles, divides the foramen magnum into a smaller anterior and a larger posterior compartment (Fig. 1.27, Flowchart 1.12).
- *Anterior compartment* transmits
 1. Odontoid process of axis
 2. Apical ligament
 3. Upper band of cruciate ligament of the atlas
 4. Membrana tectoria
- *Posterior compartment* transmits
 1. Lower end of medulla oblongata
 2. Meninges
 3. Structures passing through subarachnoid space
 - Spinal part of accessory (XI) cranial nerve
 - Two vertebral arteries

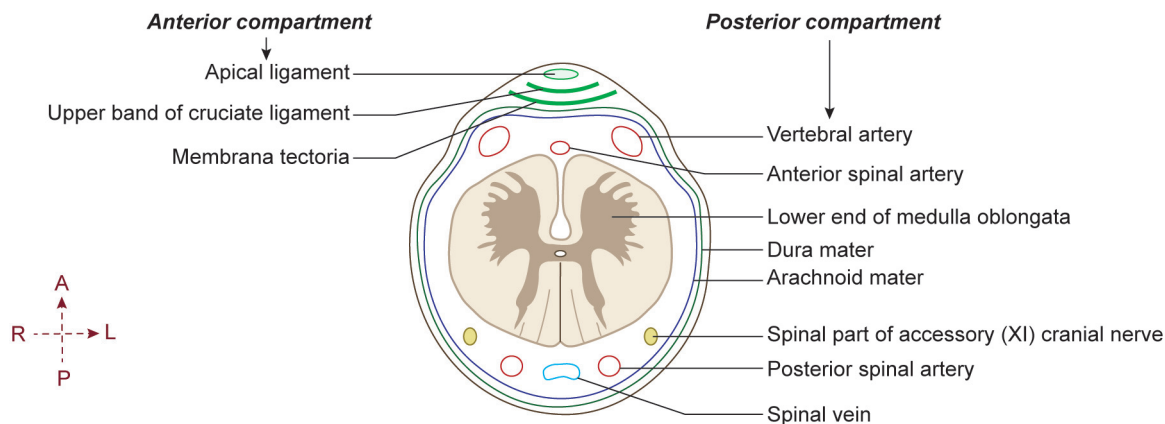
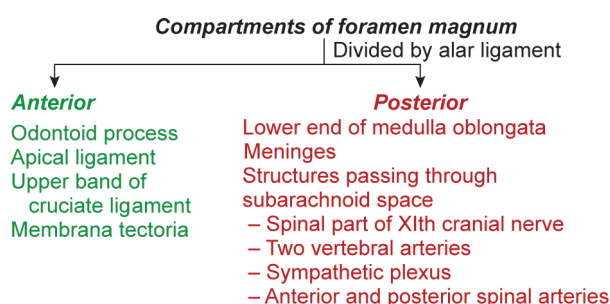


Fig. 1.27: Practice figure: Structures passing through the foramen magnum (inferior view)

- Sympathetic plexus around the vertebral artery
- Anterior and posterior spinal arteries
- **Attachments**
 - *Anterior margin* – anterior atlanto-occipital membrane
 - *Posterior margin* – posterior atlanto-occipital membrane

Flowchart 1.12: Foramen magnum



Lateral area of posterior part of norma basalis

The lateral area of posterior part of norma basalis shows the following bony projections:

- Condylar part of occipital bone
- Squamous part of occipital bone
- Styloid process of temporal bone
- Mastoid process of temporal bone.
- **Condylar part of occipital bone:** It is situated on either side of the foramen magnum. It connects the basilar part with squamous part of the occipital bone.
- **Occipital condyle:** It is convex, kidney-shaped articular process which articulates with concave surface of atlas. The long axis of occipital condyle is directed forward and medially.
- **Hypoglossal canal:** It is an opening just above the anterior end of occipital condyle.

Structures passing through: It transmits

- Hypoglossal nerve ^{Viva}
- Meninges branches of hypoglossal nerve and ascending pharyngeal artery

- Emissary vein (connecting basilar venous plexus with pterygoid venous plexus).
- **Condylar fossa:** It is a depression behind the posterior end of each occipital condyle.
- **Posterior condylar canal:** Occasionally, it is present in the condylar fossa and transmits emissary vein.
- **Jugular process of occipital bone:** It lies lateral to the occipital condyle and forms posterior boundary of jugular foramen.
- **Attachments:**
 - *Alar ligament* is attached to the medial rough area of the occipital condyle.
 - Capsular ligament of the atlanto-occipital joint is attached to the margins of occipital condyle.
- **Squamous part of occipital bone:** It is marked by superior and inferior nuchal lines.
- **Stylomastoid foramen:** It is situated between styloid process and mastoid notch.
Structures passing through: It transmits the facial nerve and the stylomastoid branch of the posterior auricular artery. ^{Viva, MCQ}
- **Mastoid process** is a conical projection from antero-inferior end of mastoid part of temporal bone.
 - **Attachments**
Sternocleidomastoid, *splenius capitis*, and *longissimus capitis* are inserted from before backward on the mastoid process.
- **Mastoid notch:** It lies on the medial side of the mastoid process.
Attachment: Posterior belly of *digastric* muscle originates from mastoid notch.
- **Mastoid canaliculus** (Arnold's canal) lies in the lateral wall of the jugular fossa. It transmits the auricular branch of vagus nerve or Arnold's nerve.



Box 1.7: Jugular foramen

- It is a large, elongated opening between the petrous part of temporal bone anteriorly and condylar part of occipital bone posteriorly (Fig. 1.28, Flowchart 1.13). It is located at the posterior end of petro-occipital suture.

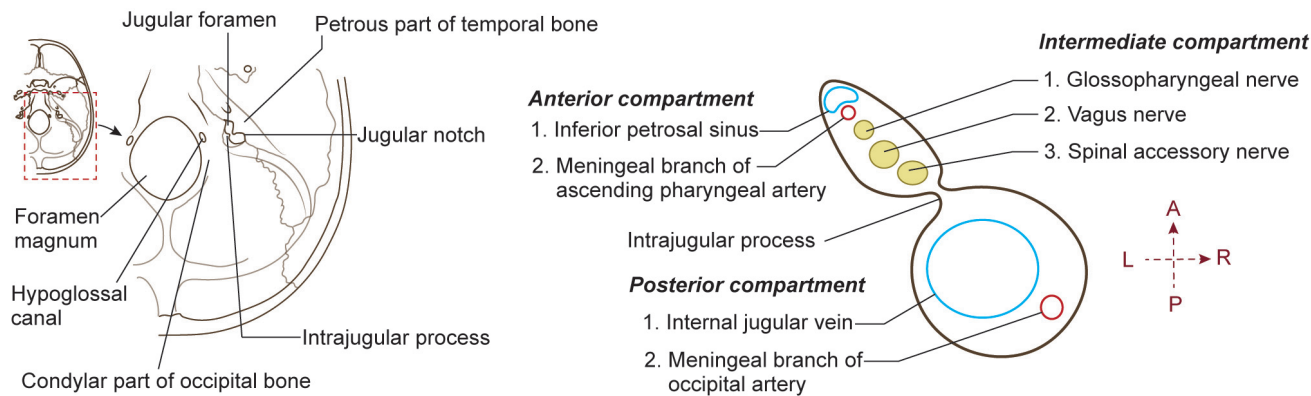


Fig. 1.28: Practice figure: Jugular foramen (right, superior view)

Flowchart 1.13: Jugular foramen

Compartments of jugular foramen

Anterior	Intermediate	Posterior
Inferior petrosal sinus Meningeal branch of ascending artery	IXth nerve Xth nerve XIth nerve	Internal jugular vein Meningeal branch of occipital artery

- **Jugular fossa:** The petrous part of temporal bone has a shallow depression called jugular fossa. The jugular fossa lodges the superior bulb of *internal jugular vein*.
- **Jugular process:** From the junction of condylar part and the squamous part, a short process projects lateralward called jugular process.
Attachment: Inferior surface of jugular process gives attachment to *rectus capitis lateralis*.
- **Jugular notch:** It is a concavity on the anterior surface of the jugular process of occipital bone. It forms the posterior boundary of the jugular foramen.
- **Structures passing through:** The jugular foramen is divided into anterior, posterior, and intermediate compartments by two bony spicules called intrajugular processes.
 - **Anterior compartment**
It transmits
 1. Inferior petrosal sinus
 2. Meningeal branch of ascending pharyngeal artery
 - **Posterior compartment**
It transmits
 1. Internal jugular vein
 2. Meningeal branch of occipital artery
 - **Intermediate compartment**
It transmits
 1. Glossopharyngeal nerve
 2. Vagus nerve
 3. Spinal accessory nerve
- **Tympanic canaliculus:** It opens on the thin edge of the bone between the jugular fossa and lower end of carotid canal.

Structures passing through: It transmits the tympanic branch of the glossopharyngeal nerve to the middle ear cavity.

FETAL SKULL AND GROWTH OF SKULL

- At birth, the skull is relatively larger in proportion to other parts of the skeleton (Fig. 1.29). The cranial part is much larger than the facial skeleton. The facial skeleton forms about 1/8th of cranial part of the skull, whereas in the adults, it is about half of the cranium.
- In newborn
 1. Mandible and maxillae are rudimentary with absence of the teeth.
 2. Maxillary air sinuses are smaller.
 3. Nasal cavities are smaller.
 4. Base of skull is smaller and narrower.
 5. Internal ear is almost as large as that in adult. ^{MCQ}
 6. Maxillary air sinus is absent; therefore, the maxilla is short, and floor of orbit and palate are close to each other.
 7. Edges of parietal and frontal bones are not serrated.
 8. **Fontanelles:** These are membranous gaps between corners of parietal bones and their adjacent bones. It allows molding during passage of fetal skull through small birth canal (for details, see Box 1.8). ^{Viva}
 9. Mastoid process of the temporal bone is not developed. Hence, the stylomastoid foramen and the facial nerve are subcutaneous and is in danger of being cut by an incision behind the ear.
 10. Internal ear, tympanic cavity, ear ossicles, and mastoid antrum are almost equal to the adult size. ^{Viva}
 11. Tympanic plate is not fully developed. It is an incomplete ring of bone.
 12. Bony part of external acoustic meatus is mostly represented by fibrocartilaginous plate. External acoustic meatus is short and straight.
 13. **Structure:** The bones of the skull vault are unilaminar, and diploe is absent.

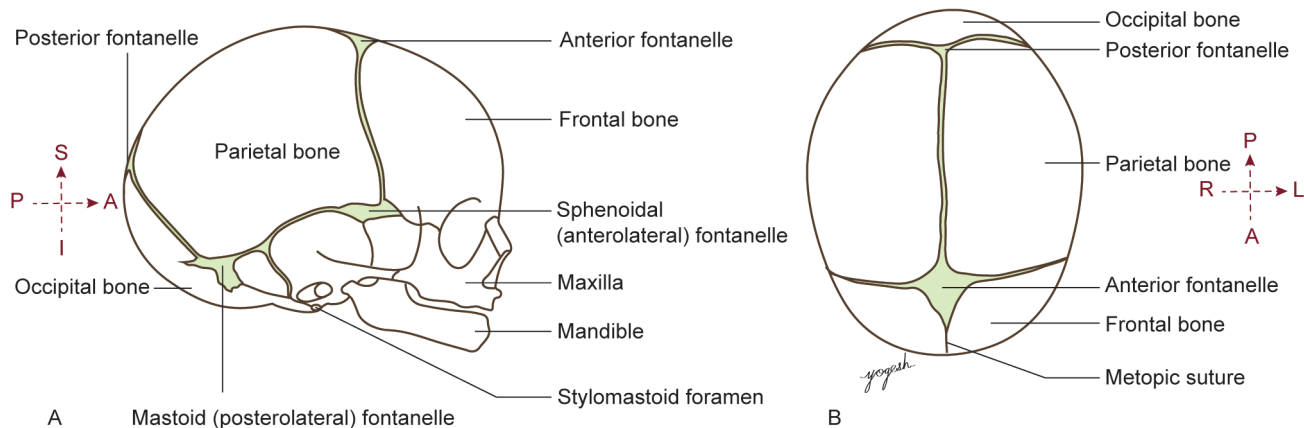


Fig. 1.29: Fetal skull. A: Lateral aspect. B: Superior aspect

Growth of the Skull

Growth of neurocranium

- It is rapid in first two years and by seven years it reaches almost of adult size.
- By the first year of life, the sutures begin to appear.
- **Structure**
 - At birth, the bones of skull vault are unilaminar. By the fourth year, two tables are present, and diploe begins to appear.
 - Fully grown diploe and two tables by thirty-fifth year.
- **Growth of the base of skull:** It takes place at the expense of the cartilaginous joints by the process of ossification. The maximum growth occurs at the occipitospheoid joint and sphenothmoid joint.
- By 25th year, the occipitospheoid synchondrosis (primary cartilaginous joint) closes by synostosis (= fusion of cranial bones).

Growth of facial skeleton

- It is rapid after 1st year. It mostly related to the eruption of temporary and permanent teeth.
- Eruption of teeth and development of maxillary sinuses are the major noticeable change during the growth of the facial skeleton.
- In old age, due to loss of teeth and absorption of alveolar processes of maxillae and mandible, the face becomes shorter.
- **Eruption of teeth:** It is listed in Table 1.1.

Suture Union of the Skull

- With advancing age, obliteration of the sutures occurs. At first, the union takes place on the internal surface, followed by union at the external surface. ^{Viva}
- Obliteration of suture and age
 1. Sagittal suture: 35 years
 2. Coronal suture: 38–41 years

Table 1.1: Time of eruption of teeth (Source: Textbook of Human Embryology, 2nd edn., Yogesh Sontakke)

Q. Enlist the timings of eruption of temporary and permanent teeth.

Teeth	Time of eruption
Deciduous	
Lower central incisors	6–9 months
Upper incisors	8–10 months
Lower lateral incisors	12–20 months
First molar	12–20 months
Canines	16–20 months
Second molars	20–39 months
Permanent	
Central incisor	7–8 years
Lateral incisor	8–9 years
Canine	10–12 years
First premolar	10–11 years
Second premolar	11–12 years
First molar	6–7 years
Second molar	12 years
Third molar	18–25 years

3. Vomer-ethmoid suture: 45 years
 4. Lambdoid suture: Before 50 years
 5. Sphenoparietal and sphenofrontal suture: 65 years
 6. Temporaspheoid suture: 70 years
- Craniosynostosis is premature closure of the sutures.
 - Obliteration of suture depends on:
 1. Genetic constitution of an individual
 2. Nutrition and metabolic disorders
 3. Biomechanical forces
 - Study of obliteration of sutures is useful for age determination particularly after the age of 25 years. ^{Practical guide}



Box 1.8: Fontanelles

- Fontanelles are soft membranous gaps present in the skull vault of newborn.
- There are 6 fontanelles at birth as follows (Fig. 1.29):
 - Anterior fontanelle between frontal and parietal bones. Anterior fontanelle is the largest fontanelle. It lies at the *bregma*.
 - Posterior fontanelle between occipital and parietal bones. It lies at the *lambda*.
 - Anterolateral (sphenoid) fontanelle between greater wing of sphenoid, squamous temporal, frontal, and parietal bones. It lies at the *pterion*.
 - Posterolateral (mastoid) fontanelle between parietal, occipital, squamous temporal, and occipital bones. It lies at the *asterion*.
- Closure of fontanelle
 - All fontanelles close within 3–4 months after birth.
 - Anterior fontanelle closes by 2–3 years of age.
- Function of fontanelles
 - Allow moulding of skull during the birth passage of body.
 - Permit growth of skull bones to increase the cranial capacity.
 - Accommodate developing brain.
- Clinical aspects
 1. Closure of fontanelles gives an idea about the age of the newborn.
 2. The anterior fontanelle is largest and of great clinical significance. Appearance of anterior fontanelle gives an idea of intracranial pressure.
- Bulging fontanelles indicate increased intracranial pressure.
- Depressed fontanelles indicate dehydration cases.

SEXUAL DIFFERENCES OF THE SKULL

- The sex-related differences of the skull are listed in Table 1.2.

Table 1.2: Sex-related differences of the skull^{Viva}

Feature	Male	Female
Bones	Thicker and heavier	Thinner and lighter
Cranial capacity	Larger	Smaller
Mid sagittal arc	Less arched skull vault	Highly arched skull vault
Bony points: Mastoid process, frontal and parietal eminences, muscular ridges, glabella, superciliary arches, superior nuchal lines, external occipital protuberance	More marked (prominent)	Less marked (less prominent)
Tympanic plate	Larger	Smaller
Supraorbital margin	Round	Sharp
Forehead	Sloping	Vertical
Air sinuses, dental arch, size of teeth, maxillae	Larger	Smaller

CRANIOMETRY

- *Craniometry* is the process of recording various measurements of the skull.
- *Anthropology* is the science that deals with the study of humanity, concerned with human behavior, culture, and linguistics.

Cranial Reference Points

- These are points on the skull used for the measurements of the skull dimensions. These include points in midline and on lateral side of the skull.

Midline reference points^{Viva}

1. *Bregma* – meeting point of coronal and sagittal sutures.
2. *Glabella* – midpoint of superciliary arches.
3. *Nasion* – meeting point of nasal and front bones in midline.
4. *Acanthion* – a point at the anterior nasal spine.
5. *Prosthion* – a point on the alveolar arch, midway between the upper incisor teeth.
6. *Ganthion* – lowest midpoint of the chin.
7. *Lambda* – meeting point of sagittal and lambdoid sutures.
8. *Inion* – tip of the external occipital protuberance.
9. *Opisthion* – midline point of the posterior margin of foramen magnum.
10. *Basion* – midpoint on the anterior margin of foramen magnum.

Reference points on the side of skull

1. *Pterion* – H-shaped suture formed by frontal, parietal, greater wing of sphenoid and squamous part of temporal bones.^{Viva}
2. *Gonion* – point at the angle of mandible (lowest, posterior, and lateralmost point).
3. *Porion* – point at the upper margin of external auditory meatus on the posterior root of zygomatic arch.
4. *Dacryon* – meeting point of lacrimomaxillary and frontomaxillary sutures.

Classification of human skulls

- *Dolichocephalic skull*: Cephalic index 75 or less. These are called long-headed and found in Eskimos, Nigros, and so on.
- *Mesaticephalic skull*: Cephalic index 76–80
- *Brachycephalic skull*: Cephalic index >80. These are short-headed or round-headed and found in Europeans.

Facial angle

- It is an angle between two lines: One line drawn from nasion to basion and another line drawn from nasion to the prosthion.
- It indicates the angle between *viscerocranium* and *neurocranium* and also a rough index of degree of brain development.
- Facial angle is smallest in the most evolved races and larger in lower races.

Oxycephaly

- It is an abnormally tall skull. It is also called *tower-skull* or *steeple skull*. Skull is short anteroposteriorly.
- *Cause*: It occurs due to the premature closure of suture between presphenoid and postsphenoid parts of skull base and coronal suture.

Scaphocephaly

- It is a boat-shaped skull. It occurs due to premature synostosis of sagittal suture. It is side-to-side narrow and anteroposteriorly elongated skull.

5. *Asterion* – meeting point of occipital parietal and temporal bones. ^{Viva}

Cephalic Index

- It is the ratio of maximum breadth and maximum length of the skull. ^{Viva}

$$\text{Cephalic index} = \frac{\text{Maximum breadth of skull}}{\text{Maximum length of skull}} \times 100$$

- Maximum length of skull = Distance between glabella and opisthocranion (Occipital point – Posterior most point of occipital bone).
- Maximum breadth of skull = Widest diameter which is perpendicular to the median plane.