HUMAN OSTEOLOGY

Human Osteology
for Dental Students

Inderbir Singh

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Headquarter

Jaypee Brothers Medical Publishers (P) Ltd
4838/24, Ansari Road, Daryaganj
New Delhi 110 002, India
Phone: +91-11-43574357
Fax: +91-11-43574314
Email: jaypee@jaypeebrothers.com

Overseas Offices

JP Medical Ltd,
83 Victoria Street London
SW1H 0HW (UK)
Phone: +44-2031708910
Fax: +02-03-0086180
Email: info@jpmedpub.com

Jaypee-Highlights Medical Publishers Inc
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Human Osteology for Dental Students

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Preface

The *Human Osteology for Dental Students* has been prepared keeping in mind the requirements of undergraduate and postgraduate dental students. The entire text has been thoroughly edited to enable dental students understand head and neck anatomy in a simple manner. Special effort has been made to have the text as near as possible to the relevant illustration with special emphasis on the bones of skull and cervical vertebra.

The book has numerous multi-colored simple illustrations which simplify the subject of anatomy both with regard to appearance and to content. The value of the book has been greatly increased by the addition of an entirely new concept, presenting an atlas of muscle attachments in chapter 4, "(Some Muscles of Head and Neck)". I believe that students will find this chapter very useful as it will considerably reduce the burden of remembering the numerous attachments of muscles to the skull.

I am grateful to the numerous teachers of Anatomy, who have encouraged me in my book writing endeavours. I am equally grateful to the many students who have written letters, and have provided useful suggestions.

The support of Shri Jitendar P Vij, Chairman and Managing Director, M/s Jaypee Brothers Medical Publishers (P) Ltd. has been vital to the publication of this edition and I am deeply indebted to him.

Inderbir Singh

Contents

1 Introduction to the Human Skull

The human skeleton may be divided into (a) *the axial skeleton* (consisting of the bones of the head, neck, and trunk; and (b) the *appendicular skeleton* consisting of the bones of the limbs.

A PRELIMINARY LOOK AT THE SKULL

The skeleton of the head is called the skull. It is seen from the lateral side (Fig. 1.1) and from above (Fig. 1.2).

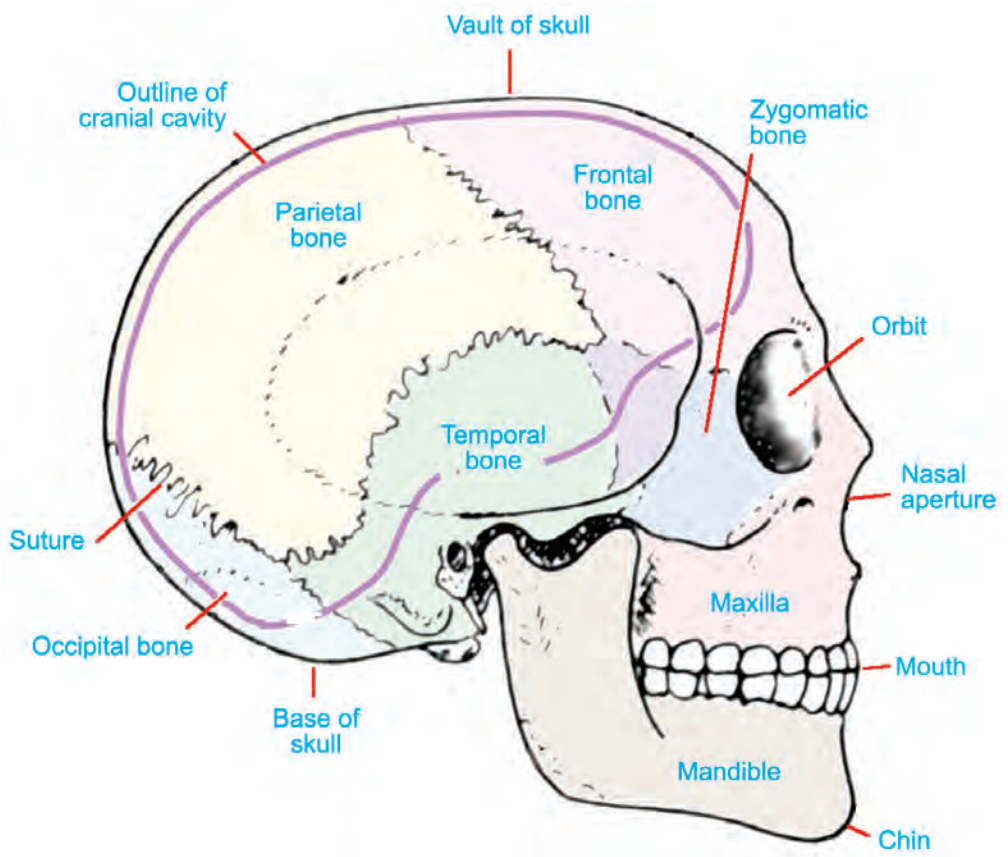


Fig. 1.1: Skull seen from the right side

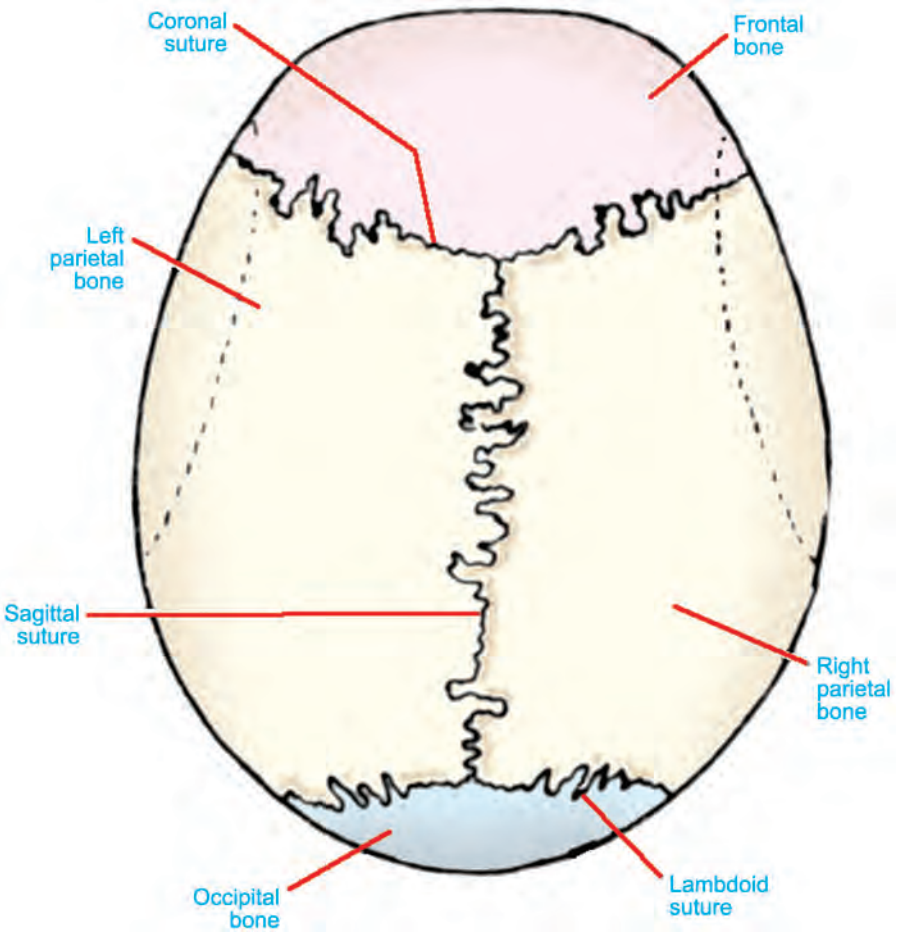


Fig. 1.2: Skull seen from above

The skull contains a large *cranial cavity* in which the brain is lodged. Just below the forehead the skull shows two large depressions, the right and left orbits, in which the eyes are lodged. In the region of the nose and mouth there are apertures that lead to the interior of the skull.

The skull is made up of a large number of bones that are firmly joined together. Some of these are as follows. In the region of the forehead there is the *frontal bone*. At the back of the head (also called the *occiput*) there is the *occipital bone*. The top of the skull, and parts of its side walls, are formed mainly by the right and left *parietal bones*. The region of the head just above the ears is referred to as the *temple*, and the bone here is the *temporal bone* (right or left). The bone that forms the upper jaw, and bears the upper teeth, is the *maxilla*. The prominence of the cheek is formed by the *zygomatic bone*. In the floor of the cranial cavity there is an unpaired bone called the *sphenoid bone*. The bone of the lower jaw is called the *mandible*. It is separate from the rest of the skull. In addition to these large bones, there are several smaller ones that will be identified when we take up the study of the skull in detail.

2 The Skull as a Whole

GENERAL REVIEW OF THE SKULL

The skull consists of a large number of bones. The purpose of this section is to make the student familiar with their names as a preliminary to further study.

The bone forming the lower jaw is called the *mandible* (Fig. 2.1). The other bones of the skull are firmly united to one another at joints called *sutures*: these bones collectively form the *cranium*. (Cranium = skull minus mandible).

The cranium consists of two main parts. Its upper and posterior part contains a large *cranial cavity* in which the brain lies. Anteriorly, and inferiorly, the cranium forms the skeleton of the face including the walls of the orbits (in which the eyeballs lie), the cavity of the nose, and the upper part of the cavity of the mouth. The upper dome-like part of the skull is called the vault or skull cap. It forms the upper, lateral, anterior and posterior walls of the cranial cavity. Note that its anterior wall forms the

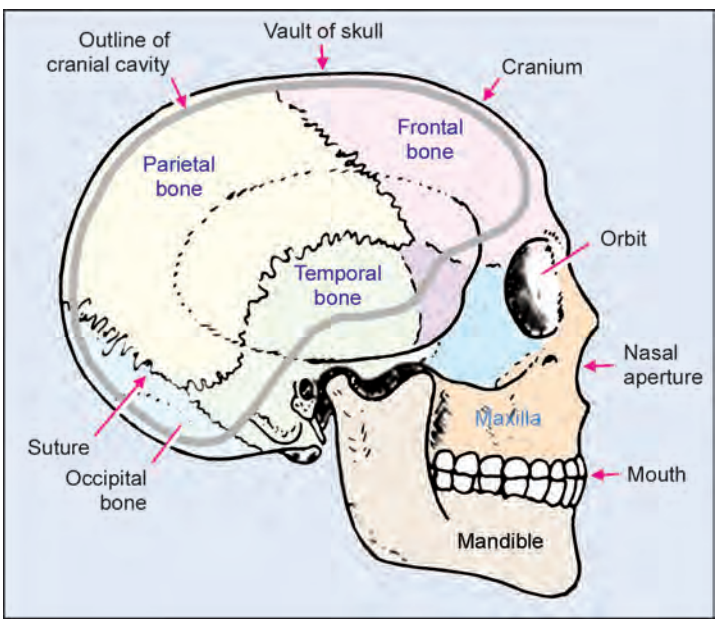


Fig. 2.1: Some features of the skull as seen from the lateral side

forehead. The part of the skull forming the floor of the cranial cavity is called the base.

With these preliminary remarks we can proceed to identify the individual bones of the skull.

Looking at the skull from above (Fig. 2.2) we see four bones. The bone forming the anterior part of the vault is the frontal bone. The greater part of the roof and side walls of the cranial cavity are formed by the right and left parietal bones. The two parietal bones meet in the midline at the sagittal suture. Their anterior margins join the frontal bone at the coronal suture which runs transversely across the vault. The posterior part of the vault is formed by the occipital bone which is better seen when the skull is viewed from behind (Fig. 2.3). The suture joining the occipital bone to the parietal bones is shaped like the Greek letter 'lambda' (which is like an inverted 'Y'). It is, therefore, called the lambdoid suture. Lateral to the occipital bone we see a part of the temporal bone [which is better seen when the skull is viewed from the lateral side (Fig. 2.4)].

When the skull is viewed from the front (Fig. 2.5) the most conspicuous features are the jaws which

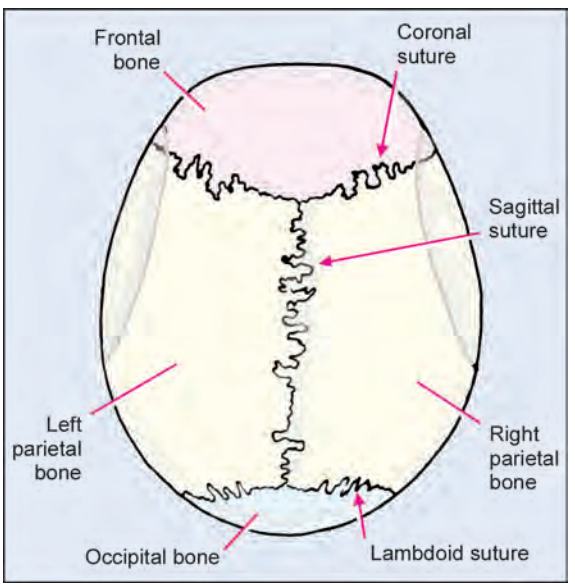


Fig. 2.2: Some features of the skull as seen from above. For details see Figure 2.14

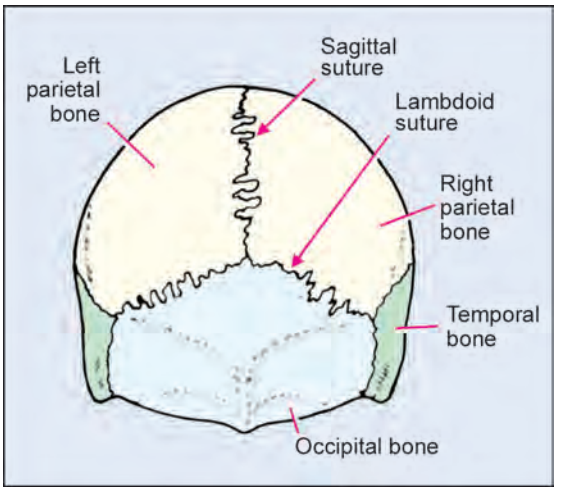


Fig. 2.3: Some features of the skull as seen from behind. For details see Figure 2.15

bear the teeth. The bone forming the lower jaw is called the mandible. The upper jaw is formed by the right and left maxillae. The region of the forehead is formed by the frontal bone. The prominence of the cheek is formed by the zygomatic bone. Three large openings can be seen. A median nasal aperture is present between the two maxillae: it leads into the nasal cavities. In the depth of the aperture we can make out parts of three bones. These are the ethmoid, the inferior nasal concha, and the vomer. Above and lateral to the nasal aperture we see two large cavities, the right and left orbits, in which the eyeballs lie. The walls of the orbits receive contributions from the frontal, zygomatic, and ethmoid bones, from the maxilla, and from two bones not mentioned so far. One of these is a small bone, the lacrimal. The other is the sphenoid. The sphenoid is a large unpaired bone present in the base of the skull, and only a small part of it is seen in each orbit. A part of the sphenoid called the greater wing is also seen on the lateral surface of the skull. Lying in the area between the two orbits we see the right and left nasal bones. They lie just above the nasal aperture.

The bones to be seen when the skull is viewed from the lateral side (Fig. 2.4). Many of these have

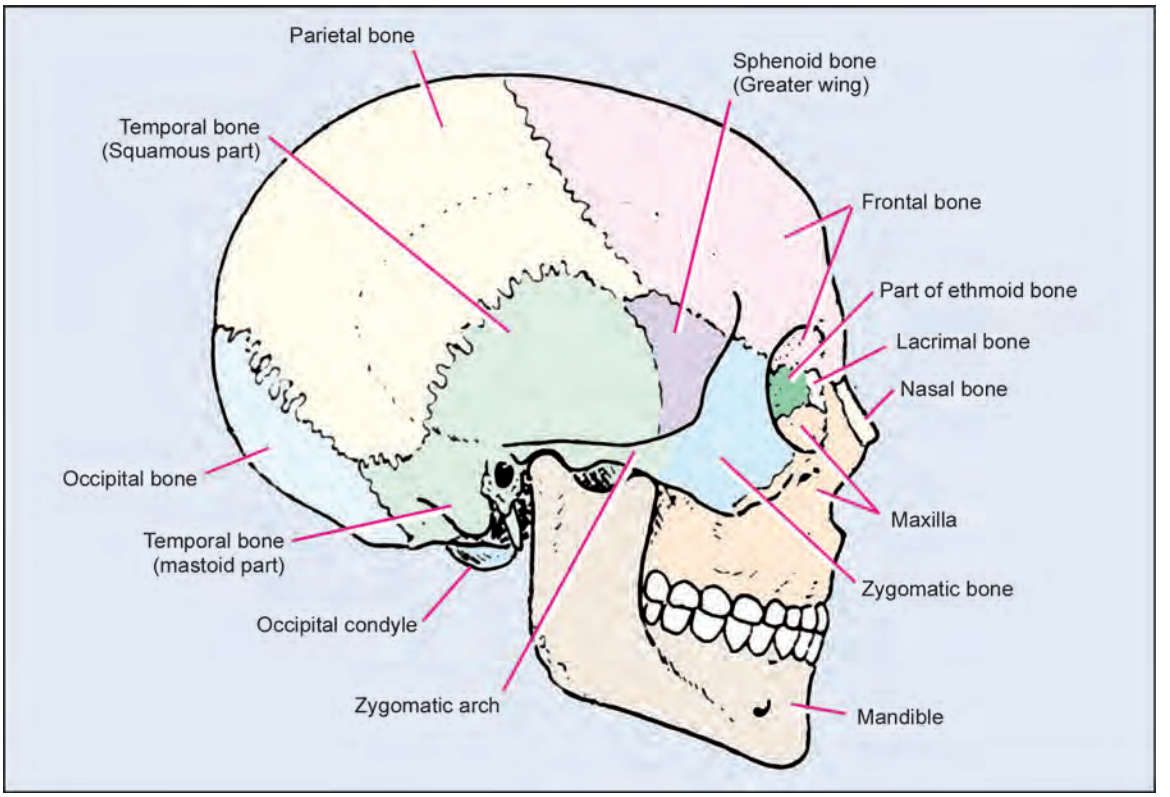


Fig. 2.4: Lateral view of the skull showing the position of individual bones. For further details see Figures 2.9, 2.16 to 2.18

already been seen from the front, from above, or from behind. These include the frontal, parietal, and occipital bones (in the vault), and the ethmoid, lacrimal, nasal and zygomatic bones (in the facial region). The maxilla, the mandible, and the greater wing of the sphenoid are also seen. Below the parietal bone the lateral wall of the cranium is formed by the squamous part of the temporal bone. Lower down the mastoid part of the same bone lies in relation to the base of skull. The temporal bone gives off a process that joins (a process of) the zygomatic bone to form the zygomatic arch.

When the skull is viewed from below (Fig. 2.6) we see parts of several bones already identified. These are the maxilla (shaded orange), the sphenoid (violet), the temporal (green) and the occipital bone (blue). We also see parts of the zygomatic bone and of the vomer; and the palatine bone which is seen for the first time.

The maxillae bear the upper teeth. Lateral to the teeth a part of the maxilla is seen articulating with the zygomatic bone. Medial to the teeth the maxilla forms the anterior part of the bony palate. The posterior part of the palate is formed by the right and left palatine bones. Above the posterior edge of the palate we see the posterior openings of the right and left nasal cavities which are separated by the vomer. Part of the vomer has been seen on the front of the skull through the anterior nasal aperture.

Behind the vomer we see the sphenoid which is an unpaired bone. It has a median part, the body. On either side of the body there is a greater wing [which is seen partly on the base of the skull and partly on the lateral wall (Fig. 2.4)].

Posteriorly, the body of the sphenoid is continuous with the basilar part of the occipital bone. Just behind the basilar part, the occipital bone has a large foramen, the foramen magnum through which

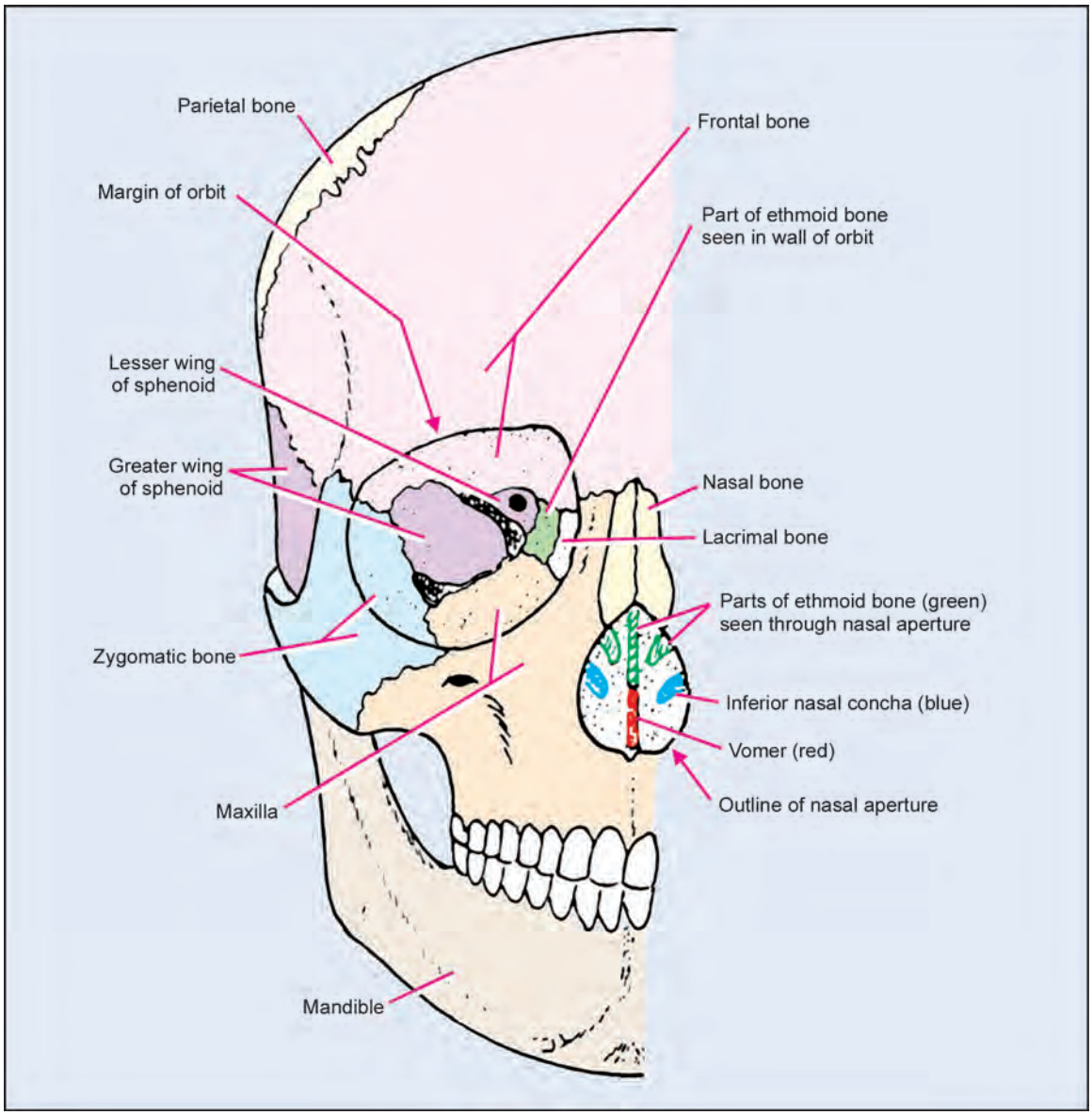


Fig. 2.5: Bones of the skull that can be seen from the front. For details see Figure 2.8

the cranial cavity communicates with the vertebral canal. Posterior to the foramen magnum the occipital bone forms a large part of the base of the skull.

The lateral part of the base of the skull is formed by the temporal bone which is wedged in between the sphenoid and occipital bones. It consists of a medial petrous (= stone like) part, a posterolateral mastoid part, and an anterolateral squamous part that is seen mainly on the lateral wall of the skull. The temporal bone gives off a process that joins the zygomatic bone to form the zygomatic arch. (Some other parts of the temporal bone will be identified latter).

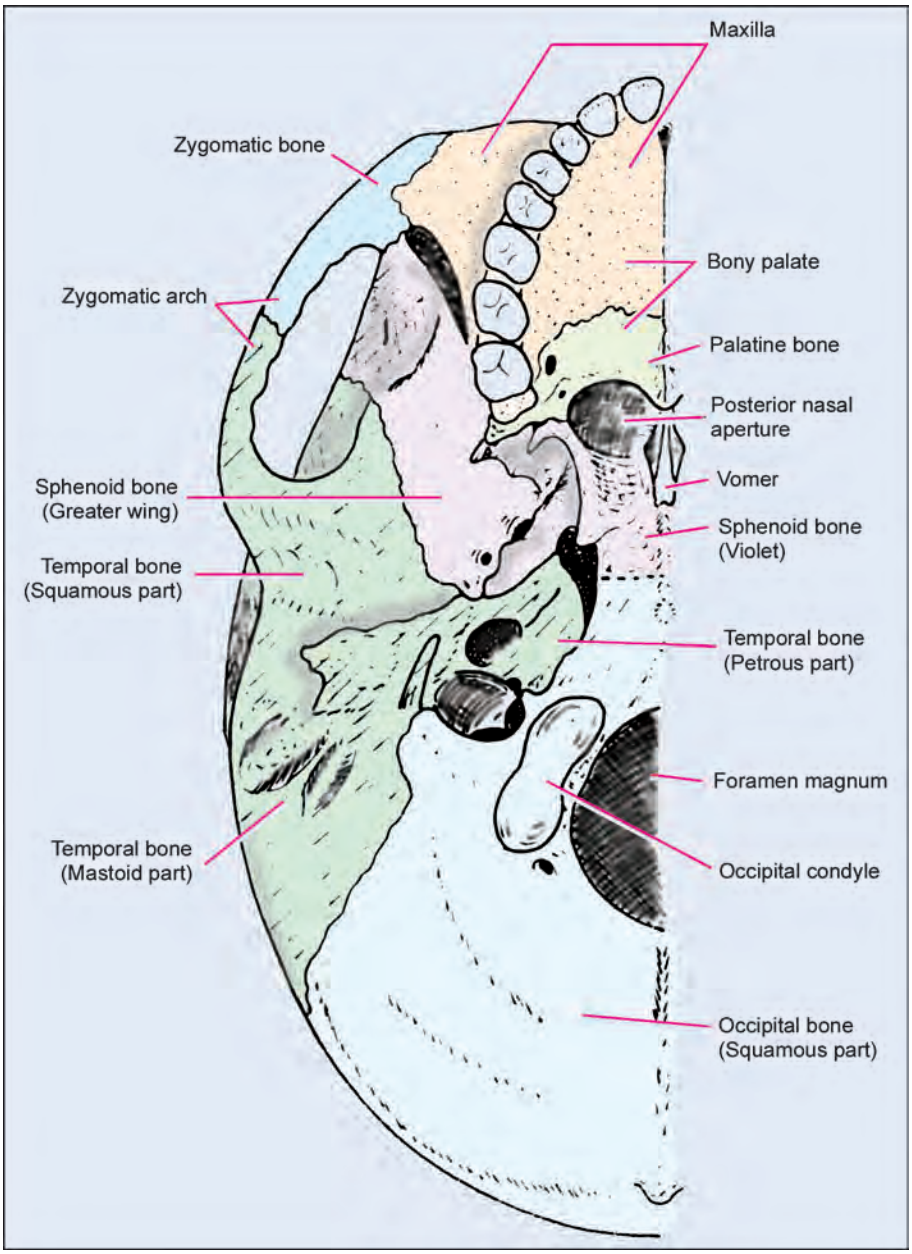


Fig. 2.6: Some features of the skull as seen from below. For details see Figures 2.21, 2.25 and 2.27

When the top of the skull (skull cap) is removed by a transverse cut we can view the floor of the cranial cavity (Fig. 2.7). It is seen to be divided into three depressions called the cranial fossae: anterior, middle (shaded with dots), and posterior. The floor of the anterior cranial fossa is formed mainly by the frontal bone, but near the midline, anteriorly, a small part is formed by the ethmoid. This bone lies mainly in the wall of the nasal cavity. A part of it has been seen in the wall of the orbit, and another part through the

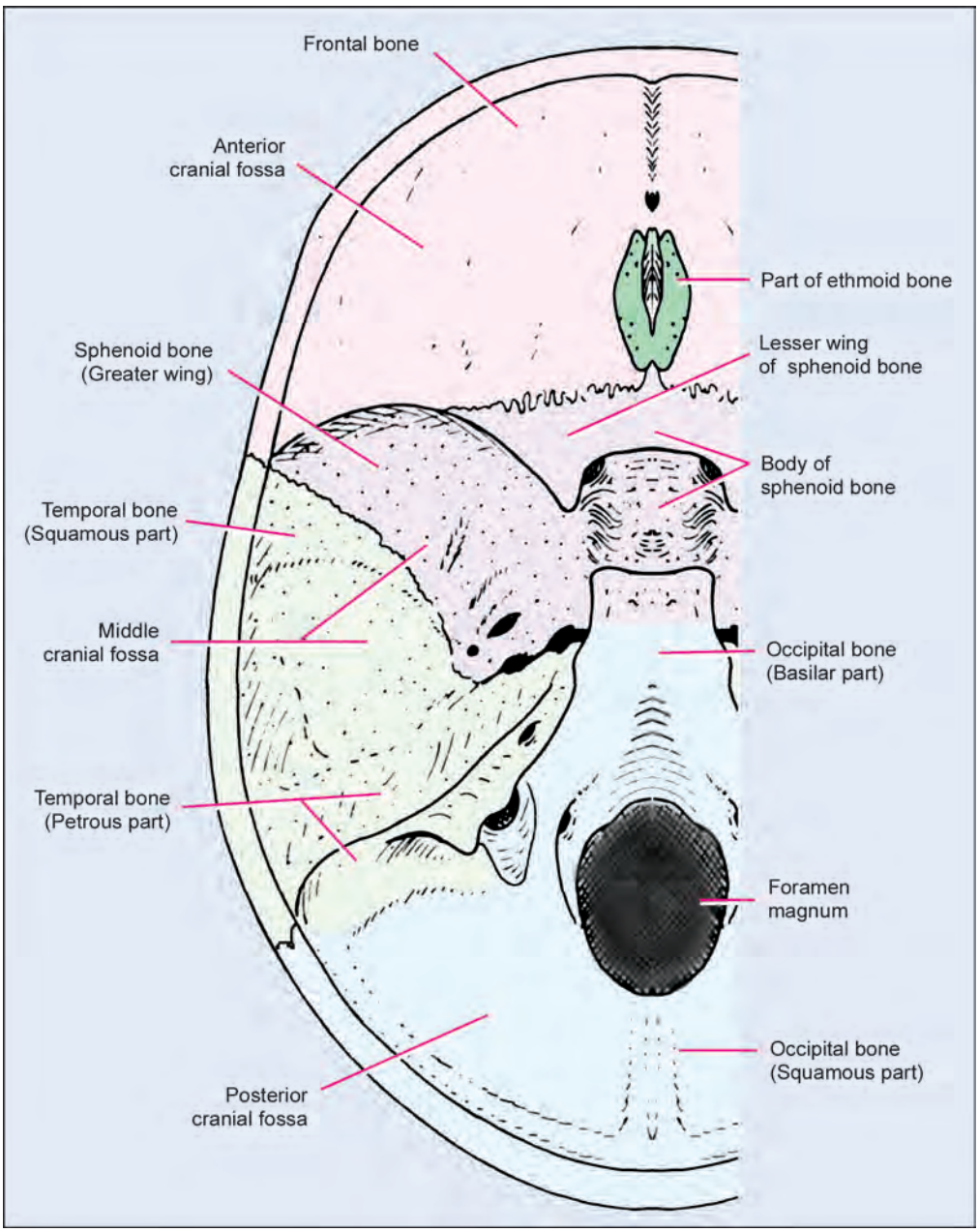


Fig. 2.7: Bones of the skull as seen in the floor of the cranial cavity. The skull is viewed from above after removing the skull cap. Also see Figures 2.29 and 2.31

anterior nasal aperture. More posteriorly the median part of the floor of the anterior fossa is formed by a part of the body of the sphenoid; and the lateral parts by the lesser wings of the sphenoid.

The floor of each half of the anterior cranial fossa has a sharp posterior margin that separates it from the middle cranial fossa. The medial part of the margin is formed by the

lesser wing of the sphenoid, and its lateral part by the frontal bone.

The floor of the middle cranial fossa is narrow (anteroposteriorly) in its median part, and broad laterally. The narrow median part is formed by the body of the sphenoid. The broad lateral part (which is also much deeper) is formed by the greater wing of the sphenoid, the squamous part of the temporal bone, and by the anterior surface of the petrous part of the same bone.

The greater part of the floor of the posterior cranial fossa is formed by the occipital bone. The foramen magnum is seen in the deepest part of the fossa. The anterolateral part of the floor is formed by the posterior surface of the petrous temporal bone.

The various bones to be seen on different aspects of the skull have been identified. We will now proceed to undertake a more detailed study of the skull as seen from various aspects.

THE SKULL AS SEEN FROM THE FRONT

The bones seen when the skull is viewed from the front have already been identified, and the presence of the orbits and the anterior nasal aperture noted. We shall now consider further details (Fig. 2.8). The orbits and the mandible will be considered separately.

Articulations

Lateral to the orbit the frontal bone ends in the zygomatic process which joins the frontal process of the zygomatic bone at the frontozygomatic suture. The nasal part of the frontal bone projects downwards between the two orbits. On either side of the midline it meets the frontal process of the maxilla at the frontomaxillary suture, and the nasal bone at the frontonasal suture. The nasal bones join each other at the internasal suture, and the frontal process of the maxilla at the nasomaxillary suture. Below the nasal aperture the right and left maxillae meet at the intermaxillary suture. Laterally, the maxilla has a prominent zygomatic process which articulates with the maxillary process of the zygomatic bone at the zygomaticomaxillary suture.

Other Named Features

The surface of the frontal bone seen from the front is called the external surface. About 3 cm above the orbit it is somewhat more convex than elsewhere: this area is called the frontal tuber or frontal eminence. Just above the medial part of the orbit there is a raised ridge called the superciliary arch. The arches of the two sides meet in the midline at the glabella. The point where the frontonasal and internasal sutures meet is called the nasion. The zygomatic process of the frontal bone has a sharp lateral edge. When traced upwards it is continued as a ridge which is continuous posteriorly with the temporal lines. The ridge separates the external surface of the frontal bone from the temporal surface [which is better seen from the lateral side (Fig. 2.9)].

The features to be seen on the maxilla are as follows. The frontal process is marked by a sharp vertical ridge called the anterior lacrimal crest. This crest forms part of the medial margin of the orbit. The part of the frontal process behind the crest takes part in forming the lacrimal groove (Also see Figure 2.11). In the lower part of the nasal aperture, in the midline, the maxillae show a sharp forward projection called the anterior nasal spine. The part of the maxilla that bears the teeth is called the alveolar process. Each maxilla bears eight teeth. Beginning from the midline there are two incisors, one canine, two premolars and three molars. Just above the canine tooth the maxilla shows a vertical elevation produced by the root of this tooth: this is the canine eminence. Medial to this eminence and above the incisor teeth there is a depression called the incisive fossa; and lateral to it there is another depression, the canine fossa.

Foramina

At the junction of the medial one-third and the lateral two-thirds of the upper margin of the orbit

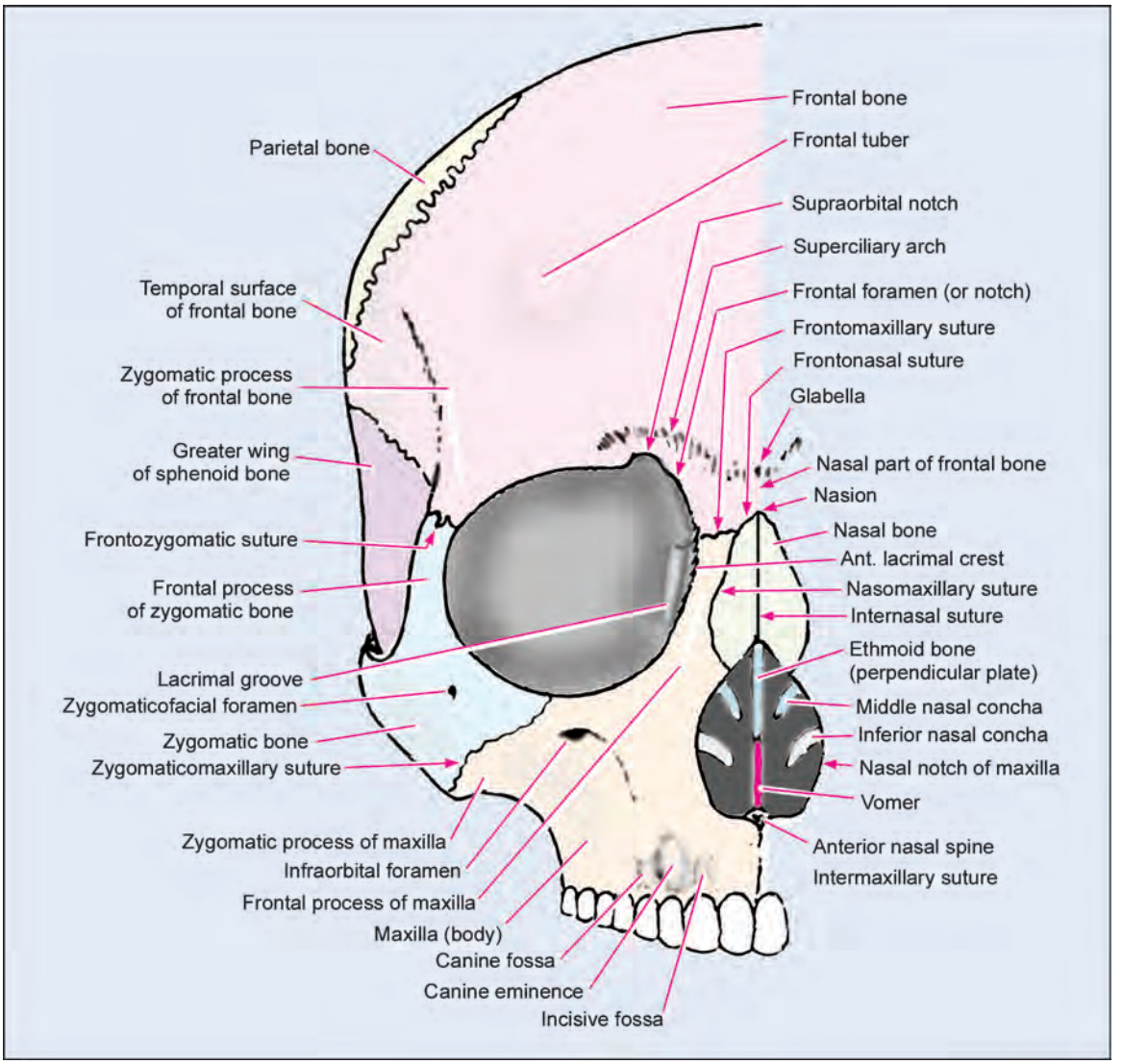


Fig. 2.8: Some details of features of the skull as seen from the front. Compare with Figure 2.5. For details within the orbit see Figure 2.12

we see the supraorbital notch which is sometimes converted into a foramen (Fig. 2.8). Medial to it a smaller frontal notch (or foramen) is often seen. On the lateral surface of the zygomatic bone we see the zygomaticofacial foramen which is sometimes double. About a centimeter below the inferior margin of the orbit there is a large infraorbital foramen on the anterior surface of the maxilla.

The Anterior Nasal Aperture

The anterior nasal aperture is a pear shaped opening (Fig. 2.8). On either side its margin is formed mainly by the nasal notch of the maxilla. Its upper part is bounded by the lower borders of the nasal bones. In the depth of the aperture we can see the nasal septum separating the right and left nasal cavities. Its upper part is formed by a part of the

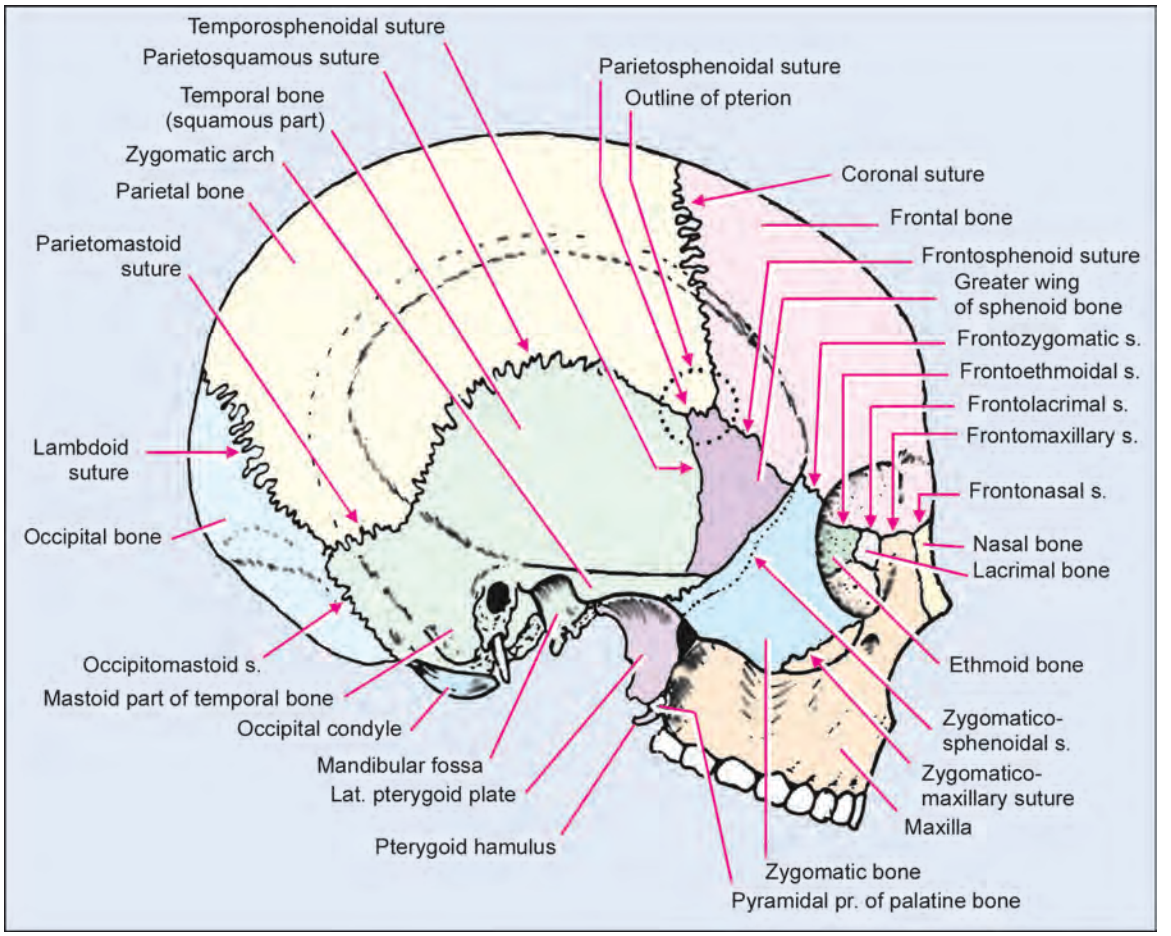


Fig. 2.9: Sutures seen on the lateral aspect of the skull

ethmoid bone called the perpendicular plate and its lower part by the vomer.

Lateral to the septum we see two curved plates of bone projecting into each nasal cavity from the lateral side. These are the middle and inferior nasal conchae. The middle concha is a part of the ethmoid bone while the inferior concha is an independent bone that is attached to the maxilla.

Some of the features mentioned above can be better visualized when we see a coronal section through the region of the nasal cavity and the orbit (Fig. 2.10). In particular, note the orientation of the ethmoid bone in relation to these cavities, and to the floor of the anterior cranial fossa.

Attachments on the Anterior aspect of the Skull

1. The orbital part of the orbicularis oculi muscle arises from the nasal part of the frontal bone, and from the frontal process of the maxilla. The lacrimal part of the orbicularis oculi arises from the part of the lacrimal bone behind the lacrimal groove (Fig. 2.11).
2. The corrugator supercilii arises from the medial end of the superciliary arch.
3. The zygomaticus major arises from the lateral surface of the zygomatic bone in front of the zygomaticotemporal suture.

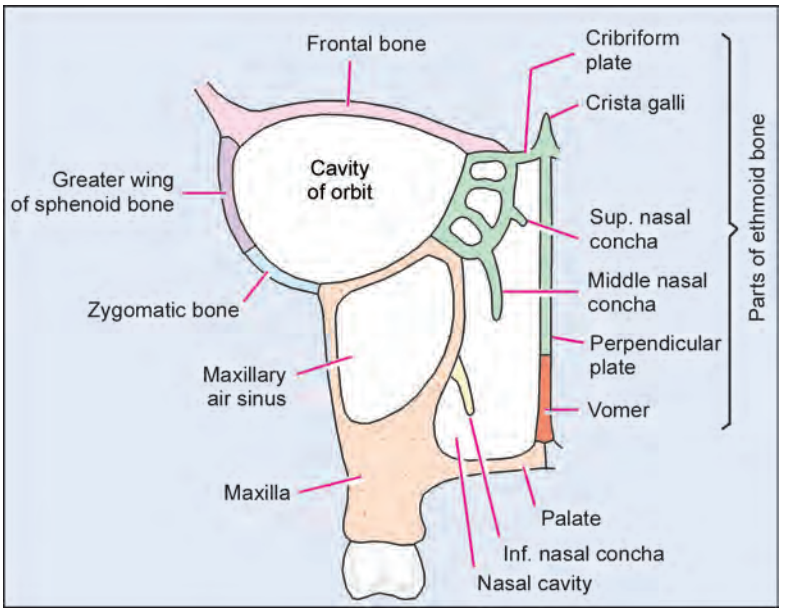


Fig. 2.10: Schematic coronal section through the orbit and nasal cavity to show the bones related to them

4. The zygomaticus minor arises from the lateral surface of the zygomatic bone just behind the zygomaticomaxillary suture.
5. The levator labii superioris arises from the lower margin of the orbit, partly from the maxilla and partly from the zygomatic bone.
6. The levator anguli oris arises from the canine fossa of the maxilla below the infraorbital foramen.
7. The levator labii superioris alaeque nasi arises from the frontal process of the maxilla.
8. The procerus arises from the lower part of the nasal bone.
9. The nasalis has two parts. The transverse part arises from the maxilla just lateral to the nasal notch; and the alar part from the maxilla below and medial to the transverse part.
10. The depressor septi arises from the maxilla just above the central incisor tooth.
11. The incisivus labii superioris arises from the maxilla above the lateral incisor tooth.

In the Figure 2.11 we also see parts of the attachments of the temporalis, the masseter and the buccinator. These are better seen from the lateral side.

THE ORBIT

Orbital Margins

The upper margin of the orbit is formed by the frontal bone (Fig. 2.1). The lateral margin is formed mainly by the zygomatic bone: its upper part is formed by the zygomatic process of the frontal bone. The inferior margin is formed in its lateral part by the zygomatic bone, and in its medial part by the maxilla. The medial margin is formed mainly by the frontal process of the maxilla: its upper part is formed by the nasal part of the frontal bone.

Walls of the Orbit

Each orbit is shaped like a pyramid. The orbital opening represents the base of the pyramid, while the apex lies at the posterior end. The orbit has a roof, a floor, a medial wall and a lateral wall; but these are not sharply marked off from one another.

The roof is formed mainly by the orbital plate of the frontal bone. Posteriorly, a small part of it is formed by the lesser wing of the sphenoid. Note that these bones also form the floor of the anterior cranial fossa. The anterolateral part of the roof has

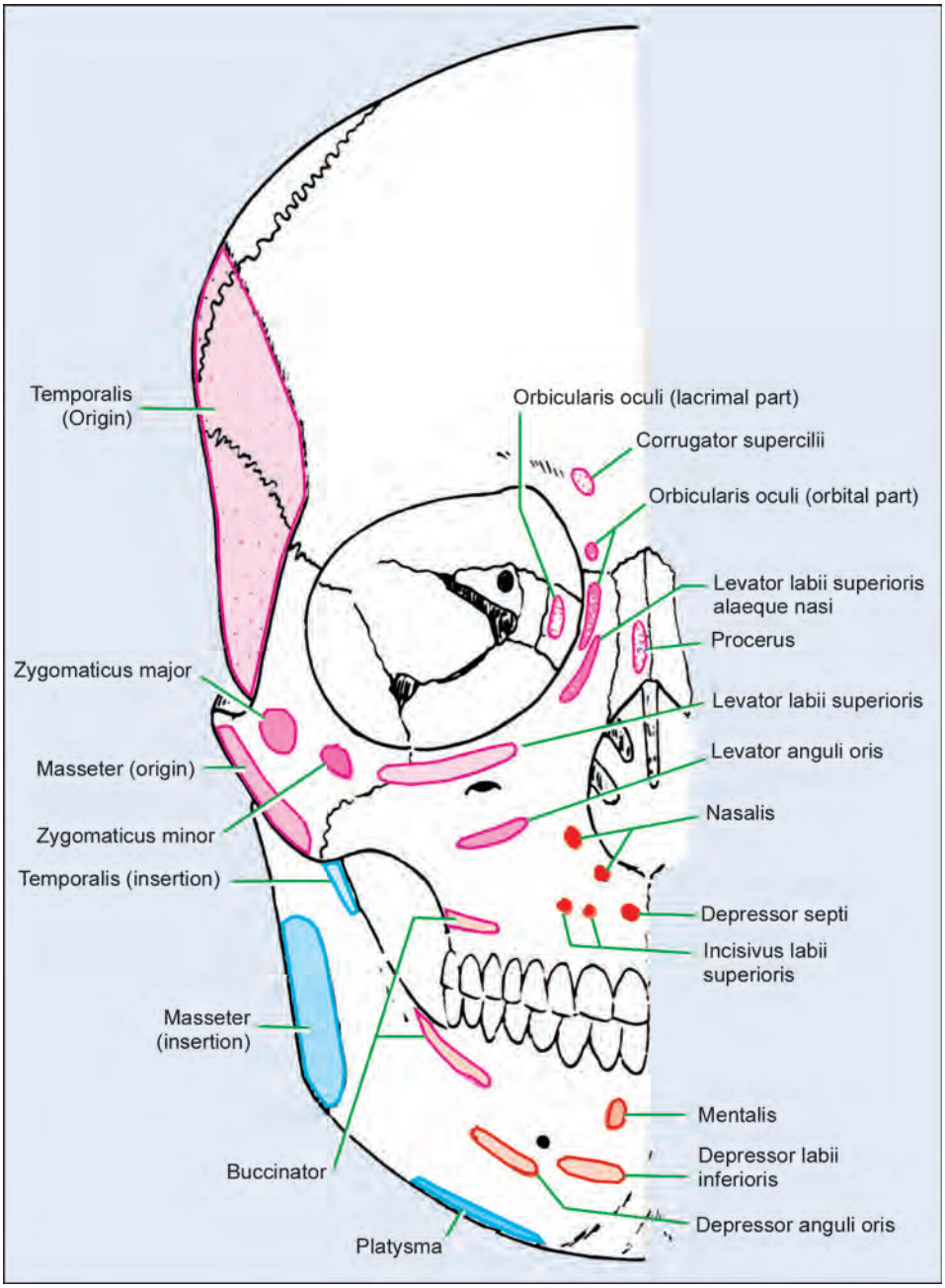


Fig. 2.11: Attachments to the anterior aspect of the skull

a depression called the lacrimal fossa. Close to the orbital margin, at the junction of the roof and medial wall, there is a small depression called the trochlear fossa.

The floor is formed mainly by the maxilla (This part of the maxilla is its orbital surface). The antero-lateral part of the floor is formed by the zygomatic

bone. Posteromedially, a small part of the floor is formed by a part of the palatine bone (called the orbital process).

The lateral wall is formed, in its anterior part by the zygomatic bone, and in its posterior part by the greater wing of the sphenoid.

The medial wall is formed mainly by the orbital plate of the ethmoid. Posterior to the ethmoid a small part of this wall is formed by the body of the sphenoid. Anterior to the ethmoid the wall is formed by the lacrimal bone, and still further anteriorly by the frontal process of the maxilla. The region of the medial wall formed by the lacrimal bone and by the maxilla shows a deep lacrimal groove (for the lacrimal sac). The groove is bounded anteriorly by the anterior lacrimal crest on the frontal process of the maxilla; and posteriorly by the crest of the lacrimal bone (which is a sharp vertical ridge). The suture joining the maxilla and the lacrimal bone runs vertically in the floor of the lacrimal groove. The groove is continuous, inferiorly, with the nasolacrimal canal, the lower end of which opens into the nasal cavity.

Apertures in the Orbit

The superior orbital fissure is a prominent cleft that separates the posterior parts of the roof and lateral wall (Fig. 2.12). It is bounded above and

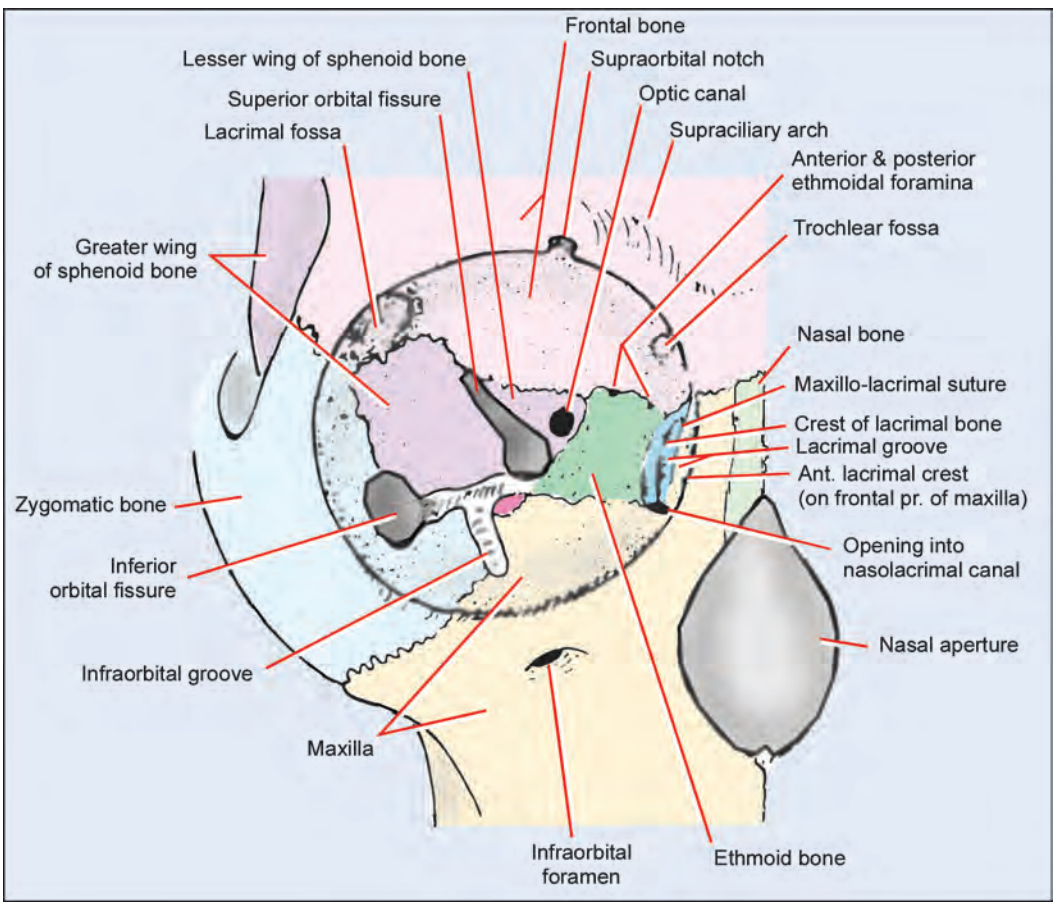


Fig. 2.12: The orbit and surrounding structures. The figure is schematic to the extent that all features shown cannot be seen from one fixed angle of viewing

medially by the lesser wing of the sphenoid; and below and laterally by the greater wing. Medial to it, at the apex of the orbit, there is the opening of the optic canal. This canal lies between the body of the sphenoid, and its lesser wing.

The inferior orbital fissure intervenes between the posterior parts of the floor and the lateral wall of the orbit. It is bounded above and laterally by the greater wing of the sphenoid, and below and medially by the orbital surface of the maxilla. The fissure is continuous anteriorly with the infraorbital groove on the maxilla. Anteriorly, the groove ends in a canal which passes through the bony substance of the maxilla to open on the surface through the infraorbital foramen. At the junction of the roof and the medial wall, on the suture separating the orbital plate of the ethmoid from the frontal bone, we see the anterior and posterior ethmoidal foramina. On the lateral wall there are two small foramina on the orbital surface of the zygomatic bone: they open into canals within the bone. The other end of one of these canals opens on the external surface of the zygomatic bone as the zygomaticofacial foramen; and that of the other canal opens on the temporal surface of the zygomatic bone as the zygomaticotemporal foramen (Fig. 2.13).

THE SKULL AS SEEN FROM ABOVE

The names of the bones, and of the sutures, that are seen when the skull is viewed from above have already been mentioned. Some additional features may now be noted (Fig. 2.14).

The point where the coronal and sagittal sutures meet is called the bregma, while the point where the sagittal suture meets the lambdoid suture is called the lambda. In the fetal skull (and for a few months after birth) there are gaps in the bones of the skull in these situations, these being filled by membranes. These gaps are called the anterior and posterior fontanelles. Examination of the parietal bone shows that in one area (in its posterolateral part) it is more convex than at other places: this area is called the parietal tuber (or eminence). Near the posterior part of the sagittal suture each parietal bone has a parietal foramen (which may sometimes

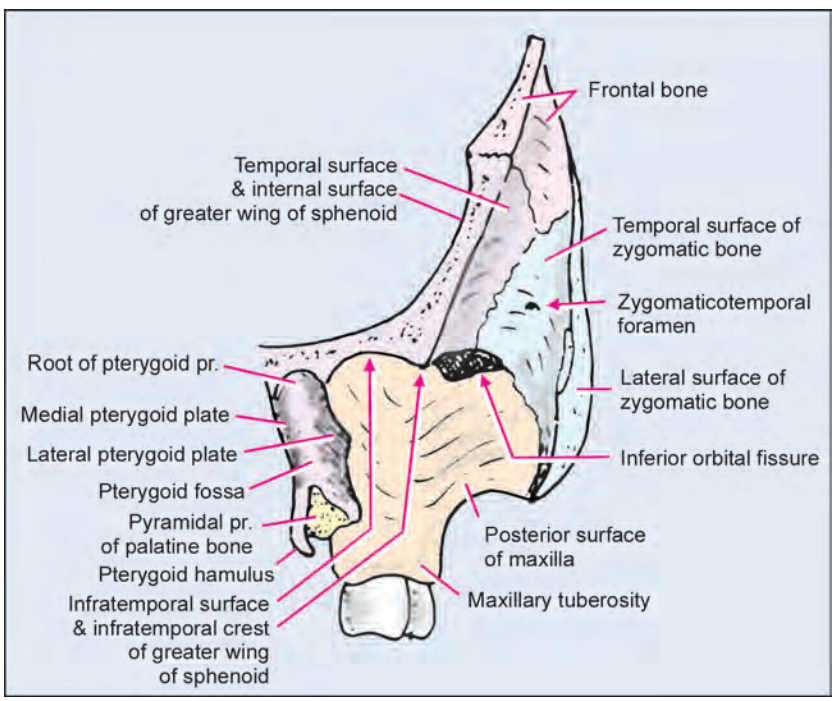


Fig. 2.13: Anterior wall of temporal and infratemporal fossae seen from behind. The zygomatic process of the temporal bone has been removed, and a coronal section cut through the middle cranial fossa

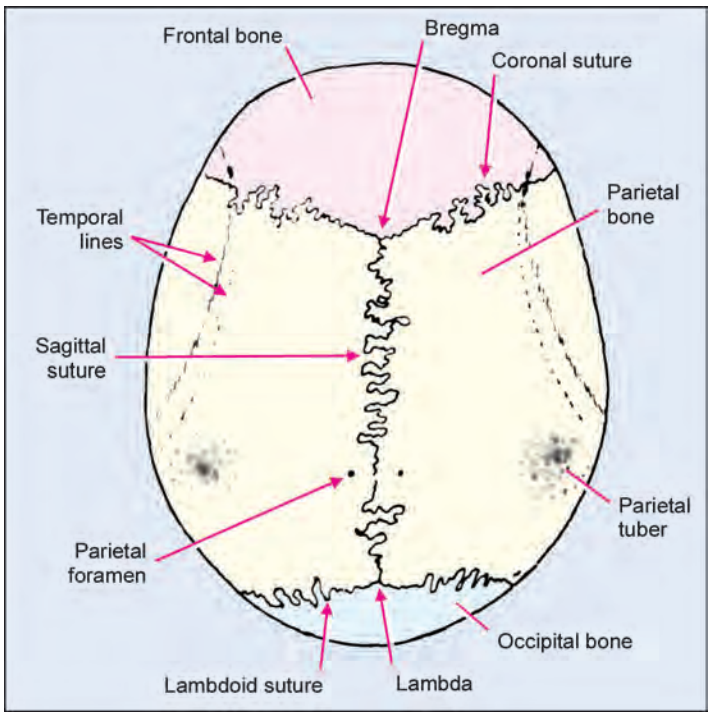


Fig. 2.14: Features seen on the skull when viewed from above. Compare with Figure 2.2

be absent). The temporal lines can be seen on the lateral part of the parietal and frontal bones.

THE SKULL AS SEEN FROM BEHIND

When the skull is viewed from behind we again see the parietal tuber, the parietal foramen, the temporal lines, the sagittal suture, the lambdoid suture and the lambda (Fig. 2.15)

The outline of the lambdoid suture may be extremely complicated, and sometimes small pieces of bone are completely surrounded by parts of the suture: these are called sutural bones. Below the lambdoid suture we see the occipitomastoid suture which unites the lower part of the lateral border of the occipital bone to the mastoid part of the temporal bone. We also see the parietomastoid suture that unites the posterior part of the parietal bone to the mastoid part of the temporal bone.

The part of the occipital bone seen from behind is the squamous part. It can be subdivided into an upper triangular part which is smooth, and forms the posterior part of the vault of the skull; and a lower part which is rough and forms the posterior part of the base of the skull. At the junction of these two parts there is a prominent projection in the midline called the external occipital protuberance. Running laterally from the protuberance there are the prominent superior nuchal lines. A little above these lines we see the highest nuchal lines which are faint and not always present. Below the external occipital protuberance there is a median ridge, the external occipital crest. Running laterally from the crest there are the right and left inferior nuchal lines.

THE SKULL AS SEEN FROM THE LATERAL SIDE

Articulations

The lower margin of the frontal bone articulates with several bones forming the frontonasal, fronto-maxillary, frontolacrimal, frontoethmoid and frontozygomatic sutures (Fig. 2.9). These have

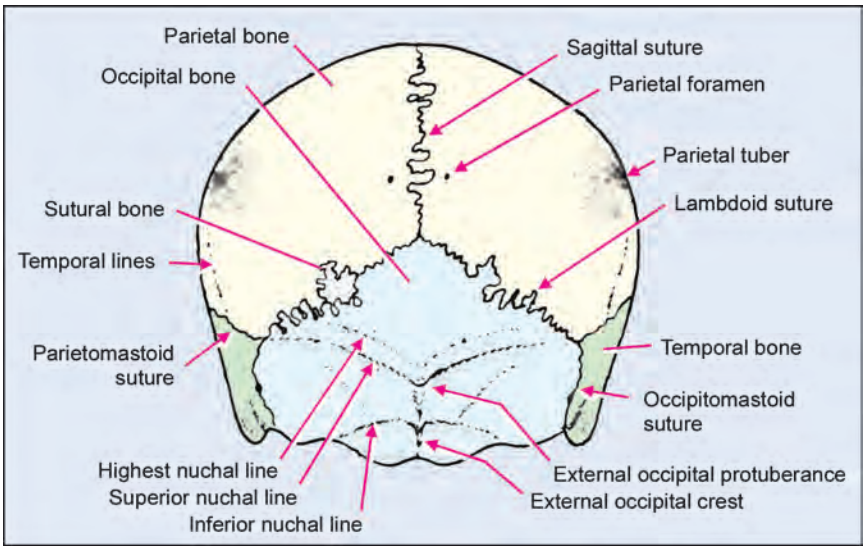


Fig. 2.15: Features seen on the skull when viewed from behind. Compare with Figure 2.3

already been seen from the front. Behind the frontozygomatic suture the frontal bone articulates with the upper border of the greater wing of the sphenoid at the frontosphenoid suture. The posterior end of this suture meets the coronal suture.

We have already seen that the anterior end of the parietal bone meets the posterior border of the frontal bone at the coronal suture. Other articulations of the parietal bone are as follows. Its anteroinferior angle joins the greater wing of the sphenoid at the parietosphenoid suture. Further back the inferior border articulates with the squamous and mastoid parts of the temporal bone at the parietosquamous and parietomastoid sutures. The posterior border of the bone is joined to the occipital bone through the lambdoid suture. Each parietal bone articulates with the the parietal bone of the opposite side through the sagittal suture. Near the anteroinferior angle of the parietal bone the sutures form an 'H' shaped arrangement. Four bones, the parietal, frontal, sphenoid (greater wing) and temporal (squamous part) come together and a small circle drawn here encloses parts of all these bones. The area enclosed by the circle is called the pterion. (The centre of the pterion lies 4 cm above the zygomatic arch, and 3.5 cm behind the frontozygomatic suture. This fact is of surgical importance). We have already seen that the frontal process of the zygomatic bone joins the frontal bone, and that its maxillary process articulates with the maxilla. The bone also gives off a temporal process that runs backwards to join the zygomatic process of the temporal bone to form the zygomatic arch. Posteriorly, the frontal process of the zygomatic bone articulates with the anterior margin of the greater wing of the sphenoid (This suture is hidden from view by the frontal process: it is indicated in dotted line in Fig. 2.9).

The temporal bone articulates with the parietal bone above; in front with the greater wing of the sphenoid, and through its zygomatic process with the zygomatic bone; and behind (through its mastoid part) with the occipital bone. Inferiorly, it bears a fossa for articulation with the head of the mandible to form the temporomandibular joint.

The occipital bone articulates with the two parietal bones at the lambdoid suture. Lower down it articulates with the mastoid part of the temporal bone.

The posterior border of the maxilla is joined to a part of the sphenoid bone called the pterygoid process, and to a small part of the palatine bone called the pyramidal process.

Foramina

The parietal foramen and the zygomaticofacial foramen have already been identified. The zygomaticotemporal foramen is present on the temporal surface of the zygomatic bone (Fig. 2.13), and the mastoid foramen is situated on or near the occipitomastoid suture.

Other Named Features

Note the following in the Figure 2.16. The lateral side of the vault of the skull is marked by a prominent curved ridge called the temporal line. This line starts anteriorly as a continuation of the sharp lateral edge of the zygomatic process of the frontal bone, and curving backwards it crosses the coronal suture. It then runs backwards across the parietal bone. Anteriorly a single ridge is seen, but posteriorly it is usually possible to make out two lines, superior and inferior. The superior line fades away on the posteroinferior part of the parietal bone. The inferior line curves forwards on to the temporal bone to become continuous with a ridge called the supramastoid crest. This crest separates the squamous and mastoid parts of the temporal bone, and is continuous anteriorly with the posterior root of the zygomatic process. Just below this root

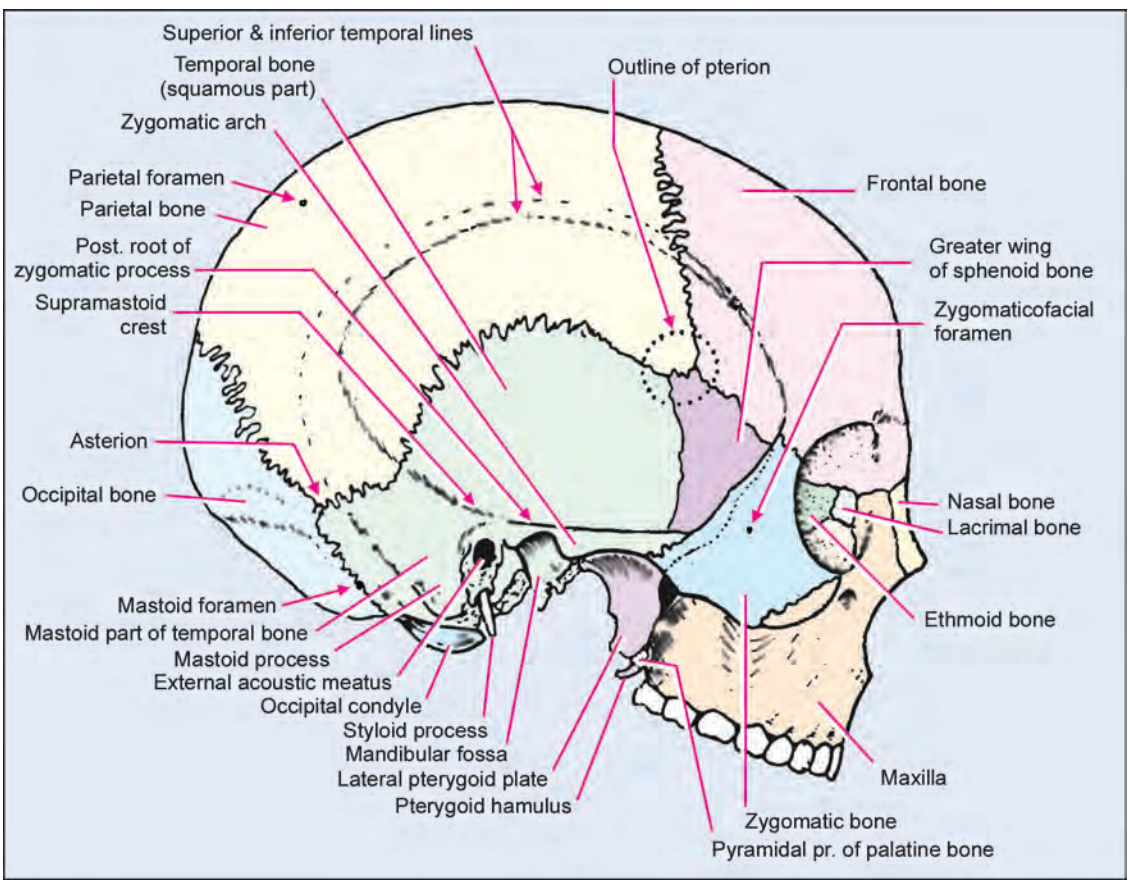


Fig. 2.16: Some features seen on the lateral aspect of the skull.
Also see figures 2.1, 2.4, 2.9, 2.17 and 2.18

we see an aperture leading into a bony tube called the external acoustic meatus. This meatus forms part of the external ear.

The region between the temporal lines (above) and the zygomatic arch (below) is called the temporal fossa. In its floor we see parts of the frontal and parietal bones; of the squamous part of the temporal bone; and of the greater wing of the sphenoid bone. The anterior wall of the fossa (Fig. 2.13) is formed mainly by the temporal surface of the zygomatic bone. It also receives contributions from the greater wing of the sphenoid, and from the frontal bone.

The mastoid part of the temporal bone lies behind the external acoustic meatus. In the young it is separated from the squamous part by the squamomastoid suture. Remnants of this suture may be visible in the adult. We have noted that the mastoid part of the temporal bone articulates with the parietal bone at the parietomastoid suture, and with the occipital bone at the occipitomastoid suture. The point at which these two sutures meet is called the asterion. Just behind the external acoustic meatus the mastoid part of the temporal bone shows a large downward projection called the mastoid process (Mastoid = like the breast). The styloid process (Styloid = needle like) is also a part of the temporal bone. It projects downwards and forwards from the inferior aspect of the bone.

A number of additional features, located in the region of the zygomatic arch, are shown in Figure 2.17. Note the following.

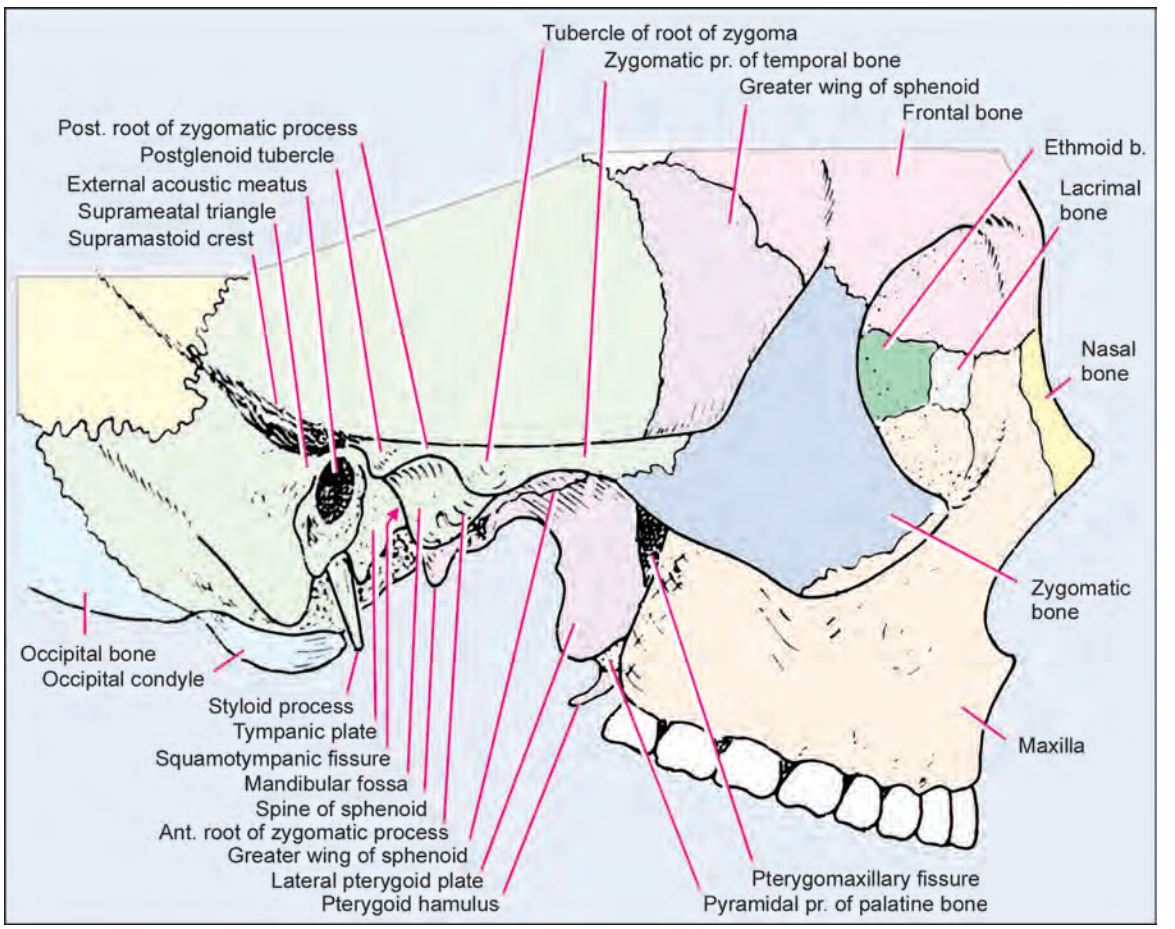


Fig. 2.17: Additional features seen on the lateral aspect of the skull. Also see Figures 2.1, 2.4, 2.9, 2.16 and 2.18

The anterior part of the zygomatic arch is formed by the temporal process of the zygomatic bone. The posterior part of the arch is formed by the zygomatic process of the temporal bone. At its posterior end the zygomatic process of the temporal bone divides into anterior and posterior roots. The posterior root passes backwards along the lateral margin of the mandibular fossa, and then above the external acoustic meatus to become continuous with the supramastoid crest. The anterior root of the zygomatic process passes medially in front of the mandibular fossa. Two projections are seen in relation to the roots of the zygomatic process. At the junction of the anterior root with the process (i.e., just in front of the mandibular fossa) there is the tubercle of the root of the zygoma. The other projection is seen just behind the mandibular fossa: it is called the postglenoid tubercle.

The bone around the opening of the external acoustic meatus is rough and serves to give attachment to the cartilaginous part of the meatus. Part of this area which forms the anterior margin, the inferior margin and the lower part of the posterior margin of the meatus belongs to the tympanic part of the temporal bone, also called the tympanic plate. Posteriorly, the tympanic part joins the mastoid part of the bone. The tympanic plate has a broad anterior surface which lies behind the mandibular fossa (which is formed by the squamous part of the temporal bone). The two are separated by the squamotympanic fissure.

Just above and behind the external acoustic meatus there is an area called the suprameatal triangle. Its upper border is formed by the supramastoid crest. Its anteroinferior border is formed by the posterosuperior part of the external acoustic meatus. Its posterior border is an imaginary vertical line touching the posterior margin of the meatus. The importance of the triangle is that an important cavity, the mastoid antrum, lies deep to it in the substance of the petrous part of the temporal bone. The triangle itself is, however, formed by bone belonging to the squamous part of the temporal bone.

Some features on the lateral side of the skull are obscured from view by the zygomatic arch and can be seen when the arch is cut away (Fig. 2.18). The temporal surface of the greater wing of the sphenoid has been seen in the floor of the temporal fossa. Inferiorly, this surface ends in a sharp ridge called the infratemporal crest. Medial to the crest we see the infratemporal surface of the greater wing; this surface faces downwards.

Further medially, we see another part of the sphenoid called the pterygoid process. This process projects downwards from the junction of the body and the greater wing. When viewed from behind (Fig. 2.13) the process is seen to be made up of medial and lateral pterygoid plates that are free posteriorly, but meet anteriorly to enclose the pterygoid fossa. When viewed from the side (Fig. 2.18) we see the surface of the lateral pterygoid plate. Below and medial to the mandibular fossa we see another projection from the sphenoid called the spine.

The irregular space lying lateral to the pterygoid process is called the infratemporal fossa. Its roof is formed mainly by the infratemporal surface of the greater wing of the sphenoid, with a small contribution from the squamous temporal. More laterally the fossa communicates with the temporal fossa through the gap between the zygomatic arch and the side of the skull. The anterior wall of the infratemporal fossa is formed by the posterior surface of the maxilla (Fig. 2.13). The lowest part of this surface (which corresponds to the posterior end of the alveolar process) forms a projection called the maxillary tuberosity. The medial wall is formed by the pterygoid process, but in its lower part it is formed by a small part of the palatine bone called the pyramidal process. The anterior and medial walls of the infratemporal fossa meet below, but they are separated in the upper part by the pterygomaxillary fissure. The fissure is continuous above with the inferior orbital fissure.

The pterygomaxillary fissure leads into a space called the pterygopalatine fossa which is described below.

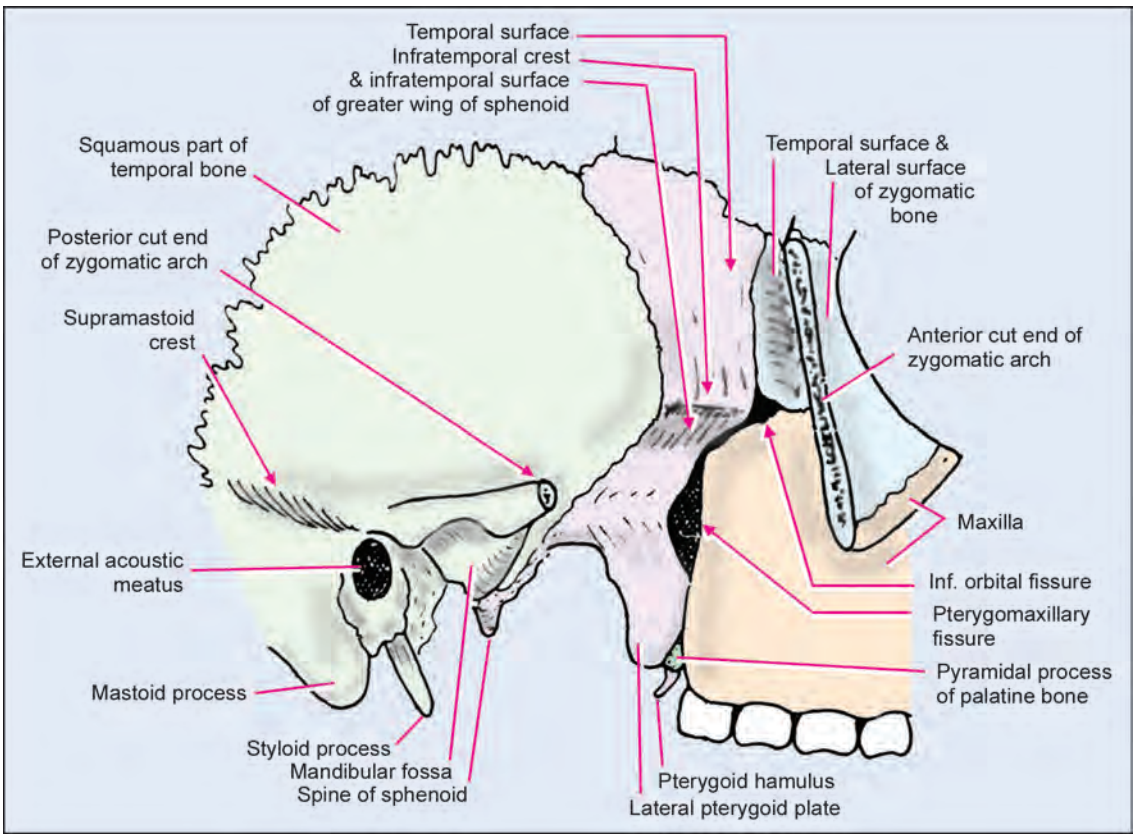


Fig. 2.18: Some details seen on the lateral aspect of the skull after removing the zygomatic arch

The Pterygopalatine Fossa

The walls of the pterygopalatine fossa are difficult to see. They are shown somewhat schematically (Fig. 2.19). The fossa has an anterior wall formed by the posterior surface of the maxilla; a posterior wall formed by the root of the pterygoid process; and a medial wall formed mainly by a part of the palatine bone (called the perpendicular plate) which separates the fossa from the nasal cavity. The uppermost part of the medial wall is formed by the body of the sphenoid bone. Laterally, the pterygopalatine fossa opens into the infratemporal fossa through the pterygomaxillary fissure. Above, the fossa communicates with the orbit through the inferior orbital fissure. The posterior wall of the fossa presents three openings. The upper and largest of these is the anterior end of the foramen rotundum (the other end of which opens into the middle cranial fossa). Below this there is the opening of the pterygoid canal. (The posterior end of this canal opens on the anterior wall of the foramen lacerum).

Still lower down on the posterior wall there is the opening of the palatinovaginal canal. The medial wall of the fossa shows a large sphenopalatine foramen through which the fossa communicates with the nasal cavity. Inferiorly, the fossa is closed on the surface by meeting of the maxilla and the pterygoid process, but at a deeper plane there is an opening in the floor of the fossa which leads into the greater palatine canal (which opens inferiorly on the posterior part of the palate).

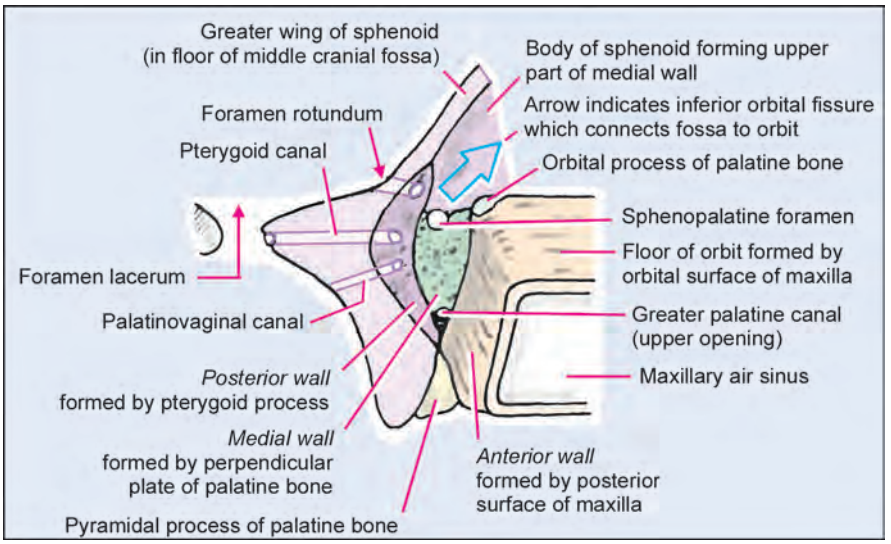


Fig. 2.19: Scheme to show the walls of the pterygopalatine fossa

Attachments on the Skull seen from the Lateral side

1. In the anterior part of the skull we see the attachments of several muscles of the face. These have already been described (Fig. 2.20).
2. The masseter arises from the zygomatic arch (lower border and deep surface).
3. The buccinator arises from the lateral aspect of the maxilla (a little above the three molar teeth). Note that this muscle also arises from the mandible.
4. The lateral pterygoid arises by two heads. The lower head arises from the lateral surface of the lateral pterygoid plate. The upper head arises from the infratemporal surface and crest of the greater wing of the sphenoid bone.
5. The superficial slip of the medial pterygoid muscle arises from the lateral aspect of the pyramidal process of the palatine bone and from the maxillary tuberosity (The main part of the muscle arises from the medial surface of the lateral pterygoid plate).
6. The temporalis arises from the whole of the temporal fossa. The area of origin is bounded above by the temporal line and below by the zygomatic arch. It includes parts of the frontal, parietal, and squamous temporal bones; and of the greater wing of the sphenoid bone.
7. The sternocleidomastoid muscle is inserted into the lateral half of the superior nuchal line; and into the lateral surface of the mastoid process (from its apex to its superior border).
8. The trapezius arises from the medial one third of the superior nuchal line, and from the external occipital protuberance (The attachment is better seen from below).
9. The occipitalis (or occipital belly of the occipitofrontalis) arises from the lateral part of the highest nuchal line and from the mastoid process.
10. The splenius capitis is inserted into the mastoid process and into the occipital bone just below the lateral one-third of the superior nuchal line (deep to the sternocleidomastoid).
11. The longissimus capitis is inserted into the mastoid process deep to the splenius capitis.
12. The styloid process gives attachment to the following:
    a. The stylohyoid muscle arises from its posterior aspect.

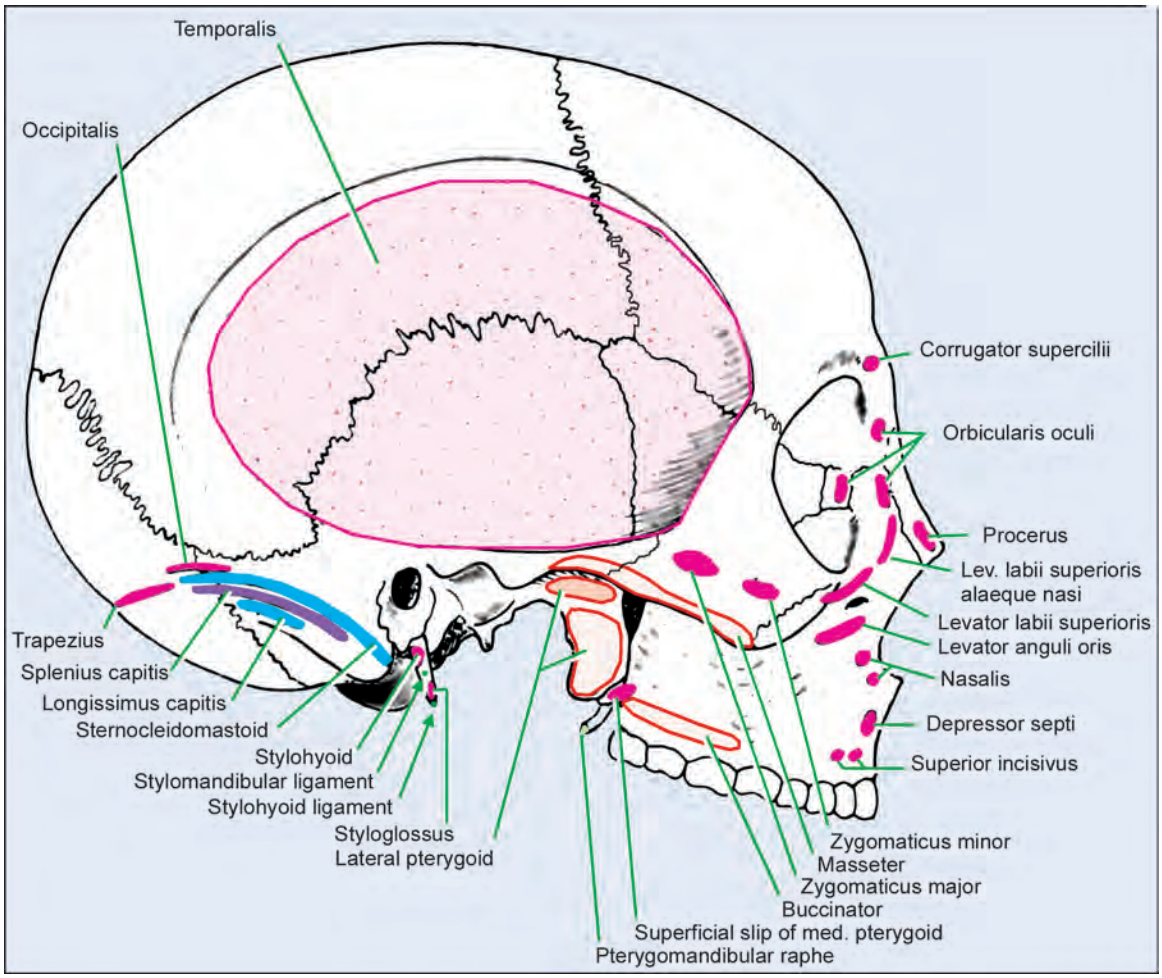


Fig. 2.20: Attachments on the skull, seen from the lateral side

b. The styloglossus muscle arises from its anterior aspect near the tip.
c. The stylopharyngeus muscle arises from its medial aspect.
d. The stylohyoid ligament is attached to its tip.
e. The stylomandibular ligament it attached to its lateral side.

THE SKULL AS SEEN FROM BELOW

The base of the skull presents a very large number of named features. The various bones that make up the base have been identified (Fig. 2.6). We shall now examine the features to be seen on each of these bones when the skull is viewed from below.

A. Note the following in the Figure 2.21.

In the anterior part of the skull we see the inferior aspect of the right and left maxillae. The alveolar process of the maxilla projects downward and provide attachment to the upper teeth. The posterior end of each alveolar process forms a backward projection called the maxillary tuberosity. Within the concavity of the alveolar arch (i.e., the arch formed by the alveolar process) we see the bony

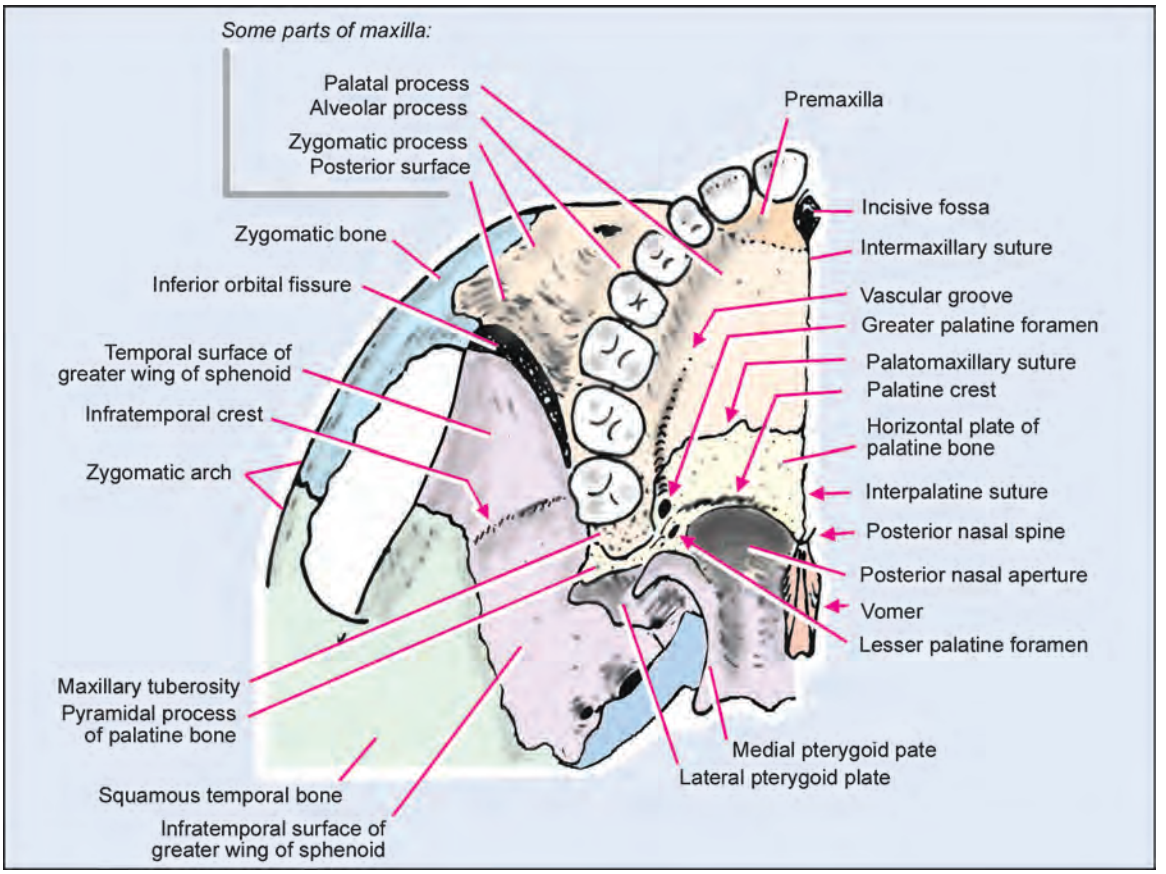


Fig. 2.21: Anterior part of the skull seen from below

palate which separates the nasal cavities (above) from the cavity of the mouth (below). The anterior part of the palate is formed by the palatal processes of the maxillae. The right and left processes meet in the midline at the intermaxillary suture. Overlying the anterior part of this suture there is a depression, the incisive fossa. On the side walls of this fossa we can see the lateral incisive foramina. In some skulls instead of the lateral incisive foramina there may be two median incisive foramina—anterior and posterior. The part of the alveolar process bearing the incisor teeth, and including the adjoining part of the palate is called the premaxilla. In the young a suture may be seen separating the premaxilla from the rest of the maxilla. Lateral to the alveolar arch we see the inferior aspect of the zygomatic process of the maxilla as it passes laterally to meet the zygomatic bone. We also see the posterior surface of the maxilla which is separated (posterolaterally) from the greater wing of the sphenoid by the inferior orbital fissure.

The posterior part of the palate is formed by the palatine bones. This part of each palatine bone is called the horizontal plate. The right and left palatine bones articulate with each other at the interpalatine suture. They articulate with the posterior margins of the palatal processes of the maxillae at the palatomaxillary sutures. The posterior borders of the horizontal plates of the palatine bones are free and form the posterior margin of the hard palate. In

the midline the margin projects backwards beyond the rest of it forming the posterior nasal spine. A little in front of the posterior border we see a curved ridge called the palatine crest. The posterolateral part of the horizontal plate gives off a projection called the pyramidal process. This process projects backwards and laterally. We have already seen that it occupies the gap between the lower ends of the medial and lateral pterygoid plates. It has been viewed from the lateral side (Fig. 2.18) and from behind (Fig. 2.13) and it is now seen from below.

The part of the palate formed by the palatine bone shows the greater and lesser palatine foramina. The greater palatine foramen lies on the most lateral part of the horizontal plate, just medial to the last molar tooth. It is the lower opening of the canal of the same name already seen in relation to the floor of the pterygopalatine fossa. Anteriorly, the foramen is continuous with a vascular groove that runs forward along the lateral margin of the palate. The lesser palatine foramina, usually two, are present on the pyramidal process just behind the greater palatine foramen.

Just above the posterior margin of the hard palate there are two posterior nasal apertures. (Note that as the skull is being viewed from below the palate appears to form the roof of the aperture, but is really the floor). Each aperture is bounded, below, by the posterior edge of the horizontal plate of the palatine bone. The lateral wall of the aperture is formed by another part of the palatine bone which is called the perpendicular plate. As indicated by its name the perpendicular plate is placed at right angles to the horizontal plate. The posterior edge of the perpendicular plate is fused to the medial pterygoid plate of the sphenoid bone, the two together forming a flat plate of bone that forms the lateral wall of the region where the nose and pharynx meet. The perpendicular plate separates the nasal cavity from the pterygopalatine fossa. At this stage it is useful to recapitulate the various parts of the palatine bone. These are the horizontal and perpendicular plates, the pyramidal process, and the orbital process (which forms a small part of the floor of the orbit). A small part of the palatine bone, called the sphenoidal process has not been mentioned so far. It projects medially from the upper end of the perpendicular plate and takes part in forming the roof of the posterior nasal aperture (Fig. 2.22).

The vomer is a flat plate of bone that forms part of the nasal septum. It has been seen through the anterior nasal aperture (Fig. 2.8). Now we see it separating the right and left posterior nasal apertures (Fig. 2.21). Superiorly, the plate of bone forming the vomer divides into two alae that articulate with the inferior surface of the body of the sphenoid (Fig. 2.22).

B. Note the following features to be seen on the sphenoid bone (Figs 2.21 to 2.25).

The sphenoid bone is large, extending across the entire width of the base of the skull and extending also onto the side wall of the vault. It is made up of several parts that have already been encountered. These are the body (which is median in position), the right and left greater and lesser wings, and the right and left pterygoid processes.

When viewed from below the body of the sphenoid is seen in the roof of the posterior part of the nasal cavity and of the adjoining nasopharynx. The region is irregular and presents a number of plates and canals. Details of these are difficult to appreciate in the actual specimen. They are shown diagrammatically in the Figure 2.22. Projecting downwards from the body of the sphenoid there is a median ridge called the rostrum. The rostrum of the sphenoid bone fits into the gap between the alae of the vomer. Projecting medially from the root of the pterygoid process there is a horizontal vaginal plate which overlaps the lateral part of the ala. Projecting medially from the upper part of the perpendicular plate of the palatine bone there is its sphenoidal process which overlaps the (anterior part of the) vaginal plate. The palatovaginal canal is placed between these two plates. It runs forwards to open on the posterior wall of the pterygopalatine fossa.

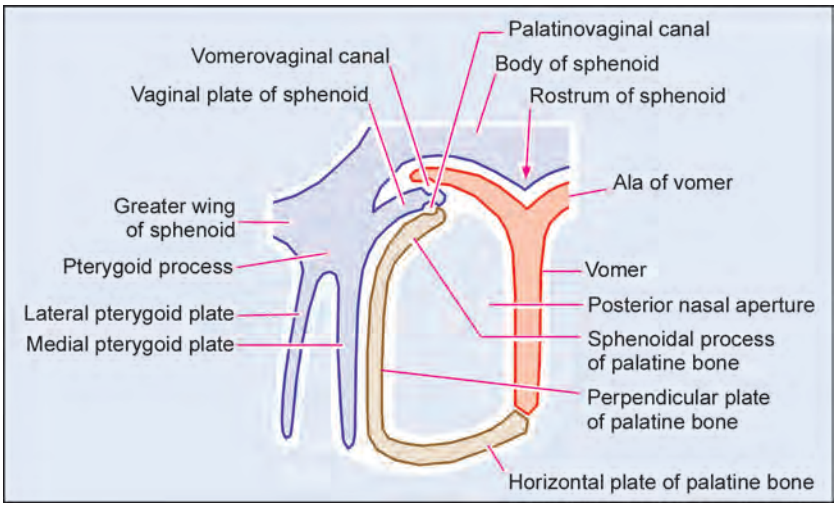


Fig. 2.22: Scheme to show the bones around the posterior nasal aperture

The vomerovaginal canal is not always present: when present it lies between the vaginal plate of the sphenoid and the ala of the vomer. It runs forwards to join the palatinovaginal canal. Posteriorly, the body of the sphenoid is directly continuous with the basilar part (or body) of the occipital bone.

The pterygoid process has already been seen from the lateral aspect (Fig. 2.18). We have seen that it projects downward from the junction of the body of the sphenoid with the greater wing, and that it consists of medial and lateral pterygoid plates. These plates meet anteriorly, but posteriorly they are free. The space between them is called the pterygoid fossa. Anteriorly, the pterygoid process is fused to the posterior aspect of the maxilla in its middle part. Higher up it is separated from the maxilla by the pterygomaxillary fissure. In the Figure 2.24A note how the perpendicular plate of the palatine bone closes the pterygopalatine fossa medially, and at the same time meets the anterior margin of the medial pterygoid plate. In their lowest parts the pterygoid plates are separated by a gap (Fig. 2.23) which is filled by the pyramidal process of the palatine bone (Figs 2.24C and 2.25). This process can be seen from behind forming the lower part of the floor of the pterygoid fossa (Fig. 2.13) and also from the lateral side, in the medial wall of the infratemporal fossa (Fig. 2.18).

The medial pterygoid plate is directed backwards so that it has medial and lateral surfaces, and a free posterior border. The upper end of this border divides to enclose a triangular depression called the scaphoid fossa (Fig. 2.25). Medial to this fossa there is a small tubercle which projects into the foramen lacerum. It hides from view the posterior opening of the pterygoid canal; the anterior end of this canal opens on the posterior wall of the pterygopalatine fossa. The lower end of the posterior border is prolonged downwards and laterally to form the pterygoid hamulus.

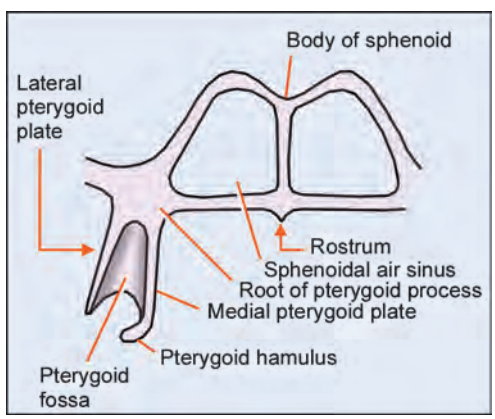
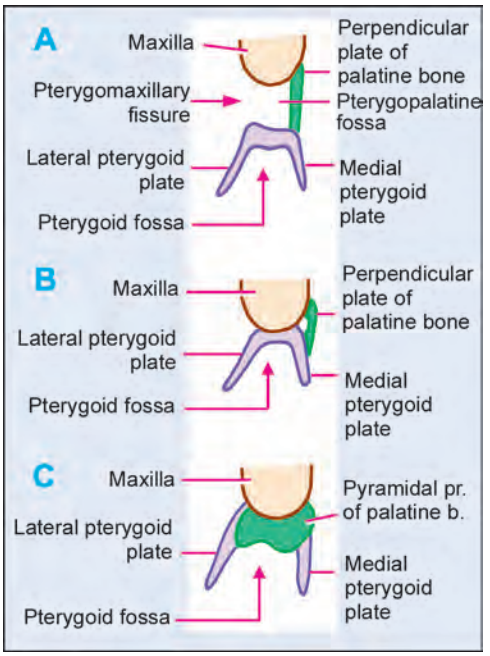


Fig. 2.23: Schematic coronal section to show relationship of the pterygoid process to the rest of the sphenoid bone



Figs 2.24A to C: Schematic transverse sections to show the arrangement of the medial and lateral pterygoid plates at (A) Upper; (B) Middle; (C) Lower levels

The lateral pterygoid plate projects backward and laterally. It has medial and lateral surfaces. At its upper end its lateral surface becomes continuous with the infratemporal surface of the greater wing (Figs 2.18 and 2.23).

The greater wing of the sphenoid (Fig. 2.25) has infratemporal and temporal surfaces that can be seen from below; and an orbital surface that has already been seen in the lateral wall of the orbit (Fig. 2.12). The temporal surface has been described earlier. The anterior margin of the infratemporal surface is separated from the maxilla by the inferior orbital fissure. Laterally, it is separated from the temporal surface by the infratemporal crest. The posterior margin of the lateral part of the infratemporal surface articulates with the infratemporal surface of the squamous part of the temporal bone.

Medially, the infratemporal surface of the greater wing is continuous with the body of the sphenoid. Posteriorly, the greater wing meets the anterior margin of the petrous temporal bone.

Two important foramina are seen near the posterior border of the greater wing. The foramen ovale lies posterolateral to the upper end of the lateral pterygoid plate. Posterolateral to the foramen ovale there is a smaller round foramen called the foramen spinosum. It is so called because it lies just in front of a downward projection called the spine of the sphenoid. A third small foramen is sometimes seen medial to the foramen ovale. It is called the emissary sphenoidal foramen (Figs 2.25 and 2.26). Between the foramen ovale and the foramen spinosum another small foramen the canaliculus innominatus may be present. Posteromedial to these foramina, and to the spine of the sphenoid, the posterior margin of the greater wing forms the anterior wall of a prominent groove. The posterior wall of this groove is formed by the petrous temporal bone. The two bones meet in the floor of the groove which is meant for the cartilaginous part of the auditory tube. Traced laterally, the groove ends in relation to the opening of the bony part of the auditory tube.

Additional features on the temporal and occipital bones (Figs 2.25 and 2.27).

In earlier pages we have seen that the temporal bone consists of squamous, petrous, mastoid and tympanic parts, and that the styloid process also belongs to it. Several landmarks that have been identified on the bone from the lateral aspect (Fig. 2.17) can be seen again from below. These are the zygomatic process, the tubercle of the root of the zygoma, the postglenoid tubercle, the mastoid process, the tympanic plate, the squamotympanic fissure, and the styloid process. We shall now examine some further details.

The squamous part of the temporal bone has a temporal surface that has been seen from the lateral aspect; part of it can be seen from below. Inferior and medial to the temporal surface the squamous part has an infratemporal surface which takes part in forming the roof of the infratemporal fossa (along with the infratemporal surface of the greater wing

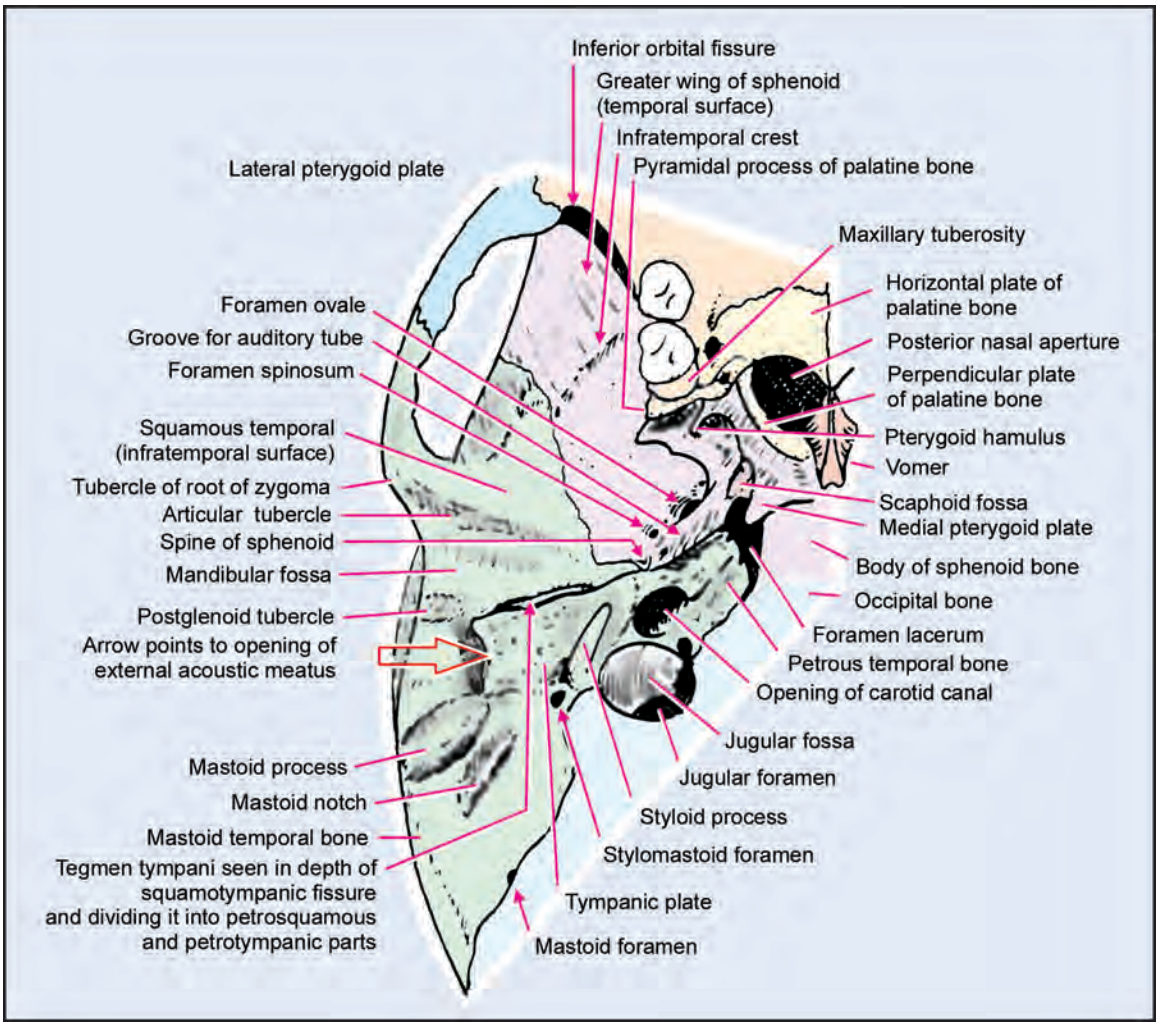


Fig. 2.25: Part of the base of the skull formed by the temporal and sphenoid bones. Some adjoining areas are also shown

of the sphenoid). Behind its infratemporal surface, the squamous part bears the mandibular fossa. This fossa is bounded anteriorly by a rounded eminence called the articular tubercle. The articular area for the mandible extends on to the tubercle.

The tympanic plate separates the mandibular fossa from the external acoustic meatus. (The arrow in the Figure 2.25 points to the opening of the meatus which cannot be seen from below). The junction of the fossa (squamous part) with the tympanic plate is marked by the squamotympanic fissure. Projecting through the fissure we sometimes see the lower edge of a plate of bone called the tegmen tympani. The tegmen tympani belongs to the petrous part of the temporal bone. When present it divides the squamotympanic fissure into a petrosquamous part (anteriorly), and a petrotympanic part (posteriorly). The posterior part of the tympanic plate partially surrounds the base of the styloid process and is fused with the mastoid part of the temporal bone.

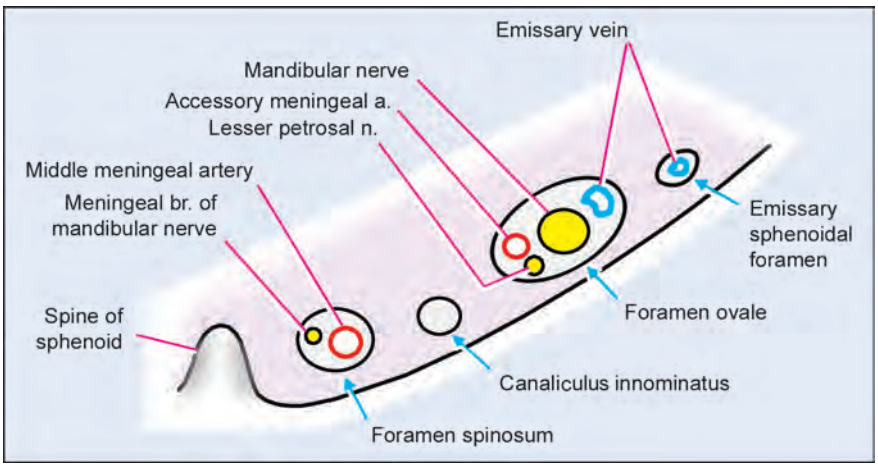


Fig. 2.26: Structures passing through the foramen ovale, and through smaller foramina near it. The lesser petrosal nerve sometimes passes through the canaliculus innominatus

We have already seen that the plate has a rough lateral margin surrounding the opening of the external acoustic meatus.

The petrous part of the temporal bone runs forwards and medially between the greater wing of the sphenoid (anterolaterally), and the occipital bone (posteromedially). Its apex is separated from the body of the sphenoid, the root of the pterygoid process, and the basilar part of the occipital bone by a very irregular aperture called the foramen lacerum. The inferior surface of the petrous temporal bone is marked by a large round opening. This is the lower opening of the carotid canal through which the internal carotid artery enters the cranial cavity. The canal passes medially, through the substance of the petrous temporal bone and opens into the posterior wall of the foramen lacerum. Behind the opening of the carotid canal there is another large depression, the jugular fossa. This fossa leads posteriorly into the jugular foramen which is bounded posteriorly and below by the occipital bone, and opens into the posterior cranial fossa.

In the mastoid part of the temporal bone we have already noted the presence of the mastoid process, and of the mastoid foramen. Medial to the mastoid process there is a deep mastoid notch. Near the anterior end of the notch, and just behind the styloid process we see the stylomastoid foramen. Medial to the mastoid notch the bone is grooved by the occipital artery.

The greater part of the occipital bone is seen when the skull is viewed from below. The most conspicuous feature on it is the large foramen magnum through which the cranial cavity communicates with the vertebral canal. The part of the bone anterior to the foramen magnum is the basilar part. Anteriorly, the basilar part is directly continuous with the body of the sphenoid bone. These two bones are separated by a plate of cartilage in the young, but fuse with each other in the adult. (In Figure 2.25 the position of this cartilage is shown in dotted line). A short distance in front of the foramen magnum the basilar part shows a small elevation in the midline called the pharyngeal tubercle.

The parts of the occipital bone lateral to each side of the foramen magnum are its lateral (or condylar) parts. Here we see the prominent occipital condyles. The long axis of each condyle is directed forwards and medially, the condyle being markedly convex in this direction. Each condyle (right or left) articulates with the corresponding superior articular facet on the atlas vertebra to form an

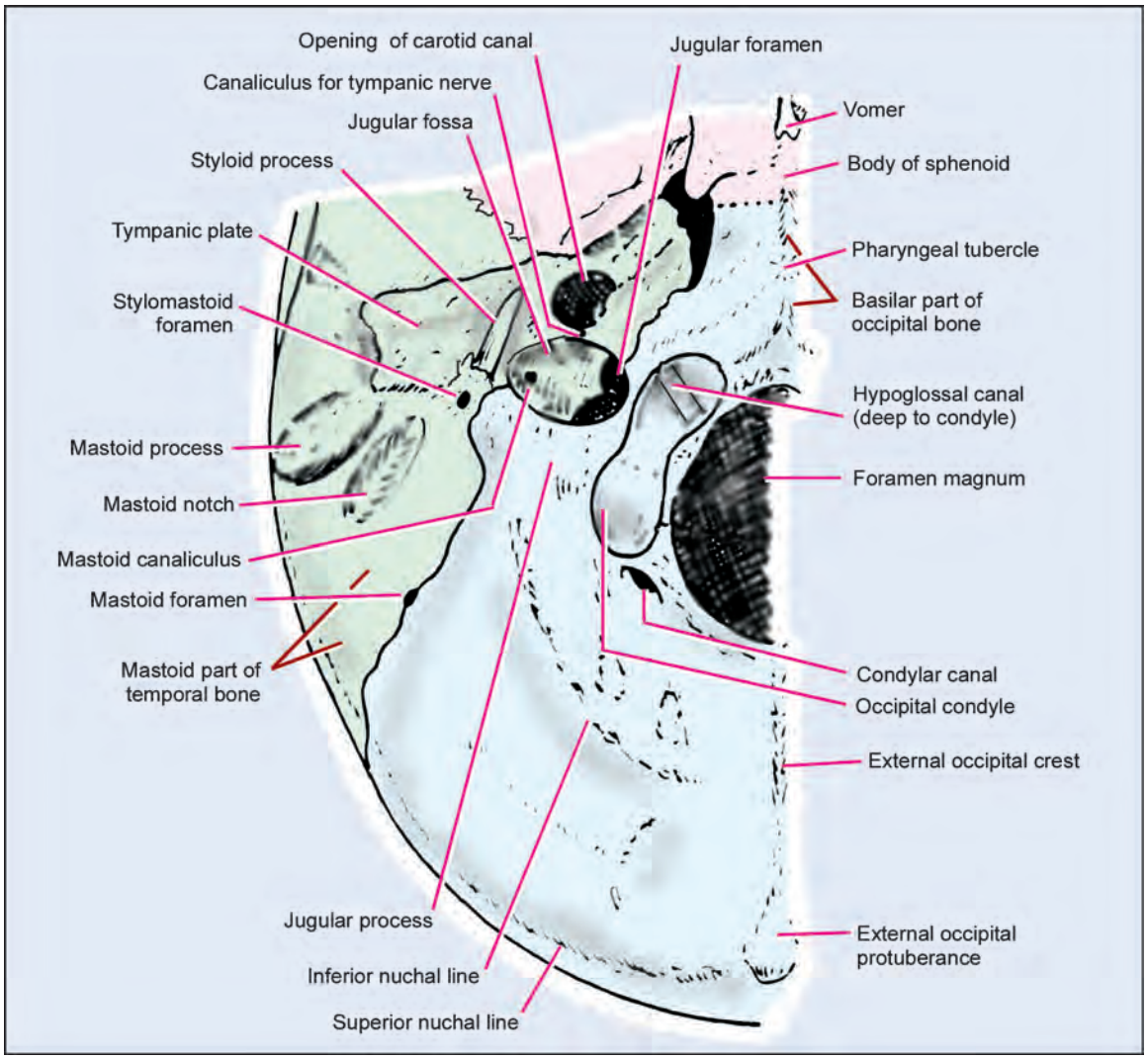


Fig. 2.27: Posterior part of base of skull (formed by the temporal and occipital bones)

atlanto-occipital joint. There are two canals closely related to the occipital condyles. The hypoglossal (or anterior condylar) canal opens on the surface of the skull just above the lateral border of the anterior part of the condyle, and is hidden from view by the condyle. (It is, therefore, shown in dotted line). The canal runs backward to open into the posterior cranial fossa. Behind the condyle there is a depression, the condylar fossa in which the opening of the posterior condylar canal is sometimes seen.

The part of the occipital bone lateral to the condyle is called the jugular process. It forms the posterior (and inferior) wall of the jugular fossa and foramen. The jugular foramen passes backward and medially from the fossa. It is often partially divided by projecting spicules of bone into anterior, middle and posterior parts. The position of two small foramina present in relation to the jugular fossa should be noted. One is present on the lateral wall of the fossa and is called the mastoid canaliculus. The

other is present on the ridge of bone that separates the jugular fossa from the opening of the carotid canal: this is the canaliculus for the tympanic nerve (tympanic canaliculus).

The part of the occipital bone behind the foramen magnum is the squamous part. It articulates with the mastoid part of the temporal bone at the occipitomastoid suture, on or near which we see the mastoid foramen. Posteriorly, the squamous part forms the posterior part of the vault of the skull and joins the right and left parietal bones at the lambdoid suture. Its external surface is marked by the external occipital protuberance; the external occipital crest; the inferior, superior and highest nuchal lines; and by numerous unnamed ridges that give it a rough surface for muscular attachments.

The attachments on the base of the skull are described below.

Attachments on the Skull as seen from Below

1. The masseter arises from the lower border of the zygomatic arch (Fig. 2.28).
2. The upper head of the lateral pterygoid arises from the infratemporal surface and infratemporal crest of the greater wing of the sphenoid. The lower head of the muscle arises from the lateral surface of the lateral pterygoid plate.
3. The medial pterygoid arises from the medial surface of the lateral pterygoid plate and from the pyramidal process of the palatine bone.
4. The tensor palati arises from the scaphoid fossa, from the medial side of the spine of the sphenoid, and from the posterior margin of the greater wing of the sphenoid. It is inserted into the posterior edge of the palatine bone.
5. The tensor tympani arises from the greater wing of the sphenoid (and from the adjoining part of the wall of the auditory tube).
6. The levator palati arises from the inferior surface of the petrous temporal bone.
7. The musculus uvulae arises from the posterior edge of the hard palate near the midline (i.e., from the posterior nasal spine).
8. The posterior belly of the digastric muscle arises from the mastoid notch on the temporal bone.
9. The longus capitis is inserted into the inferior surface of the basilar part of the occipital bone.
10. The rectus capitis anterior is inserted into the occipital bone just in front of the condyle.
11. The rectus capitis lateralis is inserted into the inferior surface of the jugular process of the occipital bone.
12. The rectus capitis posterior major is inserted into the lateral part of the area between the inferior nuchal line and the foramen magnum.
13. The rectus capitis posterior minor is inserted into the medial part of the area between the inferior nuchal line and the foramen magnum.
14. The semispinalis capitis is inserted into the medial part of the area between the superior and inferior nuchal lines.
15. The obliquus capitis superior is inserted into the lateral part of the area between the superior and inferior nuchal lines.
16. The trapezius arises from the medial one-third of the superior nuchal line and from the external occipital protuberance.
17. Other muscles whose attachments are seen in Figure 2.27 are the occipitalis, the sternocleidomastoid, the splenius capitis, and the longissimus capitis.
18. The pharyngeal tubercle (on the basilar part of the occipital bone) gives attachment to the uppermost fibres of the superior constrictor muscles of the pharynx. It also gives attachment to the upper end of a fibrous raphe that receives the insertion of lower fibres of these muscles.
19. The pterygomandibular ligament is attached to the tip of the pterygoid hamulus.
20. The pterygospinous ligament extends between the spine of the sphenoid and the upper part of the lateral pterygoid plate.

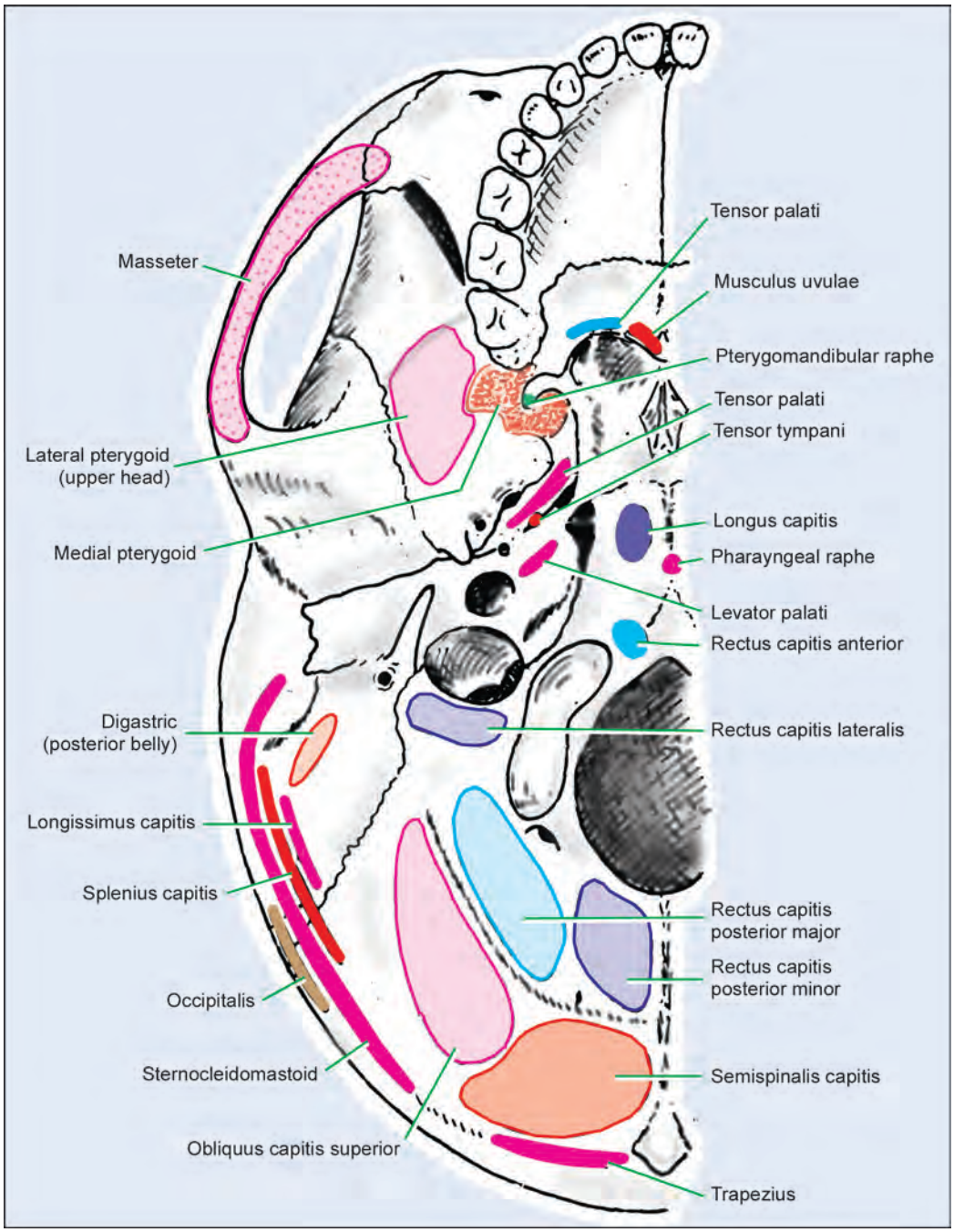


Fig. 2.28: Attachments on the skull seen from below

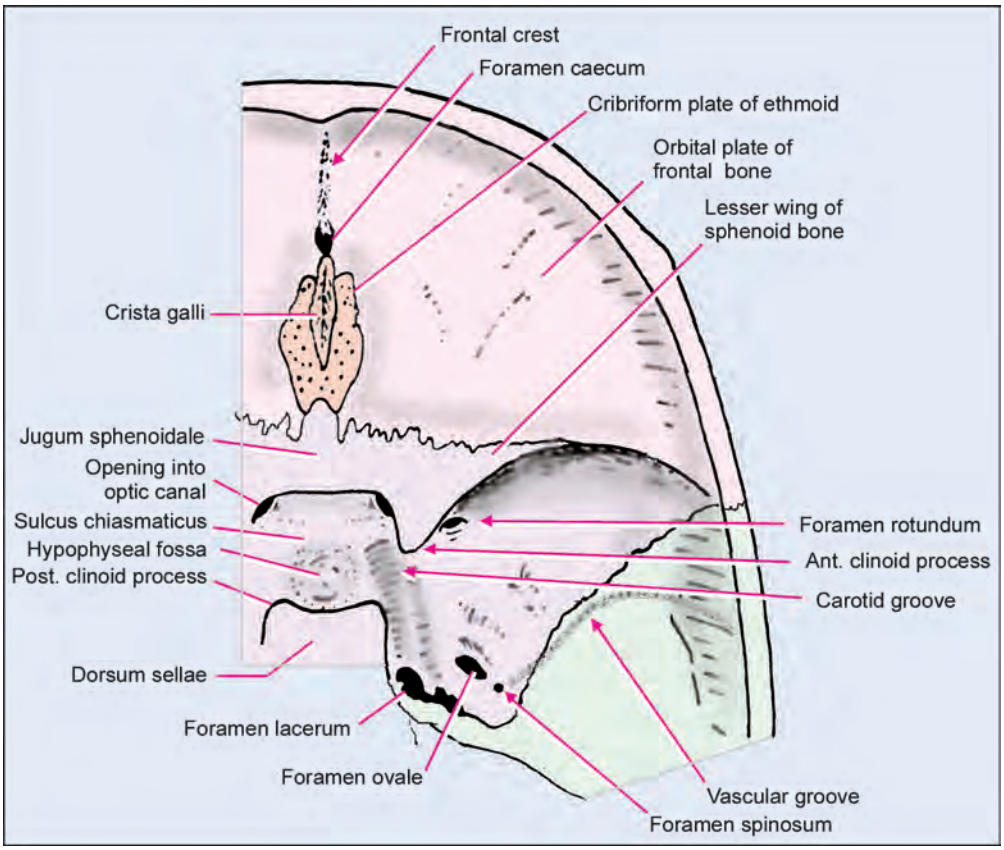


Fig. 2.29: Parts of the anterior and posterior cranial fossae seen from above. Compare with Figure 2.7

21. The sphenomandibular ligament is attached to the spine of the sphenoid.
22. The upper end of the ligamentum nuchae is attached to the external occipital protuberance, and to the external occipital crest.
23. The alar ligaments (of the dens) are attached to the occipital bone just medial to the condyles.
24. The anterior and posterior atlanto-occipital membranes are attached to corresponding margins of the foramen magnum.

THE CRANIAL FOSSAE

When the upper part of the vault of the skull is removed we can see the floor of the cranial cavity (or, in other words, the base of the skull as seen from above) (Figs 2.29 to 2.31). We have seen that the floor is subdivided into anterior, middle and posterior cranial fossae. The bones to be seen have been identified. We shall now examine the fossae in greater detail.

The floor of the anterior cranial fossa (Fig. 2.29) is formed mainly by the orbital plates (right and left) of the frontal bone. Anteriorly, the right and left halves of the frontal bone are separated by a median projection called the frontal crest. Just behind the crest there is a depression called the foramen caecum.

Between the right and left orbital plates of the frontal bone there is a notch occupied by the cribriform plate of the ethmoid bone. This plate has numerous foramina. It also bears a median vertical projection called the crista galli which lies immediately behind

the foramen caecum. The anterior and posterior ethmoidal canals (already seen on the medial wall of the orbit) open into the anterior cranial fossa near the lateral edge of the cribriform plate, but they are difficult to see. The posterior part of the floor of the anterior cranial fossa is formed by the sphenoid bone. In the median part it is formed by the anterior part of the superior surface of the body of the sphenoid: this region is called the jugum sphenoidale. Lateral to the jugum sphenoidale the floor is formed by the lesser wing of the sphenoid. The lesser wing also forms the sharp posterior edge of the floor of the anterior cranial fossa. The medial edge of each lesser wing projects backward as the anterior clinoid process.

The middle cranial fossa (Figs 2.29 to 2.31) has a raised median part formed by the body of the sphenoid bone, and two large deep hollow areas on either side (Fig. 2.30). The features to be seen in relation to the body of the sphenoid are as follows. Immediately behind the jugum sphenoidale the body of the sphenoid is crossed by a transverse shallow groove that connects the two optic canals, and is called the sulcus chiasmaticus (even though the optic chiasma does not lie over the sulcus). Behind the sulcus the superior surface of the body

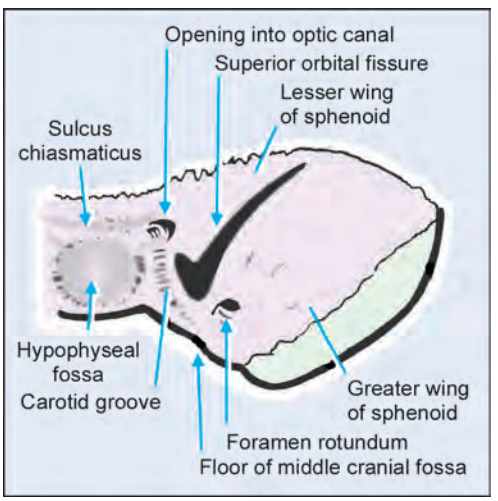


Fig. 2.30: Schematic diagram to show some features in the anterior wall of the middle cranial fossa

of the sphenoid shows a median elevation, the tuberculum sellae; and behind the tuberculum there is a depression called the hypophyseal fossa. Posterior to the fossa there is a vertical plate of bone called the dorsum sellae. The deep hollow bounded anteriorly by the tuberculum sellae, and posteriorly by the dorsum sellae is called the sella turcica. The superolateral angles of the dorsum sellae are called the posterior clinoid processes. The sides of the body of the sphenoid slope downwards (Fig. 2.30) into the floor of the deep lateral part of the middle cranial fossa. In this situation each side of the body of the sphenoid is marked by a shallow carotid groove. Posteriorly, the groove becomes continuous with the foramen lacerum. Anteriorly, it turns upward medial to the anterior clinoid process.

On either side, the anterior wall of the middle cranial fossa is formed (Fig. 2.30) by the greater and lesser wings of the sphenoid. The lesser wings are attached to the sides of the body of the sphenoid by two roots: anterior (or upper), and posterior (or lower). The optic canal passes forwards and laterally between the body of the sphenoid and the two roots of the lesser wing. The greater and lesser wings are separated by the superior orbital fissure which leads into the orbit. Just below the medial end of the fissure, and just lateral to the carotid groove we see the foramen rotundum. We have already noted that this foramen opens anteriorly into the pterygopalatine fossa.

The posterior wall of the middle cranial fossa (Fig. 2.31) is formed, on either side, by the anterior sloping surface of the petrous temporal bone. The apex of the bone is separated from the body of the sphenoid by the foramen lacerum already seen from below. A little above and lateral to the foramen the surface of the petrous temporal bone shows a shallow depression called the trigeminal impression. Lateral to this impression we see two grooves running downwards and medially. The upper and more prominent groove begins at a minute aperture called the hiatus for the greater petrosal nerve. Below and lateral to it we have another groove which begins at

the hiatus for the lesser petrosal nerve. More laterally, the anterior surface is marked by an elevation called the arcuate eminence.

Lateral to the arcuate eminence the anterior surface of the petrous temporal bone is formed by a thin plate of bone that separates the middle cranial fossa from the cavities of the middle ear, the auditory tube and the mastoid antrum. This plate is called the tegmen tympani. It is the lower end of this plate which appears in the squamotympanic fissure.

The floor of the deep lateral part of the middle cranial fossa is formed by the greater wing of the sphenoid, medially, and by the squamous part of the temporal bone, laterally. Near the posterior margin of the greater wing we see the foramen ovale, the foramen spinosum, and sometimes the emissary sphenoidal foramen, all of which have already been seen from below. The lateral wall of the middle cranial fossa is formed, anteriorly, by the greater wing of the sphenoid, and posteriorly by the squamous temporal bone. The anteroinferior angle of the parietal bone contributes to the most anterior part of the lateral wall (in the region of the pterion). A vascular groove (for the middle meningeal vessels) starts at the foramen spinosum and runs forwards on the floor. It divides into an anterior (or frontal) branch and a posterior (or parietal) branch. The frontal branch runs upward and forward to the region of the inner surface of the pterion: here the groove is often converted into a canal. It then runs upward and backward on the inner surface of the parietal bone. The parietal branch runs backward first on the squamous temporal, and then on the parietal bone.

The most prominent landmark in the posterior cranial fossa (Fig. 2.31) is the foramen magnum already seen from below. Anterior to the foramen magnum the wall of the fossa is formed by the basilar part of the occipital bone which is continuous above with the posterior surface of the body of the sphenoid: this area is called the clivus. The lateral margin of the basilar part of the occipital bone is separated from the petrous temporal bone by the petro-occipital fissure, which ends below in the jugular foramen. We have already noted that projections from the walls of the foramen partially divide it into anterior, middle and posterior parts.

Between the jugular foramen, laterally, and the anterior part of the foramen magnum, medially, there is a rounded elevation called the jugular tubercle. In the interval between the jugular tubercle and the foramen magnum there is a fossa. The hypoglossal canal opens into this fossa. When present, the posterior condylar canal opens just lateral to the jugular tubercle immediately behind the jugular foramen. The lateral part of the anterior wall of the posterior cranial fossa is formed by the posterior surface of the petrous temporal bone. A little above the jugular foramen this surface presents the opening of the internal acoustic meatus. Posterolateral to this opening a slit in the bone leads into a canal called the aqueduct of the vestibule. The floor and lateral walls of the posterior cranial fossa are formed, posteriorly, by the squamous part of the occipital bone; and in the anterolateral part by the mastoid part of the temporal bone. The posteroinferior angle of the parietal bone makes a small contribution to the anterior part of the lateral wall. Behind the foramen magnum the two halves of the fossa are separated by a ridge called the internal occipital crest. Posteriorly, the crest ends in an elevation called the internal occipital protuberance. Running laterally from the protuberance, in the transverse plane, we see a prominent wide groove (transverse sulcus) in which the transverse sinus is lodged. The groove on the right side is generally more prominent than that on the left. The groove first lies on the occipital bone, and near its lateral (or anterior) end it crosses the posteroinferior angle of the parietal bone. It then runs downwards and medially with an S-shaped curve, deeply grooving the petrous and mastoid parts of the temporal bone to reach the jugular foramen. This S-shaped part of the groove is called the sigmoid sulcus. The terminal

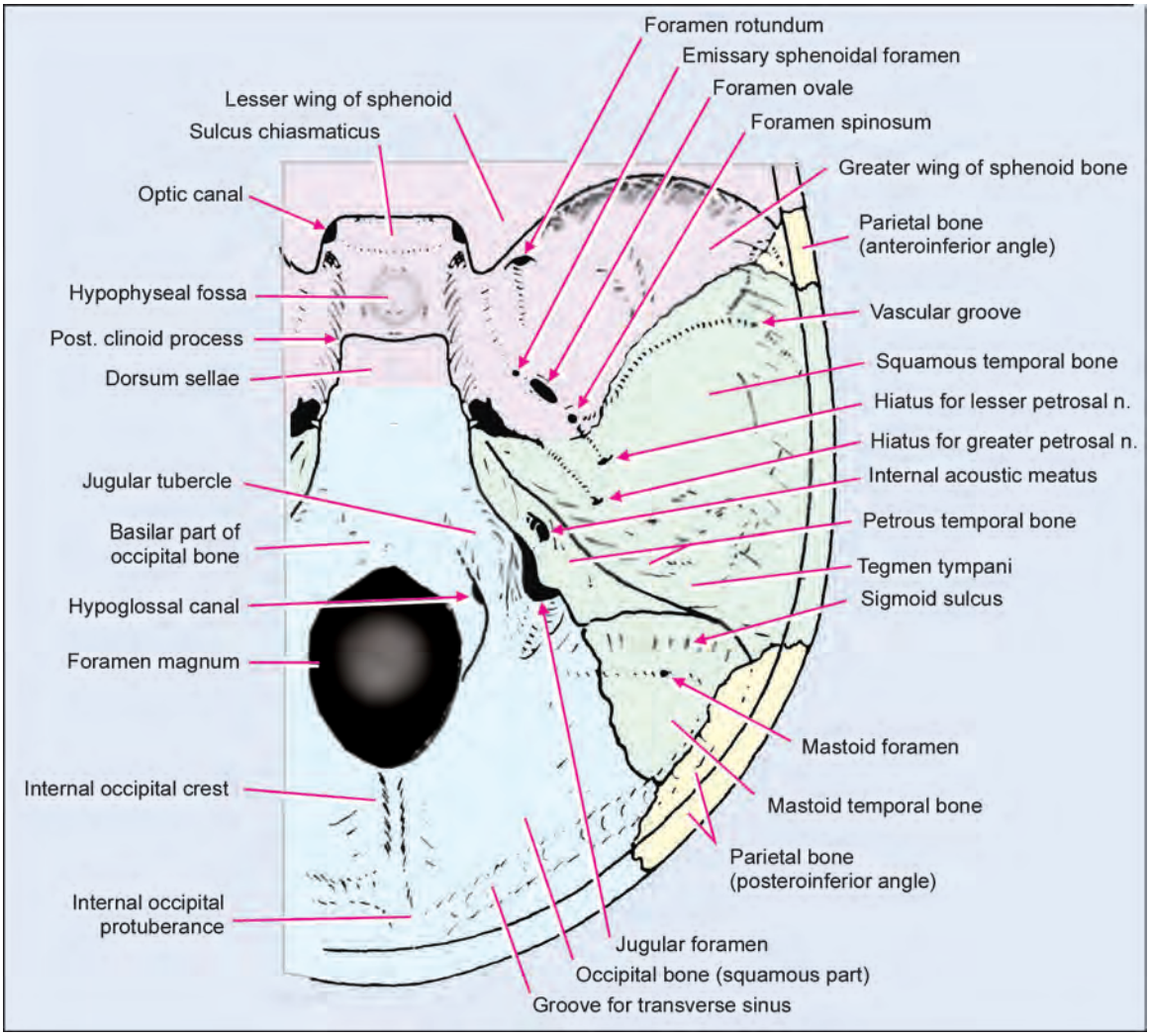


Fig. 2.31: Features to be seen in the floor of the middle and posterior cranial fossae. Compare with Figure 2.7

part of the groove lies on the occipital bone just behind the jugular foramen. The mastoid foramen (already seen on the external surface of the skull) opens into the part of the sigmoid sulcus formed by the mastoid temporal bone.

Foramina of the Skull

We have seen that the bones of the skull show numerous foramina, small and large. In this section we shall consider the structures passing through these foramina. We will first list those foramina that give passage to very important structures like cranial nerves, large blood vessels etc. This will be followed by a more complete listing of structures passing through individual foramina.

Most Important Foramina of the Skull

1. The lower end of the medulla oblongata passes through the foramen magnum to become continuous with the spinal cord.

2. The internal carotid artery enters the skull by passing through the carotid canal.
3. The junction of the upper end of the internal jugular vein with the sigmoid sinus lies in the jugular foramen.
4. Bundles of nerve fibres that constitute the olfactory nerve pass through minute apertures in the cribriform plate of the ethmoid bone. This plate intervenes between the nasal cavity and the anterior cranial fossa.
5. The optic nerve passes from the middle cranial fossa into the orbit through the optic canal.
6. The oculomotor, trochlear and abducent nerves enter the orbit through the superior orbital fissure.
7. The trigeminal nerve has three divisions, each of which leaves the middle cranial fossa through a different foramen. The ophthalmic division enters the orbit through the superior orbital fissure. The maxillary division passes into the foramen rotundum, while the mandibular division passes through the foramen ovale to reach the infratemporal region.
8. The facial nerve leaves the posterior cranial fossa by passing into the internal acoustic meatus. After a complicated course through the petrous part of the temporal bone, it leaves the cranial cavity through the stylomastoid foramen.
9. The vestibulocochlear nerve leaves the posterior cranial fossa by passing through the internal acoustic meatus, to reach the internal ear which lies within the substance of the petrous part of the temporal bone.
10. The glossopharyngeal, vagus and accessory nerves leave the posterior cranial fossa through the jugular foramen, to enter the neck.
11. The hypoglossal nerve leaves the posterior cranial fossa through the hypoglossal canal.

DETAILED LIST OF FORAMINA OF THE SKULL AND OF STRUCTURES PASSING THROUGH THEM

A. Foramina on the Anterior Aspect of the Skull (Fig. 2.8)

The supraorbital notch (or foramen), the infraorbital foramen, and the zygomatico-facial foramen transmit nerves and vessels of the same names.

B. Foramina in the Orbit (Figs 2.12, 2.32)

1. The optic canal transmits the optic nerve (surrounded by meninges); and the ophthalmic artery.
2. The structures passing through the superior orbital fissure are as follows (Fig. 2.32).

Through the upper (and lateral) part:

a. Trochlear nerve.
b. Frontal and lacrimal branches of the ophthalmic division of the trigeminal nerve.
c. Recurrent branch of the ophthalmic artery.
d. Superior ophthalmic vein.

Through the middle part (within the tendinous ring):

a. Superior and inferior divisions of oculomotor nerve.
b. Nasociliary branch of ophthalmic division of the trigeminal nerve.
c. Abducent nerve.

Through the lower (and medial) part:

a. Inferior ophthalmic vein.

3. The structures passing through the inferior orbital fissure are (Fig. 2.32):
   a. Maxillary nerve.
   b. Zygomatic nerve.
   c. Infraorbital vessels.
   d. Emissary veins connecting the inferior ophthalmic veins to the pterygoid plexus.
4. The infraorbital groove and canal transmit the infraorbital nerve (continuation of maxillary nerve) and the infraorbital vessels.

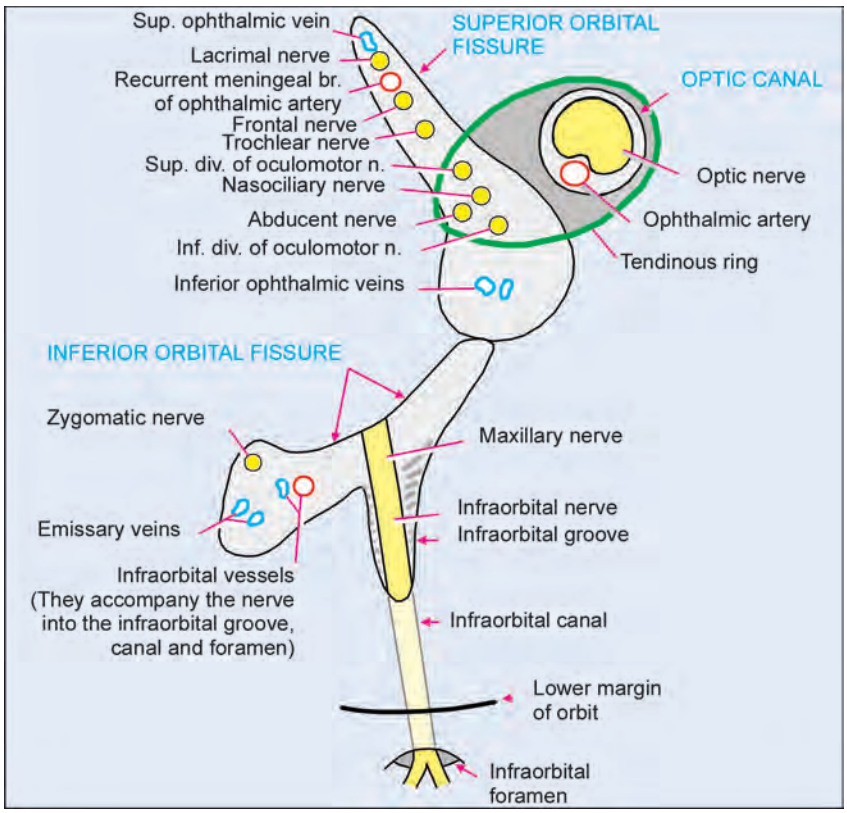


Fig. 2.32: Structures passing through the optic canal, the superior orbital fissure, and the inferior orbital fissure

5. The nasolacrimal canal transmits the nasolacrimal duct.
6. The lateral wall of the orbit has openings for the zygomaticotemporal and zygomaticofacial nerves and vessels. These structures pass through the thickness of the zygomatic bone.

   The zygomaticofacial nerve and vessels appear on the lateral surface of the bone through the zygomaticofacial foramen. The zygomaticotemporal nerves and vessels appear on the temporal surface of the bone (on the anterior wall of the temporal fossa) through the zygomaticotemporal foramen.
7. The medial wall of the orbit shows the openings of the anterior and posterior ethmoidal canals. The openings lie on the suture between the frontal and ethmoid bones. The canals pass through the interval between these bones to reach the floor of the anterior cranial fossa at the lateral edge of the cribriform plate. They transmit the anterior and posterior ethmoidal nerves and vessels.

C. Foramina seen on the Lateral Side of the Skull

1. The zygomaticotemporal foramen has been mentioned above.
2. The terminal part of the maxillary artery enters the pterygomaxillary fissure. The maxillary nerve passes across the upper part of the fissure.
3. The sphenopalatine foramen (in the medial wall of the pterygopalatine fossa (Fig. 2.19) gives passage to the nasopalatine nerve and vessels.

4. The mastoid foramen is traversed by an emissary vein connecting the sigmoid sinus to occipital veins.
5. The parietal foramen is traversed by an emissary vein connecting the superior sagittal sinus to the veins of the scalp.

D. Foramina seen on the Base of the Skull

Note that many of the foramina considered below are also seen in the floor of the cranial fossae.

1. The lateral incisive foramina are present in the lateral wall of the incisive fossa (Fig. 2.21). They lead into the incisive canals which transmit the terminal branches of the greater palatine vessels (from the palate to the floor of the nose); and of the nasopalatine nerves (from the nose to the palate). The right and left incisive foramina are sometimes replaced by anterior and posterior foramina; in that case the left nasopalatine nerve passes through the anterior foramen and the right through the posterior foramen.
2. The greater and lesser palatine foramina are seen on the posterior part of the palate (Fig. 2.21). They transmit nerves and vessels of the same names.
3. The foramen ovale (Fig. 2.26) transmits the mandibular division of the trigeminal nerve, the accessory meningeal artery, and emissary veins connecting the cavernous sinus to the pterygoid venous plexus. When the canaliculus innominatus is not present, the foramen ovale transmits the lesser petrosal nerve also.
4. The foramen spinosum (Fig. 2.26) transmits the middle meningeal artery, a meningeal branch of the mandibular nerve, and an emissary vein.
5. The canaliculus innominatus (Fig. 2.26) is not always present. When present, it transmits the lesser petrosal nerve.
6. The emissary sphenoidal foramen (present occasionally) transmits some veins connecting the cavernous sinus to the pterygoid plexus of veins.
7. The carotid canal and the foramen lacerum: When the skull is viewed from below, we see an opening on the inferior aspect of the petrous temporal bone. This is the lower opening of the carotid canal (Fig. 2.33). The canal itself passes forwards and medially through the substance of the petrous temporal bone and opens on the posterior wall of the foramen lacerum. The internal carotid artery enters the skull by passing through the carotid canal and through the upper part of the foramen lacerum. Inferiorly, the foramen lacerum is closed by

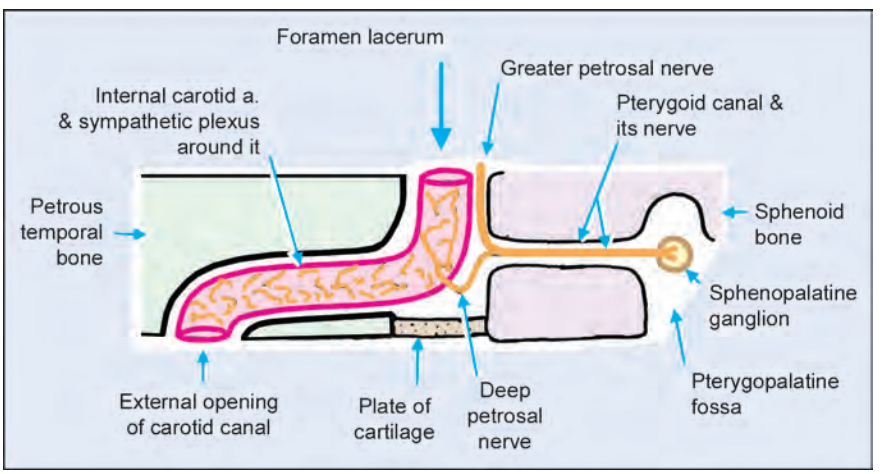


Fig. 2.33: Scheme to show the structures passing through the carotid canal and the foramen lacerum

a plate of cartilage. In addition to the internal carotid artery, the structures passing through the carotid canal and the foramen lacerum include: (a) the sympathetic plexus on the artery; (b) and a venous plexus which connects the cavernous sinus with the pharyngeal venous plexus. In addition, the foramen contains (c) the deep petrosal nerve which arises from the sympathetic plexus, in the foramen; (d) the greater petrosal nerve which enters the foramen from above; and (e) the nerve of the pterygoid canal formed by the union of (c) and (d). The only structures passing through the whole length of the foramen are (f) a meningeal branch of the ascending pharyngeal artery; and (g) some emissary veins that pierce the cartilage closing the lower end of the foramen.

8. The jugular foramen consists of anterior, middle and posterior parts. The structures passing through them are as follows (Fig. 2.34).

Through anterior part:
Inferior petrosal sinus.

Through middle part:
a. Glossopharyngeal nerve
b. Vagus nerve
c. Accessory nerve.
d. Meningeal branch of ascending pharyngeal artery.

Through posterior part:
a. Lower end of sigmoid sinus.
b. Emissary veins connecting the sigmoid sinus to the occipital veins.
c. Meningeal branch of the occipital artery.

9. Closely associated with the jugular foramen there are two foramina that are inconspicuous, but are important (Fig. 2.35).
   a. The glossopharyngeal nerve carries secretomotor fibres for the parotid gland. These fibres leave the nerve through its tympanic branch. This branch enters a small foramen opening on the ridge separating the jugular foramen from the lower opening of the carotid canal. This opening leads into a canal called the tympanic canaliculus which passes through the substance of the petrous temporal bone to reach the middle ear. In the middle ear, the fibres of the tympanic branch pass through the tympanic plexus into the lesser petrosal nerve. This nerve emerges from the petrous temporal bone on its anterior surface (i.e., into the middle cranial fossa) through the hiatus for the lesser petrosal nerve. We have already seen that the nerve then passes through the foramen ovale (or through the canaliculus innominatus) to reach the infratemporal fossa.

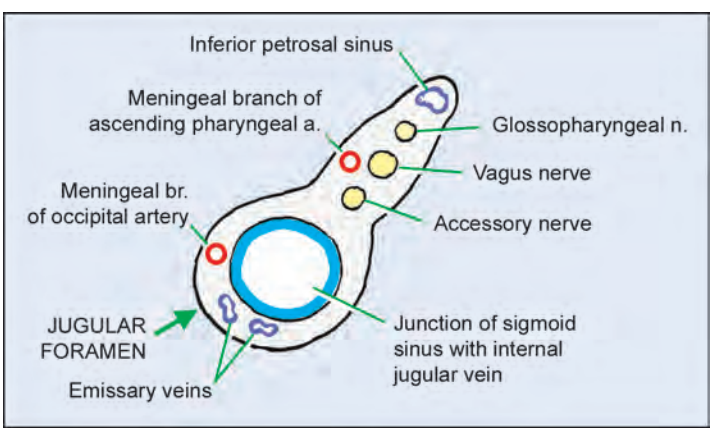


Fig. 2.34: Scheme to show the structures passing through the jugular foramen

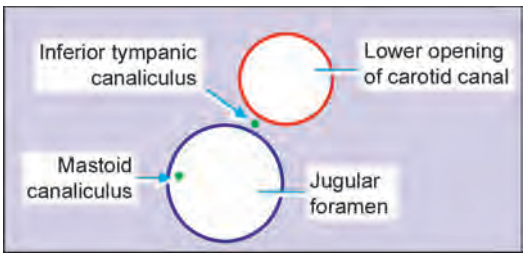


Fig. 2.35: Scheme to show the position of the opening of the inferior tympanic canaliculus and of the mastoid canaliculus

b. Another nerve traversing the substance of the petrous temporal bone is the auricular branch of the vagus. This nerve enters the bone through the mastoid canaliculus that opens on the lateral wall of the jugular fossa. It emerges from the bone through the tympanomastoid fissure (behind the external acoustic meatus).

10. The foramen magnum is the largest foramen in the skull. Through it, the cranial cavity communicates with the vertebral canal. The structures passing through it are as follows:
    a. Lower end of medulla surrounded by meninges, and accompanied by the anterior and posterior spinal arteries.
    b. Lying in the subarachnoid space around the medulla there are (on each side) the lower end of the tonsil of the cerebellum, the vertebral artery, and the spinal root of the accessory nerve.
    c. The anterior (narrow) part of the foramen magnum gives passage to the apical ligament of the dens, the superior band of the cruciform ligament, and the membrana tectoria (Fig. 2.36).

    The alar ligaments of the dens are attached just below the lateral margin of the foramen.
11. The hypoglossal canal transmits:
    a. The hypoglossal nerve.
    b. A meningeal branch of the ascending pharyngeal artery.
    c. An emissary vein connecting the sigmoid sinus to the internal jugular vein.
12. When present, the (posterior) condylar canal transmits an emissary vein that connects the lower end of the sigmoid sinus to occipital veins.
13. The stylomastoid foramen gives exit to the facial nerve. It also transmits the stylomastoid branch of the posterior auricular artery.

E. Foramina to be seen on the Floor of the Cranial Fossae

The foramina already seen on the base of the skull are not included in this list.

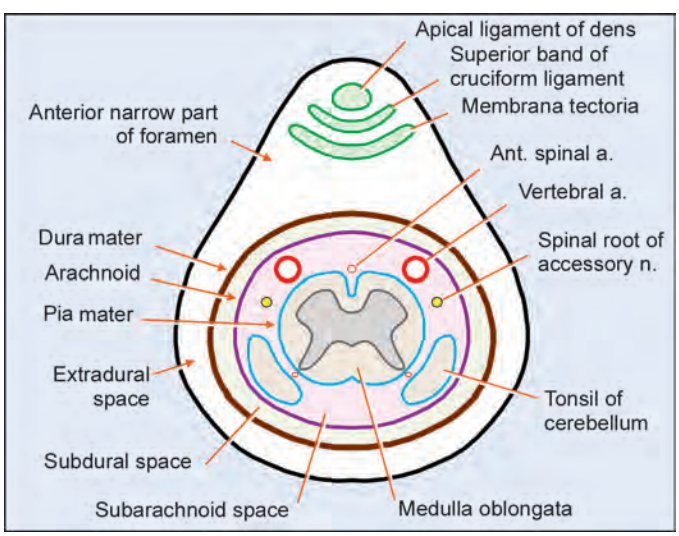


Fig. 2.36: Scheme to show the arrangement of structures passing through the foramen magnum

1. The apertures on the cribriform plate of the ethmoid give passage to bundles of the olfactory nerves.
2. The foramen caecum is usually blind, but sometimes it is patent and a vein passes through it and connects the veins of the nose to the superior sagittal sinus.
3. The anterior ethmoidal canals open on the suture between the orbital plate of the frontal bone and the cribriform plate, and transmit the anterior ethmoidal nerves and vessels. These nerves and vessels run forwards and enter the nasal cavity by passing through slit-like foramina on the sides of the crista galli. (The slits are difficult to see).
4. The posterior ethmoidal canals, which transmit the posterior ethmoidal nerves and vessels, open at the posterolateral corner of the cribriform plate.
5. The foramen rotundum opens posteriorly into the middle cranial fossa, and anteriorly into the pterygopalatine fossa. The maxillary division of the trigeminal nerve passes through the foramen: then through the upper part of the pterygopalatine fossa; and finally through the inferior orbital fissure to reach the orbit where we have already seen it.
6. The greater and lesser petrosal nerves enter the middle cranial fossa by emerging through the hiatuses for these nerves present on the anterior aspect of the petrous temporal bone. We have seen that the greater petrosal nerve descends to the foramen lacerum (Fig. 2.33) and that the lesser petrosal nerve leaves the skull through the foramen ovale, or through the canaliculus innominatus.
7. The internal acoustic meatus is seen on the posterior aspect of the petrous temporal bone. The structures entering it are:
   a. The facial nerve (motor root and nervus intermedius).
   b. The vestibulocochlear nerve.
   c. The labyrinthine vessels.

The vestibulocochlear nerve terminates within the petrous temporal bone by supplying the membranous labyrinth. The facial nerve follows a complicated course through the bone and finally emerges on the base of the skull through the stylomastoid foramen. A little above its exit from this foramen, the facial nerve gives off the chorda tympani nerve. This nerve passes through a posterior canaliculus to enter the cavity of the middle ear, which it leaves through an anterior canaliculus that opens to the outside through the medial end of the petrotympanic fissure. Here the nerve comes to lie just medial to the spine of the sphenoid. It is of interest to note that the spine is related to another nerve, the auriculotemporal, on its lateral side.

THE NASAL CAVITY

The nasal cavity consists of right and left halves that are separated by a nasal septum (Figs 2.37 to 2.39). The cavity opens, anteriorly, on the front of the skull through the anterior nasal aperture; and, posteriorly, on the base of the skull just above the posterior edge of the bony palate, through the right and left posterior nasal apertures. Each half of the cavity has a lateral wall, a medial wall formed by the septum, a floor formed by the upper surface of the palate, and a roof.

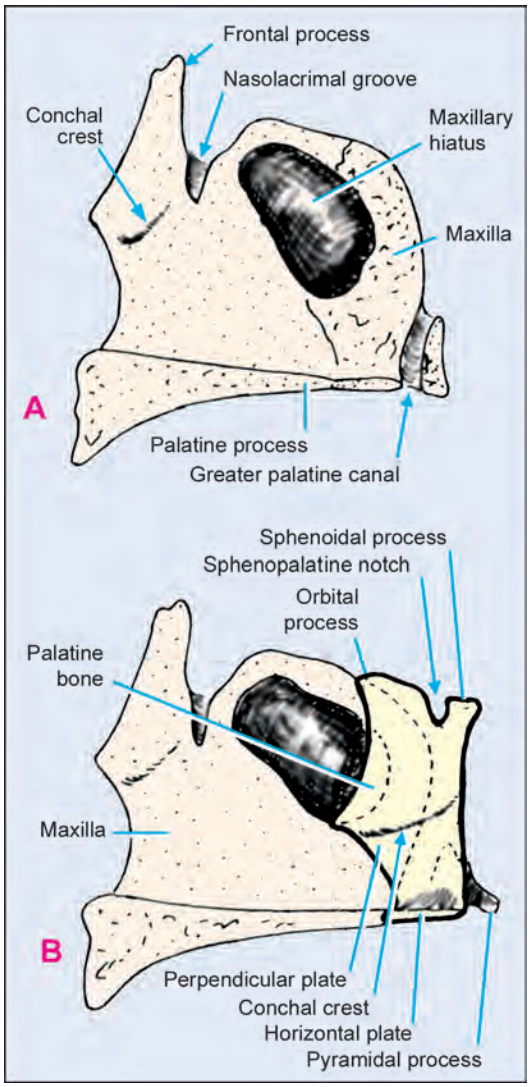
The formation of the lateral wall is complicated and to understand it properly it has to be built up layer by layer. In Figure 2.37A we see the medial surface of the maxilla, which forms the base of the lateral wall over which other bones are attached. The features to be noted are: (a) the large opening of the maxillary air sinus called the maxillary hiatus; (b) the nasolacrimal groove lying behind the lower part of the frontal process; and (c) the groove for the greater palatine canal in the posteroinferior part.

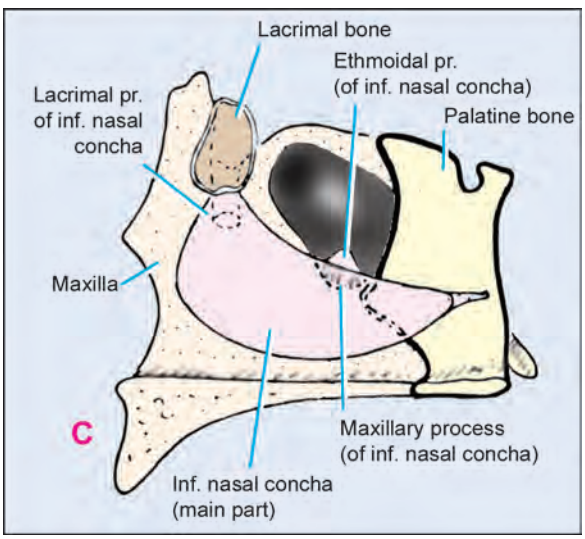
In Figure 2.37B we see the palatine bone (perpendicular plate) overlapping the posterior part of the maxilla. By this overlapping, the greater palatine groove is converted into a canal, its medial wall being formed by the palatine bone. Note also

that the palatine bone overlaps the posterior part of the maxillary hiatus reducing its size.

In Figure 2.37C we see two additional bones. Behind the frontal process of the maxilla we see the lacrimal bone. Articulating with its lower border we see the inferior nasal concha. The lower part of the lacrimal bone, and the upper part of the inferior nasal concha (lacrimal process) convert the nasolacrimal groove of the maxilla into a canal and form its medial wall. The inferior concha is attached anteriorly to the conchal crest of the maxilla (Fig. 2.37A) and posteriorly to the conchal crest of the palatine bone (Fig. 2.37B). Its upper margin overlaps the lower part of the maxillary hiatus. Here a downward projection of the concha called the maxillary process descends deep to the rest of the concha to articulate with the lower edge of the hiatus. Another projection, the ethmoidal process juts upwards into the hiatus. The space between the concha (medially) and the maxilla and palatine bones (laterally) is the inferior meatus.

In Figure 2.38 we see part of the ethmoid bone overlapping the lacrimal bone and the upper parts of the maxilla and palatine bones. The relationship of the ethmoid to the nasal cavity is best visualised by the study of a coronal section through the region (Figs 2.10 and 2.39). The ethmoid bone consists of a labyrinth that is closed medially by a vertical medial plate. It is this plate that is seen in the lateral wall of the nasal cavity. The plate descends vertically from the cribriform plate; and its lower part, which is free, forms the middle nasal concha. Above the middle concha, a smaller projection, the superior nasal concha, arises from the medial plate.





Figs 2.37A to C: Bones in the lateral wall of the nose. A. Medial aspect of maxilla. B. Palatine bone overlapping maxilla. C. Lacrimal bone and inferior nasal concha overlapping the maxilla and palatine bone. (Also see Figure 2.38)

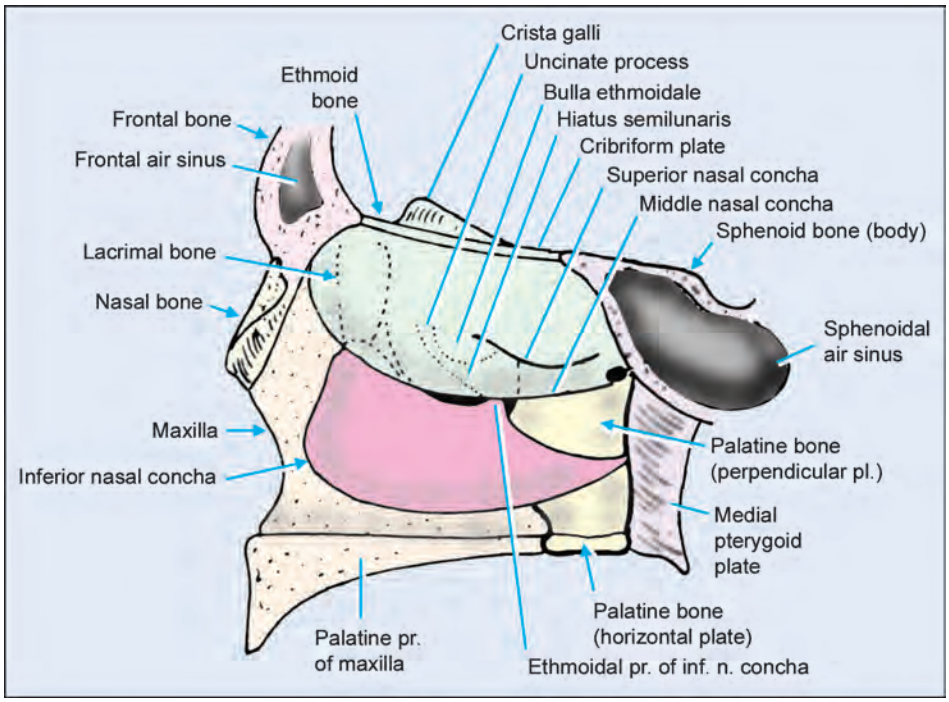


Fig. 2.38: Lateral wall of the nasal cavity seen with the ethmoid bone in place. The parts shown in dotted line can be seen only when the middle concha is lifted off. (Compare with Figure 2.37C)

The spaces deep to these conchae are called the middle and superior meatuses respectively. The middle concha almost completely hides the maxillary hiatus from view. Deep to the concha, a rounded prominence called the bulla ethmoidalis, is seen in relation to the upper part of the hiatus. A little below the bulla, a curved plate of bone runs downwards and backwards. This is the uncinate process of the ethmoid. Its posterior end joins the ethmoidal process of the inferior concha. The curved gap between the bulla ethmoidalis and the uncinate process is called the hiatus semilunaris.

The floor of the nasal cavity is formed by the upper surface of the bony palate. We have already seen that each half of the palate is formed anteriorly by the palatine process of the maxilla, and posteriorly by the horizontal plate of the palatine bone.

Several bones take part in forming the roof of the nasal cavity. From front to back these are parts of the nasal bone, the frontal bone, the cribriform plate of the ethmoid and the anterior surface of the body of the sphenoid bone.

The medial wall or nasal septum (Fig. 2.39) is formed in its upper part by the perpendicular plate of the ethmoid bone (see also Fig. 2.10), and its lower part by the vomer. Anteriorly, there is a gap in the septum which is filled in by cartilage. Around the edges of the septum there are small contributions from the nasal, frontal, sphenoid, maxillary and palatine bones.

The openings into the nasal cavity are described along with the paranasal sinuses.

THE PARANASAL SINUSES

The paranasal sinuses are spaces present in bones around the nasal cavity, and into which they open (Figs 2.40 to 2.42).

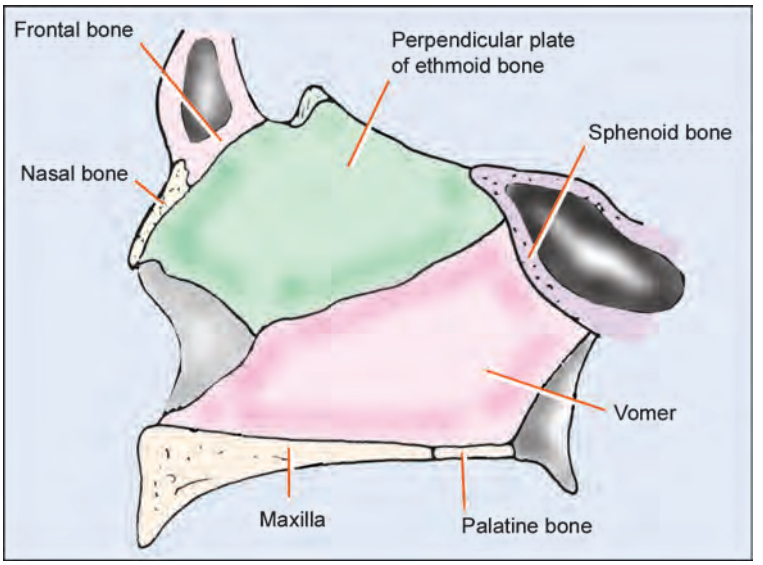


Fig. 2.39: Main bones taking part in forming the nasal septum

We have already noted that the maxillary sinus lies within the maxilla; and that the large maxillary hiatus is considerably narrowed by projections from the palatine bone, the inferior nasal concha, the ethmoid bone and the lacrimal bone. The opening is further narrowed by the mucous membrane covering these bones and the sinus usually opens into middle meatus of the nasal cavity by an opening in the lower part of the hiatus semilunaris (Fig. 2.41).

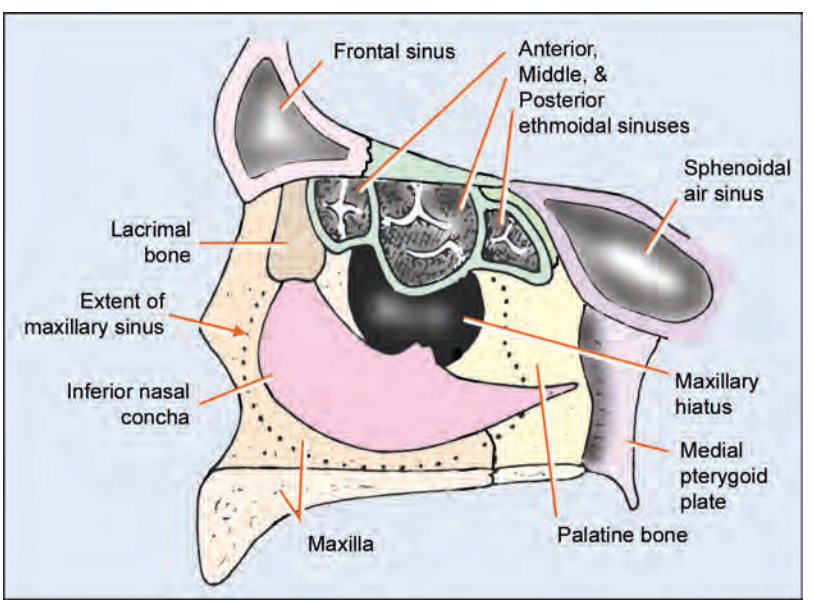


Fig. 2.40: Lateral wall of the nasal cavity seen after removal of the medial plate of the ethmoid bone to expose the ethmoidal air sinuses

The right and left frontal sinuses are present in the part of the frontal bone deep to the superciliary arches. Each sinus lies deep to a triangular area the angles of which are placed as follows:

a. At the nasion.
b. At a point about 3 cm above the nasion.
c. At a point on the supraorbital margin at the junction of the medial one-third with the lateral two-thirds.

The sinus extends for some distance into the orbital plate of the frontal bone between the roof of the orbit and the floor of the anterior cranial fossa. Each frontal sinus usually opens into the middle meatus through a funnel like space, the ethmoidal infundibulum (Fig. 2.41) which is continuous with the upper end of the hiatus semilunaris.

The right and left sphenoidal sinuses are present in the body of the sphenoid bone. Each sinus opens into the corresponding half of the nasal cavity through an aperture on the anterior aspect of the body of the sphenoid. The part of the nasal cavity into which the sinus opens lies above the superior nasal concha and is called sphenoethmoidal recess (Fig. 2.41).

The ethmoidal air sinuses are located within the lateral part (or labyrinth) of the ethmoid bone. Each labyrinth (right or left) is bounded medially by the medial plate and laterally by the orbital plate. The ethmoidal air sinuses lie between these plates. They can be divided into anterior, middle and posterior groups. In the Figure 2.40 they are seen from the medial side after removing the superior and middle nasal conchae, and the medial plate. The walls of some of these sinuses are incomplete. In the intact skull they are completed by parts of the frontal, maxillary, lacrimal, sphenoidal and palatine bones.

The anterior ethmoidal sinuses open into the ethmoidal infundibulum, or into the upper part of the hiatus semilunaris. The middle ethmoidal sinuses open on or near the bulla ethmoidalis. The posterior ethmoidal sinuses open into the superior meatus.

Other Apertures in the Nasal Cavity

In addition to the anterior and posterior nasal apertures, and the openings of the paranasal sinuses, we see the following openings in the nasal cavity:

a. The nasolacrimal canal opens into the inferior meatus.

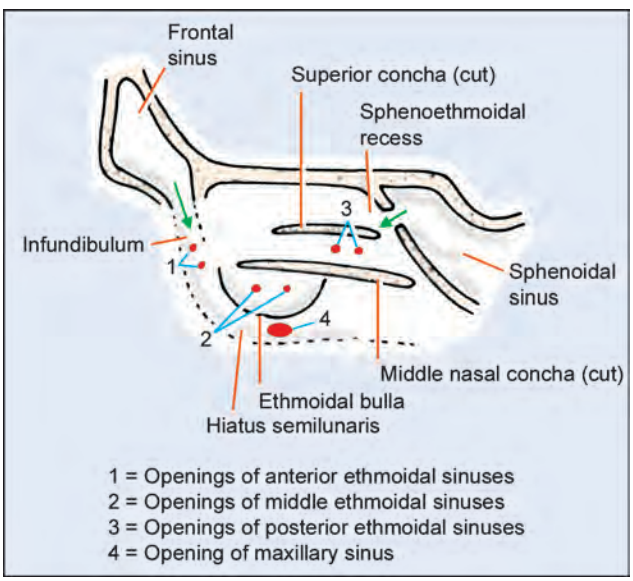


Fig. 2.41: Schematic diagram to show the positions of the openings of paranasal sinuses into the nasal cavity

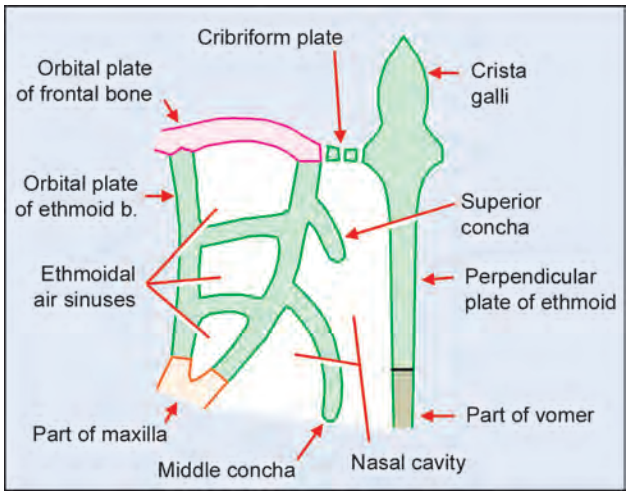


Fig. 2.42: Scheme to show the parts of the ethmoid bone

b. The sphenopalatine foramen opens behind the superior meatus, just above the posterior end of the middle concha (Fig. 2.38). This foramen has been seen in the medial wall of the pterygopalatine fossa.
c. The nasal cavity communicates with the anterior cranial fossa through numerous apertures in the cribriform plate of the ethmoid bone (Fig. 2.28), and through the anterior ethmoidal canals.
d. In the anterior part of the floor of the nasal cavity there is a funnel shaped opening that leads into the incisive canals which open on the lower surface of the palate.

Ossification of the Skull

The development and ossification of the skull is complex, and details of the process are beyond the scope of medical students. The following account is a summary of the most relevant features.

The skull develops from mesenchyme surrounding the developing brain. The mesoderm of the occipital myotomes, the otic capsule, the nasal capsule and the first branchial arch also contributes to the formation of the skull.

The mesenchyme shows condensations in regions where the skull bones are to develop. A number of chondrification centres appear in relation to the base of the skull. The cartilages formed do not correspond to individual bones, but follow a complicated pattern. The base of the skull is formed by ossification in relation to these cartilages.

The mesenchyme that is to form the sides and vault of the skull, and also the facial skeleton is not chondrified, but is converted into bone by intramembranous ossification. It follows that some bones of the skull are formed in membrane, some in cartilage, and some partly in membrane and partly in cartilage, as listed below:

a. *Bones that are formed entirely in membrane:* These are the frontal, parietal, zygomatic, palatine, nasal, and lacrimal bones, the maxilla and the vomer.
b. *Bones that are formed entirely in cartilage:* These are the ethmoid and the inferior nasal concha.
c. *Bones that are formed partly in cartilage and partly in membrane:* These are the occipital, sphenoid and temporal bones; and the mandible.

The times at which individual skull bones begin to ossify is highly variable. Centres of ossification appear in many of them in the 7th or 8th prenatal week; but in some ossification begins after birth.

The number of ossification centres is also highly variable.

The zygomatic, palatine, lacrimal and nasal bones; the vomer; and the inferior nasal concha have only one centre each.

The parietal bone ossifies from two centres that appear in the region of the future tuber. Also see fontanelles below.

The frontal bone has two centres on each side. At birth the bone is in two halves. The two halves occasionally remain separate and are united by a midline suture called the metopic suture.

The ethmoid bone has three centres of ossification: one for the perpendicular plate, and one for each labyrinth.

Each maxilla has one main centre, but additional centres appear in its anterior part. There is considerable controversy on whether or not the anterior centres correspond to the premaxilla.

The occipital bone ossifies from several centres. In the newborn this bone consists of separate squamous, condylar (lateral) and basilar parts that are united by cartilage. These parts fuse with one another by the 6th year. The basilar part of the occipital bone fuses with the corresponding part of the sphenoid bone between 18 and 25 years.

The sphenoid bone also ossifies from several centres. At birth the bone is in three pieces: one central, and right and left lateral. The central piece consists of the body and lesser wings; while each lateral piece consists of a greater wing and a pterygoid process. The pieces unite during the first year of life. The body of the sphenoid fuses with the basilar part of the occipital bone between 18 and 25 years of age.

The temporal bone ossifies from several centres. The squamous, tympanic, and styloid parts ossify independently. The petrous and mastoid parts constitute one petromastoid morphological element, that has several centres of ossification. The squamous part is the first to ossify. At birth the tympanic part is rudimentary and is U-shaped (It is miscalled the tympanic ring). Subsequently, this part grows laterally forming the bony part of the external acoustic meatus. It also extends backwards to surround the base of the styloid process, and medially to reach the carotid canal. At birth the mastoid part is poorly developed and a mastoid process is not seen. Postnatally, mastoid air cells develop leading to formation of the mastoid process (by about 2 years of age). The facial canal and the stylomastoid foramen are at first near the lateral surface of the bone, but with the formation of the mastoid process they become deeper.

The Fontanelles

In the skull of the newborn, there are some gaps in the vault of the skull that are filled by membrane. These gaps are called fontanelles or fonticuli. They are located in relation to the angles of the parietal bone as follows:

a. The anterior fontanelle is large and rhomboid in shape. It lies at the junction of the sagittal, coronal and frontal sutures. (Note that, at birth, the frontal bone is in two halves that are separated by a frontal suture).
b. The posterior fontanelle is triangular. It lies at the junction of the sagittal and lambdoid sutures.
c. The sphenoidal (anterolateral) fontanelle is present in relation to the anteroinferior angle of the parietal bone, where it meets the greater wing of the sphenoid.
d. The mastoid fontanelle (posterolateral) is present in relation to the posteroinferior angle of the parietal bone (which meets the mastoid bone).

The fontanelles disappear (by growth of the bones around them) at different ages after birth. The posterior and sphenoidal fontanelles disappear within two or three months after birth; the mastoid fontanelle by the end of the first year; and the anterior fontanelle by the middle of the second year.

3 Individual Bones of the Skull

THE MANDIBLE

The mandible is the bone of the lower jaw and bears the lower teeth (Figs 3.1 to 3.5). It consists of an anterior U-shaped body, and of two rami (right and left) that project upwards from the posterior part of the body. The bone has internal (or medial) and external (or lateral) surfaces. The body has an upper part that bears the teeth (alveolar process), and a lower border that is called the base. The ramus has a posterior border, a sharp anterior border, and a lower border that is continuous with the base of the body. The posterior and inferior borders of the ramus meet at the *angle* of the mandible. The anterior border of the ramus is continued downwards and forwards on the lateral surface of the body as the oblique line. This line ends anteriorly near the mental tubercle. A little above the anterior part of the oblique line we see the mental foramen which lies vertically below the second premolar tooth. Just below the incisor teeth the external surface of the ramus shows a shallow incisive fossa.

Arising from the upper part of the ramus there are two processes. The anterior of these is the coronoid process. It is flat (from side to side) and triangular. The posterior or condylar process is separated from the coronoid process by the mandibular notch. The upper end of the condylar process is expanded to form the head of the mandible. The head is elongated transversely and is convex both transversely and in an anteroposterior direction. It bears a smooth articular surface that articulates with the mandibular fossa of the temporal bone to form the temporomandibular joint. The part immediately below the head is constricted and forms the neck. Its anterior surface has a rough depression called the pterygoid fovea.

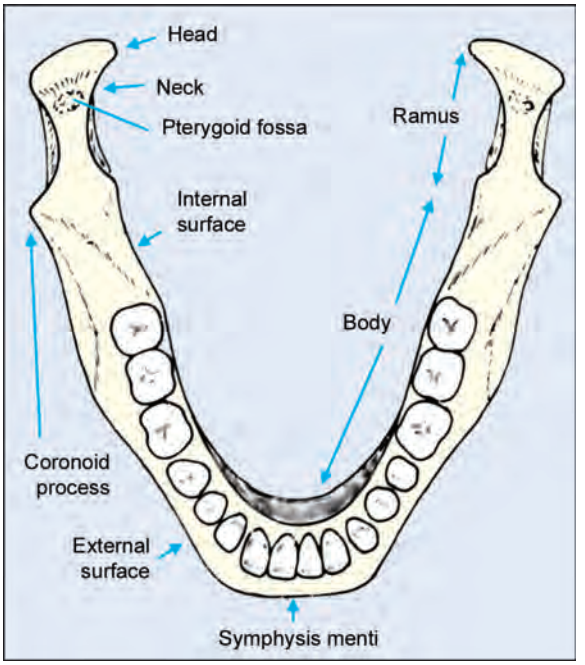


Fig. 3.1: Mandible seen from above

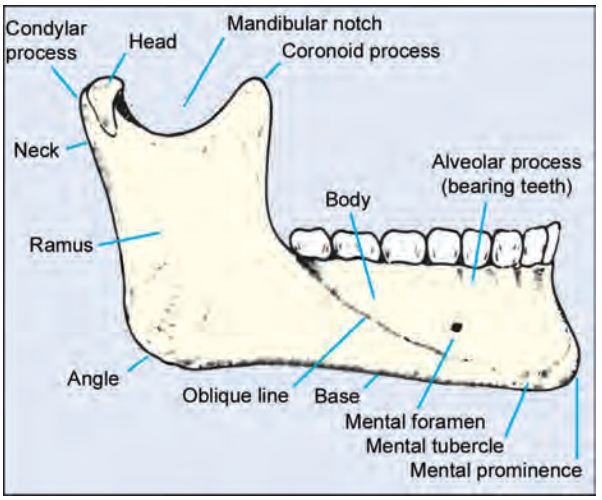


Fig. 3.2: Right half of mandible seen from the lateral side

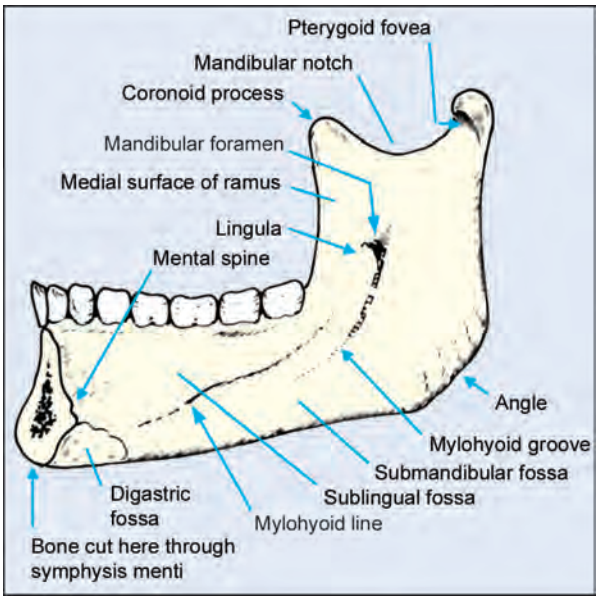


Fig. 3.3: Right half of the mandible seen from the medial side

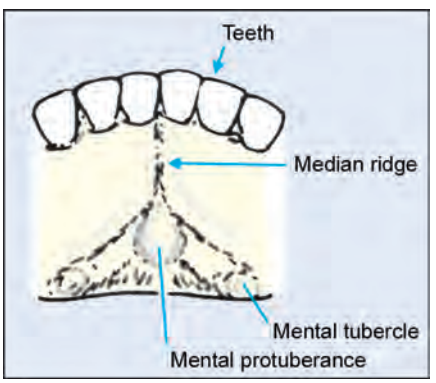


Fig. 3.4: Median part of the mandible, anterior aspect

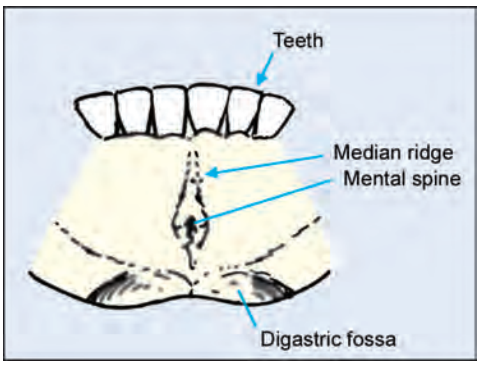


Fig. 3.5: Median part of mandible, posterior aspect

In the Figure 3.3 the mandible is seen from the medial side. A little above the centre of the medial surface of the ramus we see the mandibular foramen. It leads into the mandibular canal which runs forward in the substance of the mandible.

The medial margin of the foramen is formed by a projection called the lingula. Beginning just behind the lingula and running downwards and forwards we see the mylohyoid groove. A little above and anterior to the mylohyoid groove, the inner surface of the body of the mandible is marked by a ridge called the mylohyoid line. The posterior end of this line lies a little below and behind the third molar tooth. From here the line runs downward and forward to reach the symphysis menti (see below). The mylohyoid line divides the inner surface of the body into a sublingual fossa (lying above the line), and a submandibular fossa (lying below the line).

Just below the anterior end of the mylohyoid line the base of the mandible is marked by a deep digastric fossa. In the newborn the mandible consists of right and left halves that are joined to each other at the symphysis menti; but in later life the halves fuse to form one bone.

When viewed from the front (Fig. 3.4) the region of the symphysis menti is usually marked by a slight ridge. Inferiorly, the ridge expands to form a triangular raised area called the mental protuberance. The lateral angles of the protuberance are prominent and constitute the mental tubercles.

The posterior aspect of the symphysis menti also shows a median ridge (Fig. 3.5) the lower part of which is enlarged and may be divided into upper and lower parts called the mental spines or genial tubercles.

Attachments and Relations

A. The muscles attached on the external aspect of the mandible are as follows (Fig. 3.6):

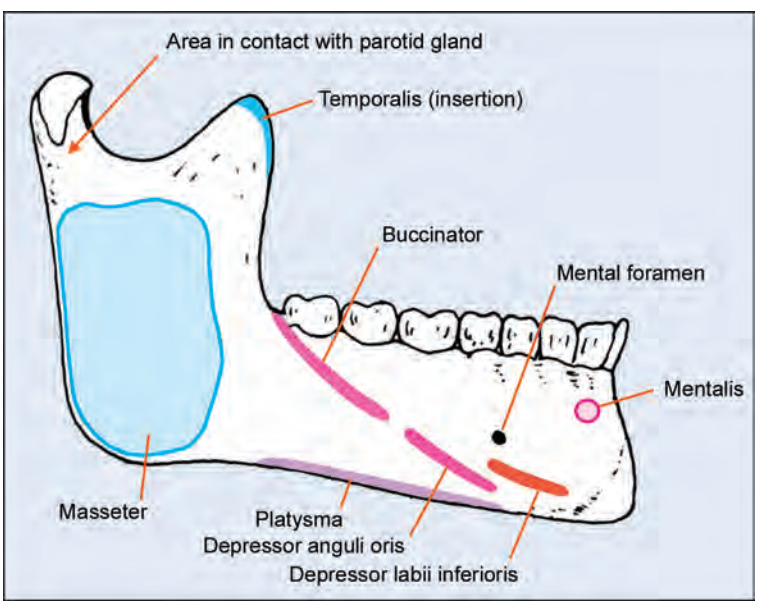


Fig. 3.6: Attachments on the mandible as seen from the lateral side

1. The masseter is inserted into the lateral surface of the ramus and of the angle.
2. The buccinator arises from the outer surface of the body just below the molar teeth.
3. The depressor labii inferioris arises from the anterior part of the oblique line.
4. The depressor anguli oris arises from the oblique line behind and below the origin of the depressor labii inferioris.
5. The mentalis arises from the incisive fossa (just below the incisor teeth).
6. Some fibres of the platysma are inserted into the lower border of the body.

B. The muscles attached on the internal surface of the mandible are as follows (Figs 3.7 and 3.8):
1. The temporalis is inserted into the medial surface of the coronoid process including its apex, and its anterior and posterior borders. The insertion extends downward along the anterior border of the ramus (Also see Fig. 3.6).
2. The lateral pterygoid is inserted into the fovea on the anterior aspect of the neck.
3. The medial pterygoid is inserted into the medial surface of the angle and the adjoining part of the ramus.
4. The anterior belly of the digastric arises from the digastric fossa (on the anterior part of the base near the midline).
5. The genioglossus takes origin from the upper mental spine.
6. The geniohyoid takes origin from the lower mental spine.
7. The mylohyoid arises from the mylohyoid line.
8. Some fibres of the superior constrictor of the pharynx take origin from the posterior end of the mylohyoid line (near the attachment of the pterygomandibular raphe).

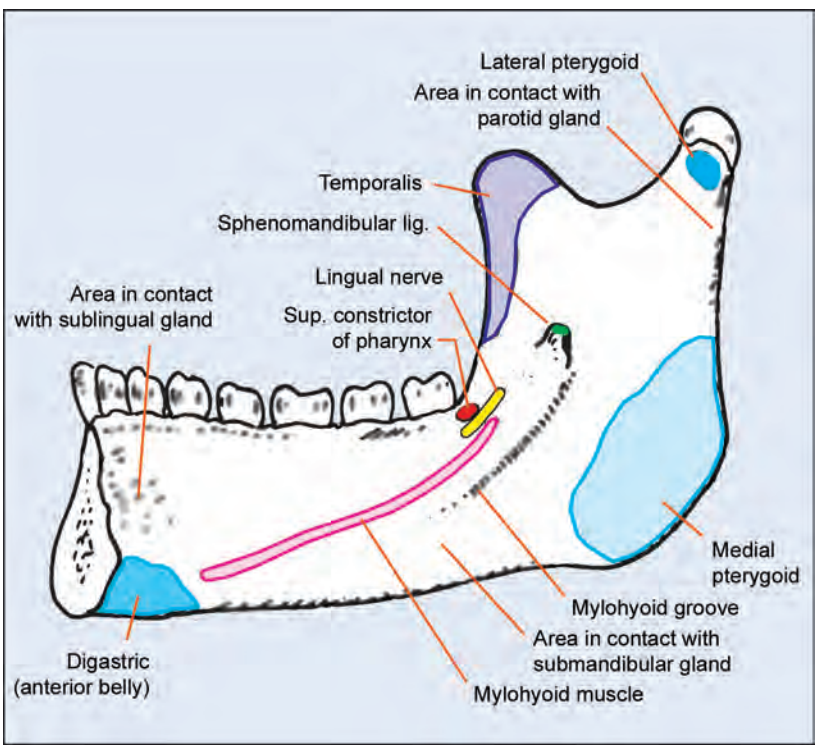


Fig. 3.7: Attachments on the mandible as seen from the medial side

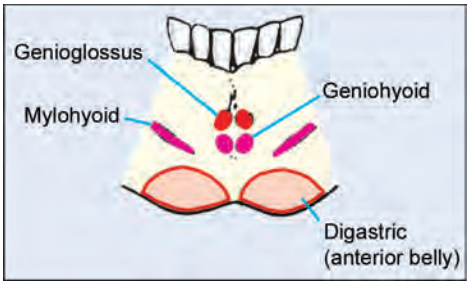


Fig. 3.8: Region of the symphysis menti, showing attachments, seen from behind

C. The ligaments attached to the mandible are as follows:
   1. The capsule of the temporomandibular joint is attached along the margins of the articular surface.
   2. The lateral temporomandibular ligament is attached to the lateral aspect of the neck of the mandible.
   3. The sphenomandibular ligament is attached to the lingula of the mandible.
   4. The stylomandibular ligament is attached to the angle and posterior border of the ramus of the mandible.
   5. The pterygomandibular raphe is attached to the posterior end of the mylohyoid line.

D. Relations to nerves and vessels
   1. The masseteric nerve and vessels pass through the mandibular notch.
   2. The inferior alveolar nerve and vessels enter the mandibular canal (which lies within the bone) through the mandibular foramen.
   3. The mylohyoid nerve and vessels run forwards in the mylohyoid groove.
   4. The mental nerve and vessels emerge through the mental foramen.
   5. The facial artery is closely related to the mandible. Its initial part lies deep to the ramus, near the angle. The artery then runs downwards and forwards deep to the ramus being separated from the bone by the medial pterygoid muscle. It reaches the lower border of the body of the mandible at the anteroinferior angle of the masseter. The artery then runs upward and forward superficial to the body of the mandible.

E. Other relations
   1. Part of the bone adjoining the alveolar border is covered by mucosa.
   2. The lingual nerve is closely related to the medial aspect of the body just above the posterior end of the mylohyoid line.
   3. The sublingual gland lies over the sublingual fossa; and the submandibular gland over the submandibular fossa. The parotid gland is related to the upper part of the posterior border of the ramus.

Development and Ossification of the Mandible

The greater part of the mandible is ossified in membrane in the mesenchyme of the mandibular process. The ventral part of Meckel's cartilage becomes embedded in the bone. Ossification of the coronoid and condyloid processes is preceded by formation of secondary cartilage in these situations.

The mandible is one of the first bones in the body to start ossifying (being next in this respect only to the clavicle). Each half of the bone is formed from one centre of ossification that appears (near the mental foramen) during the 6th week of foetal life. Small secondary centres may appear for the genial tubercles.

At birth the bone is in two halves that are united at a fibrous joint called the symphysis menti. The two halves unite between the first and third years of age.

Age Changes in the Mandible

Apart from fusion of the two halves of the bone, and the progressive increase in size, the following points are noteworthy:

1. The prominence of the chin is absent at birth. It forms during the first and second year of age.

2. At birth the mental foramen lies close to the inferior margin of the body of the mandible. It gradually shifts upward and in the adult it lies midway between the upper and lower borders of the body. With loss of teeth and alveolar bone in old age the foramen shifts nearer to the upper border. The direction of the foramen also changes with age. In the young it opens forward, but in the adult it opens backward.
3. The angle of the mandible is wide in childhood, becomes more acute in the adult, and again becomes wide after loss of teeth. The wide angle in the very young and in the very old is an adaptation to enable contact between the upper and lower jaws even in the absence of teeth.

THE MAXILLA

The right and left maxillae are seen when the skull is viewed from the front (Figs 3.4 and 3.8). They bear the upper teeth. Each maxilla takes part in forming the palate, the floor and lateral wall of the nasal cavity, and the floor of the orbit.

Each maxilla has a body, an alveolar process, a zygomatic process, a frontal process, and a palatine process (Figs 3.9 and 3.10).

The Body

The body has anterior (actually anterolateral), posterior, medial and superior surfaces. Inferiorly, the body is continuous with the alveolar process which has sockets for the teeth. The body encloses the maxillary air sinus.

The upper margin of the anterior surface (of the maxilla) becomes continuous with the superior surface at the inferior margin of the orbit. Medially, the anterior surface ends at the nasal notch which bounds the anterior nasal aperture. Other features to be seen on the anterior surface have been described earlier (Fig. 3.8). These are the infraorbital foramen, the incisive and canine fossae, the canine eminence, and the anterior nasal spine.

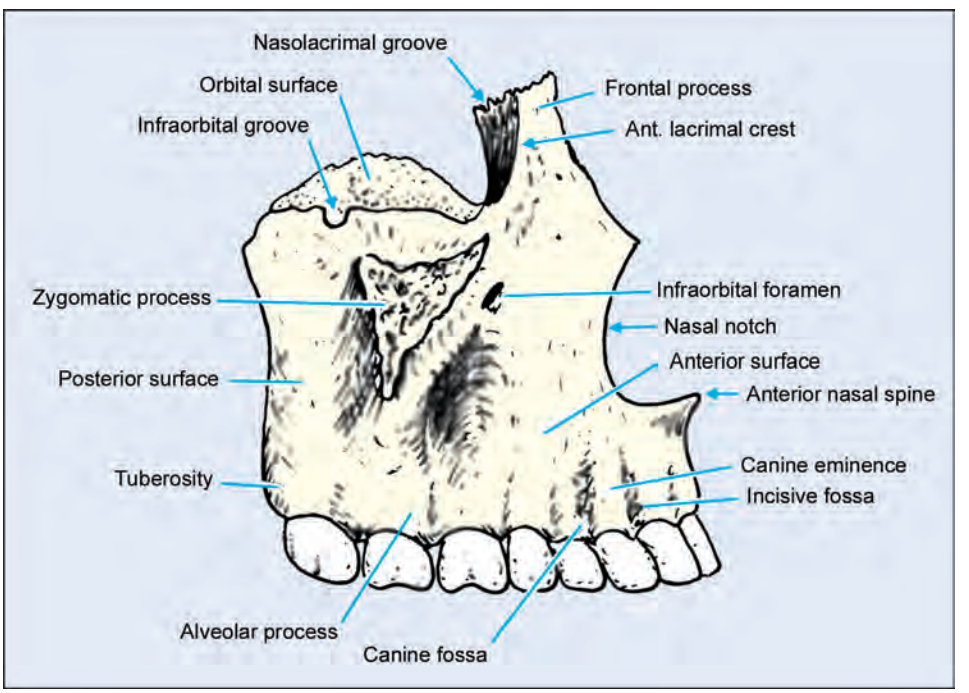


Fig. 3.9: Right maxilla, lateral aspect

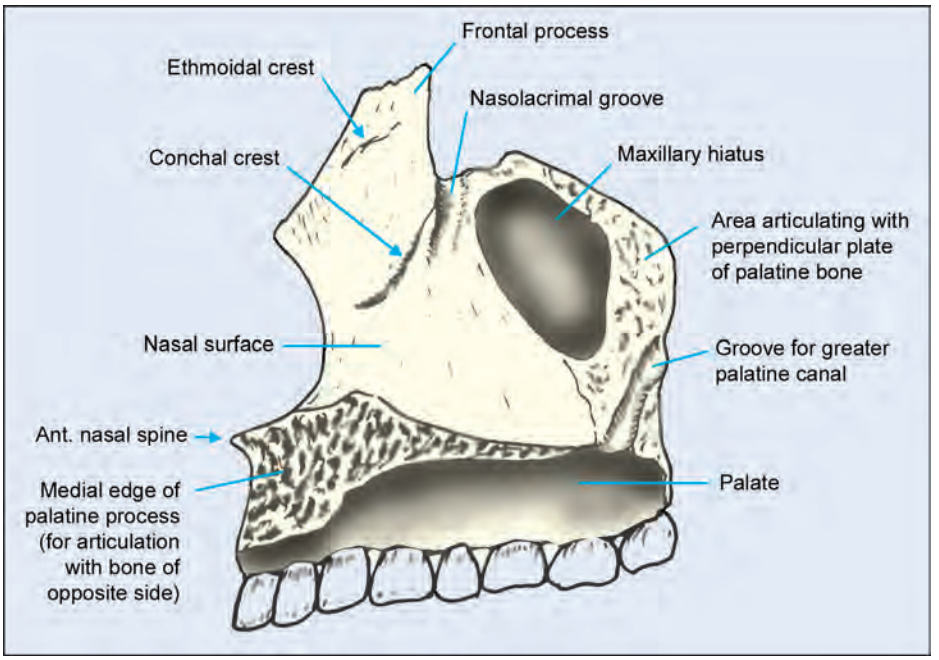


Fig. 3.10: Right maxilla, medial aspect

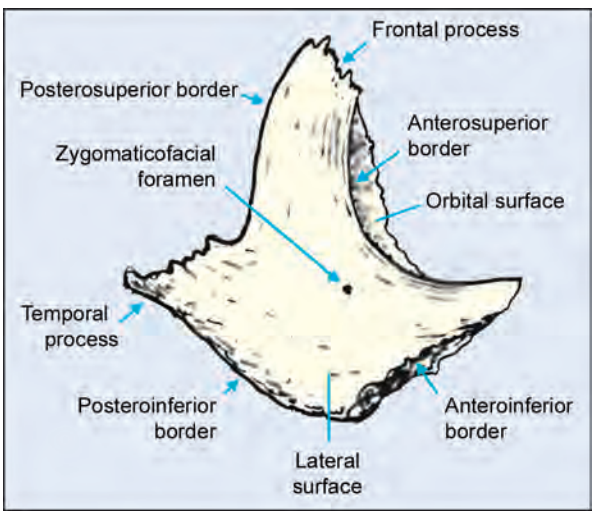


Fig. 3.11: Right zygomatic bone, lateral aspect

The superior (or orbital) surface forms the floor of the orbit (Fig. 3.11). Posterolaterally it forms the lower margin of the inferior orbital fissure. The infraorbital groove runs forward over the orbital surface. This groove starts at the inferior orbital fissure and ends a short distance from the inferior orbital margin by becoming continuous with the infraorbital canal (which opens on the anterior surface at the infraorbital foramen). Anteromedially, the orbital surface has a notch which forms the lateral margin of the upper opening of the nasolacrimal canal. The margins of the orbital

surface articulate with the zygomatic, ethmoid, and lacrimal bones, and with the orbital process of the palatine bone.

The medial (or nasal) surface of the maxilla takes part in forming the lateral wall of the nose. The features on this surface have already been examined (Figs 2.37 and 3.10). They include the maxillary hiatus, the nasolacrimal groove, the groove for the greater palatine canal, and the conchal crest. This aspect of the bone comes into intimate contact with the palatine, ethmoid and lacrimal bones, and with the inferior nasal concha.

The posterior (or infratemporal) surface forms the anterior wall of the infratemporal fossa and of the pterygopalatine fossa (Figs 3.12 and 3.13). Inferiorly, this surface bears a projection, the maxillary tuberosity which is the posterior end of the alveolar process. The upper margin of this surface becomes continuous with the orbital surface at the inferior orbital fissure. Here the surface is grooved by the maxillary nerve as the latter runs forwards to reach the infraorbital groove. Lower down the infratemporal surface bears small openings for the posterior superior alveolar nerves and vessels. The infratemporal surface meets the pterygoid process of the sphenoid bone at the lower end of the pterygomaxillary fissure.

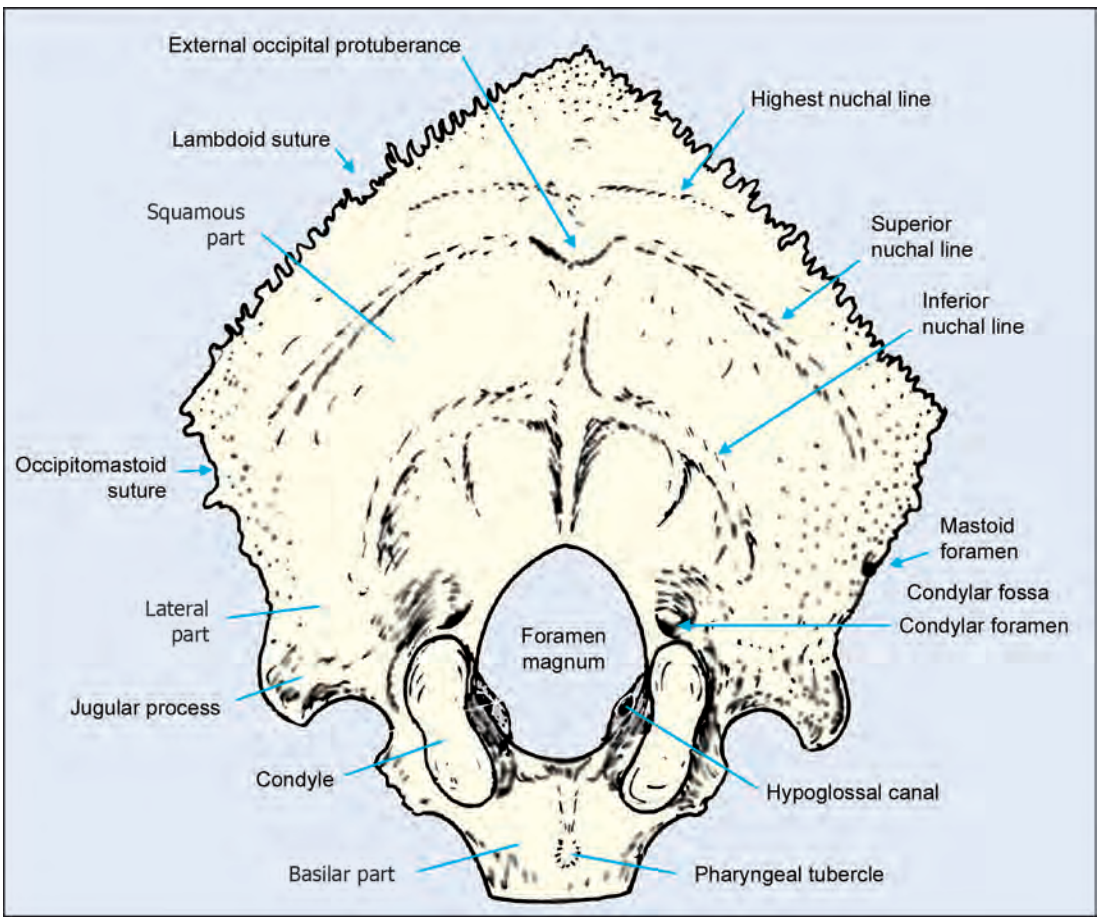


Fig. 3.12: Occipital bone, posteroinferior view

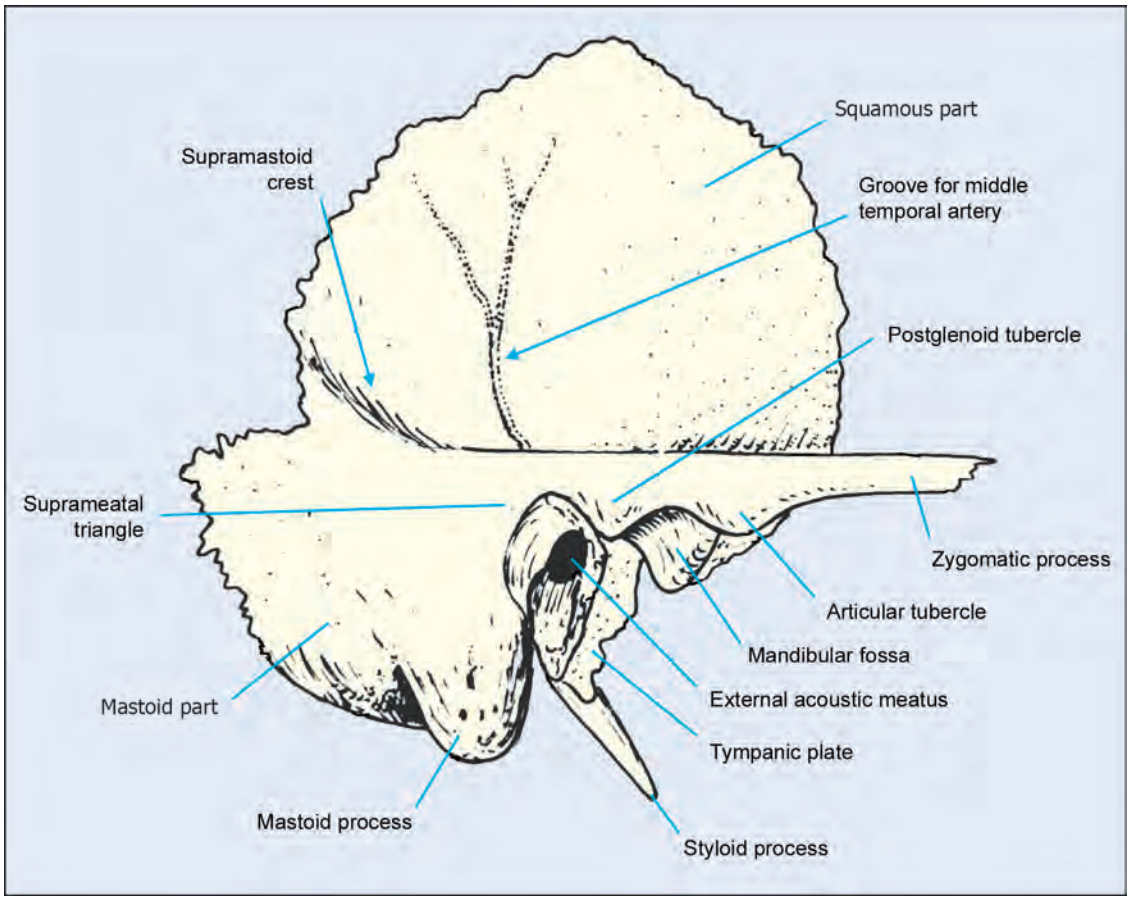


Fig. 3.13: Right temporal bone, lateral aspect

The Zygomatic Process

The zygomatic process of the maxilla is thick and strong. It projects laterally from the junction of the anterior and infratemporal surfaces and ends by articulating with the zygomatic bone.

The Palatine Process

The palatine process passes medially and forms the greater part of the palate. The inferior aspect of the palatine process has been examined earlier. The features seen include the intermaxillary suture, the incisive fossa and incisive foramina, and a vascular groove for the greater palatine vessels. Posteriorly, the palatine process meets the horizontal plate of the palatine bone at the palatomaxillary suture.

The upper surface of the palatine process forms the floor of the nasal cavity. On this surface, bone is thickened along the intermaxillary suture to form a nasal crest which articulates with the vomer, and contributes to the formation of the nasal septum. The crest is more pronounced at its anterior end where it is seen in the floor of the anterior nasal aperture as the anterior nasal spine (Fig. 3.8).

Frontal Process

The frontal process of the maxilla extends upwards and medially from the body. Its upper edge meets

the nasal part of the frontal bone. Medially (and anteriorly) it articulates with the nasal bone; and posteriorly it articulates with the lacrimal bone (Fig. 3.8). The frontal process has external and internal surfaces. The external surface bears a vertical ridge called the anterior lacrimal crest: this crest is continuous with the inferior orbital margin. Behind this crest there is a vertical groove which forms the lacrimal groove along with the groove on the lacrimal bone.

Determination of Side

The maxilla can be correctly oriented and its side determined by examining the alveolar process alone. The alveolar process bearing the teeth (or sockets for them) lies inferiorly, and laterally. The sockets for the teeth reach the midline anteriorly.

THE ZYGOMATIC BONE

The zygomatic bone is seen when the skull is viewed from the front (Figs 3.4 and 3.8) or from the side (Figs 3.9 and 3.14). It forms the prominence of the cheek. Parts of it are seen in the orbit (Fig. 3.11), and in the anterior wall of the temporal and infratemporal fossae (Fig. 3.12).

The zygomatic bone consists of a body, a frontal process, and a temporal process. The body articulates anteromedially, with the maxilla. The frontal process articulates with the zygomatic process of the frontal bone. The temporal process articulates with the zygomatic process of the temporal bone to form the zygomatic arch.

The body of the zygomatic bone has lateral, temporal, and orbital surfaces. The lateral surface forms the prominence of the cheek. It is perforated by the zygomaticofacial foramen (or foramina). The temporal surface is directed medially and posteriorly. It forms the anterior wall of the temporal fossa (and makes a small contribution to the anterior wall of the infratemporal fossa). It is pierced by the zygomaticotemporal foramen. The orbital surface forms part of the lateral wall of the orbit (Fig. 3.11). Posteriorly, this surface meets the greater wing of the sphenoid from which it is partially separated by the inferior orbital fissure. Medially it meets the orbital surface of the maxilla.

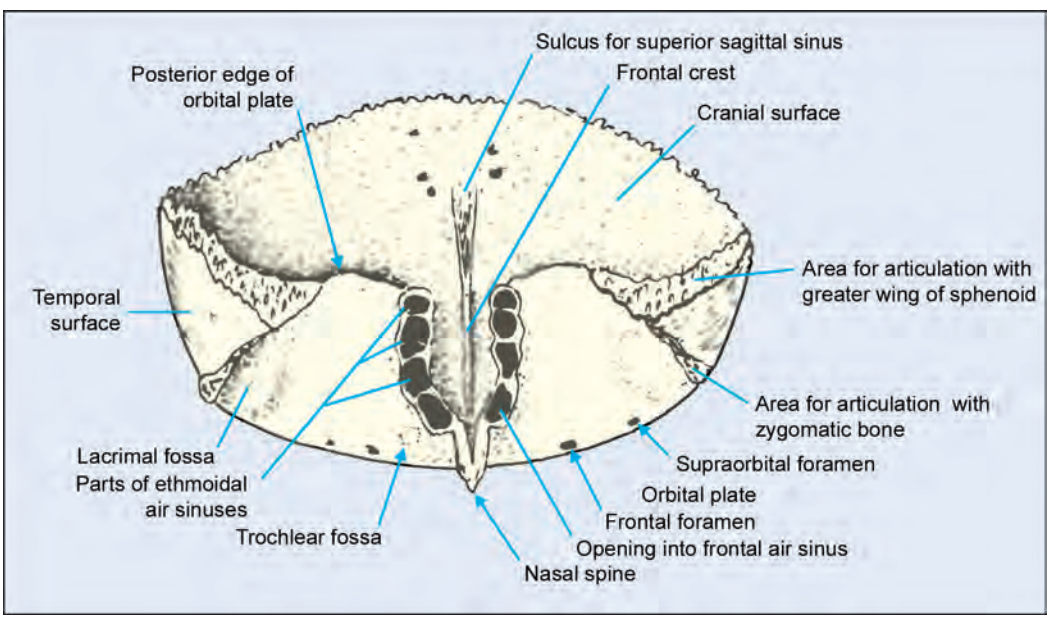


Fig. 3.14: Frontal bone, seen from below

The lateral surface of the zygomatic bone is demarcated by four borders: anterosuperior (or orbital), anteroinferior (or maxillary), posterosuperior (or temporal) and posteroinferior. The anterosuperior border is curved; it forms parts of the inferior and lateral orbital margins and separates the lateral surface from the orbital surface. The anteroinferior border articulates with the zygomatic process of the maxilla. The posterosuperior border extends from the frontozygomatic suture to the zygomaticotemporal suture: It separates the lateral and temporal surfaces. The posteroinferior border forms the anterior part of the lower border of the zygomatic arch. It extends from the zygomaticomaxillary suture to the zygomaticotemporal suture.

The temporal surface ends medially in a posteromedial border which articulates with the greater wing of the sphenoid [in the anterior wall of the temporal fossa; (Fig. 3.12)] and inferiorly with the maxilla. Note that the entire area between the anteroinferior and posteromedial borders is rough for articulation with the maxilla.

Determination of Side

The bone can be correctly oriented and its side determined by looking at the orbital margin. The orbital margin lies at the upper end of the anterior aspect. This margin contributes to the inferior and lateral margins of the orbit.

THE FRONTAL BONE

The main part of the frontal bone forms the wall of the cranial cavity in the region of the forehead. It ends inferiorly in a median downward projection which constitutes the nasal part of the bone. On either side of the nasal part the lower edge of the bone forms the superior margin of the corresponding orbit. Passing backwards from each orbital margin there is an orbital plate that forms the greater part of the roof of the orbit. The right and left orbital plates constitute the orbital part of the frontal bone. Lateral to the orbital margin there is a projection called the zygomatic process.

The Main Part

The main part of the frontal bone has external and internal surfaces. The greater part of the external surface corresponds to the forehead. This part is bounded on each side by a prominent ridge that is continuous anteriorly with the upper border of the zygomatic process, and posteriorly with the temporal lines. The part of the external surface behind this ridge, and below the temporal lines forms part of the floor of the temporal fossa.

The features to be seen on the part of the external surface corresponding to the forehead have been described earlier (Figs 3.4 and 3.8). These are the frontal tuber (or eminence), the superciliary arches, the glabella, the supraorbital notch (or foramen) and the frontal notch or foramen. The internal surface (Fig. 3.15) is marked, by a median sulcus for the superior sagittal sinus. Traced downwards the lips of this sulcus fuse to form a median ridge called the frontal crest. At the lower end of the crest there is the foramen caecum.

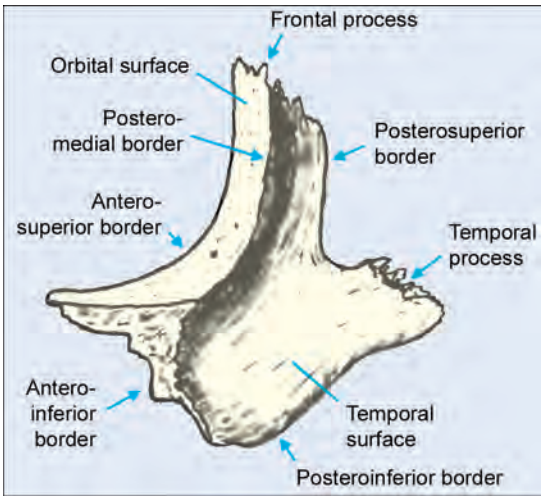


Fig. 3.15: Right zygomatic bone, medial aspect

Zygomatic Process

The zygomatic process passes downwards and laterally to meet the frontal process of the zygomatic bone.

Orbital part

The orbital plates (right and left) of the frontal bone are separated by a wide notch which is filled, in the intact skull, by the ethmoid bone (Fig. 3.14). Immediately anterior to the notch there are the openings into the right and left frontal air sinuses. Immediately lateral to the notch, the inferior aspect of the orbital plate shows two or three depressions; these are the upper parts of ethmoidal air cells that are completed in the intact skull by similar depressions on the labyrinth of the ethmoid bone. More laterally, the inferior surface of each orbital plate forms the greater portion of the roof of the corresponding orbit. The anterolateral part of the roof shows a shallow depression, the lacrimal fossa, for the lacrimal gland. The anteromedial part of the roof bears a small depression, the trochlear fossa. The superior surface of the orbital plate of the frontal bone forms the greater part of the floor of the anterior cranial fossa. (Also see Figs 3.9 and 3.11).

Nasal Part

The nasal part of the frontal bone projects downward between the right and left supraorbital margins. The lower part of the projection lies behind the nasal bones and the frontal process of the maxillae, and helps to support the bridge of the nose. The nasal part bears a median projection, the nasal spine, which contributes to the nasal septum (Fig. 2.38).

Articulations

The frontal bone articulates posteriorly with the right and left parietal bones (at the coronal suture); and with the greater wing of the sphenoid. Through its zygomatic process it articulates with the zygomatic bone. The nasal part articulates with the nasal bones, and with the frontal processes of the maxillae. The nasal spine meets the perpendicular plate of the ethmoid bone. The orbital parts articulate with the greater and lesser wings of the sphenoid, with the orbital plate of the ethmoid bone, and with the lacrimal bone of the corresponding side.

THE PARIETAL BONE

The right and left parietal bones form the greater part of the roof and side walls of the cranial cavity (Figs 3.14 to 3.16). Each bone has an external surface and an internal surface.

The features to be seen on the external surface are the parietal tuber (or eminence), the superior and inferior temporal lines, and the parietal foramen. These have been described earlier (Figs 3.14, 3.15 and 3.17).

The internal surface (Fig. 3.18) bears grooves for the frontal and parietal branches of the middle meningeal vessels. The posteroinferior angle bears a groove for part of the sigmoid sinus. There is a groove for the superior sagittal sinus along the upper (sagittal) border.

Articulations

The right and left parietal bones articulate with each other at the sagittal suture. Anteriorly, each parietal bone articulates with the frontal bone at the coronal suture.

The anteroinferior angle articulates with the greater wing of the sphenoid. The inferior border articulates with the temporal bone (squamous and mastoid), and the posterior border with the occipital bone (at the lambdoid suture).

Determination of side

The side to which a given parietal bone belongs can be determined using the following facts:

1. The superior or sagittal border is straight, while the inferior border has an irregular shape.

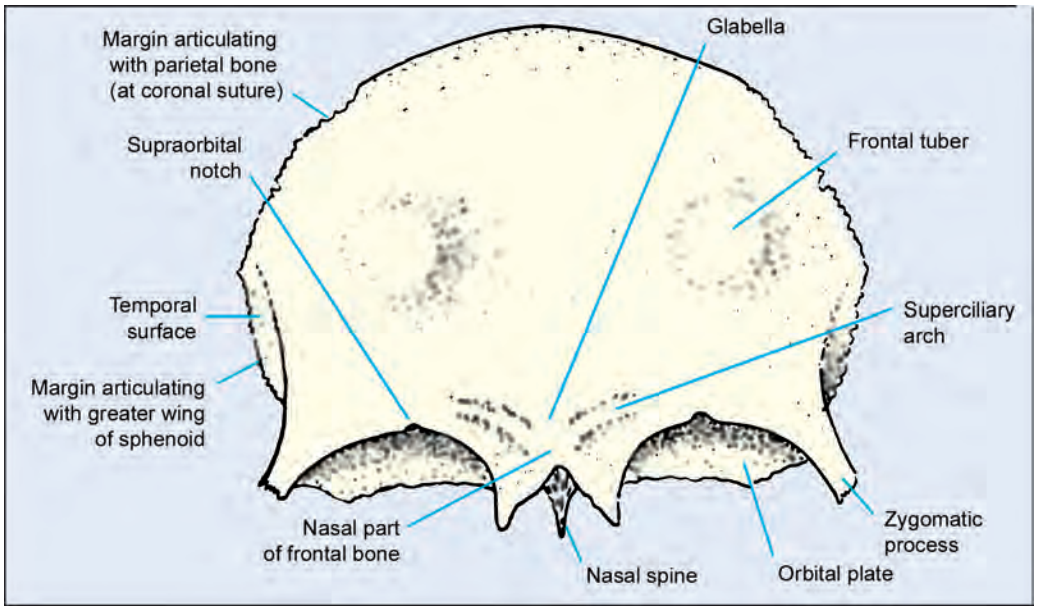


Fig. 3.16: Frontal bone seen from the front

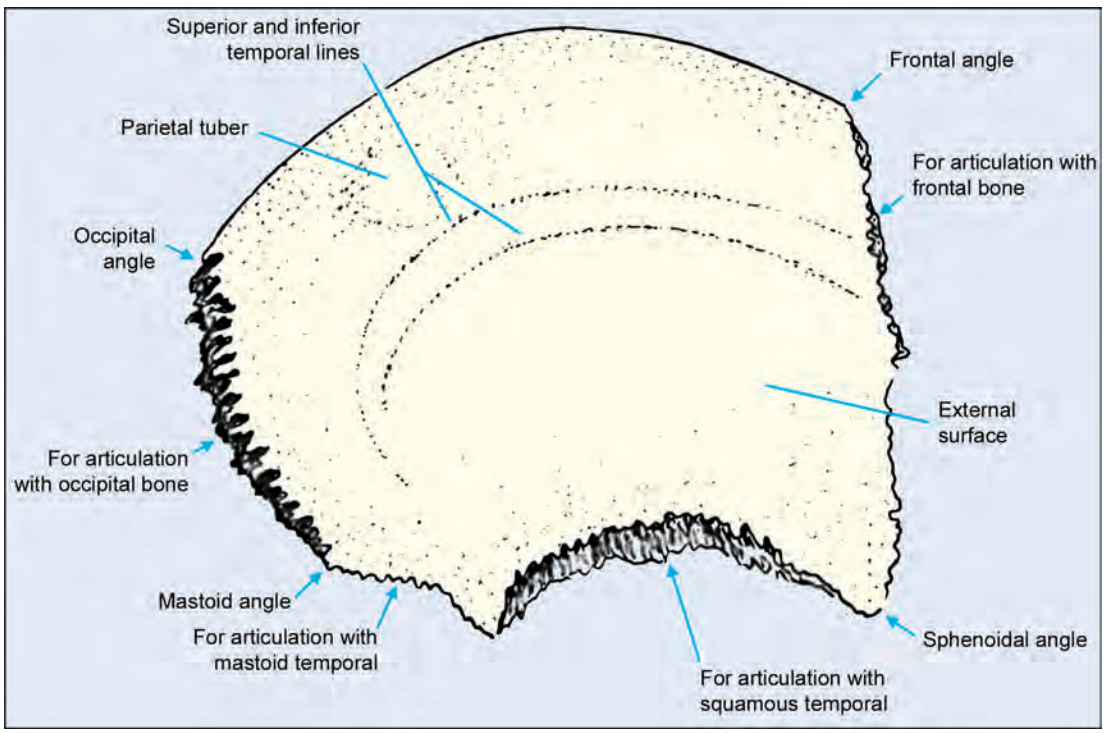


Fig. 3.17: Right parietal bone, lateral aspect

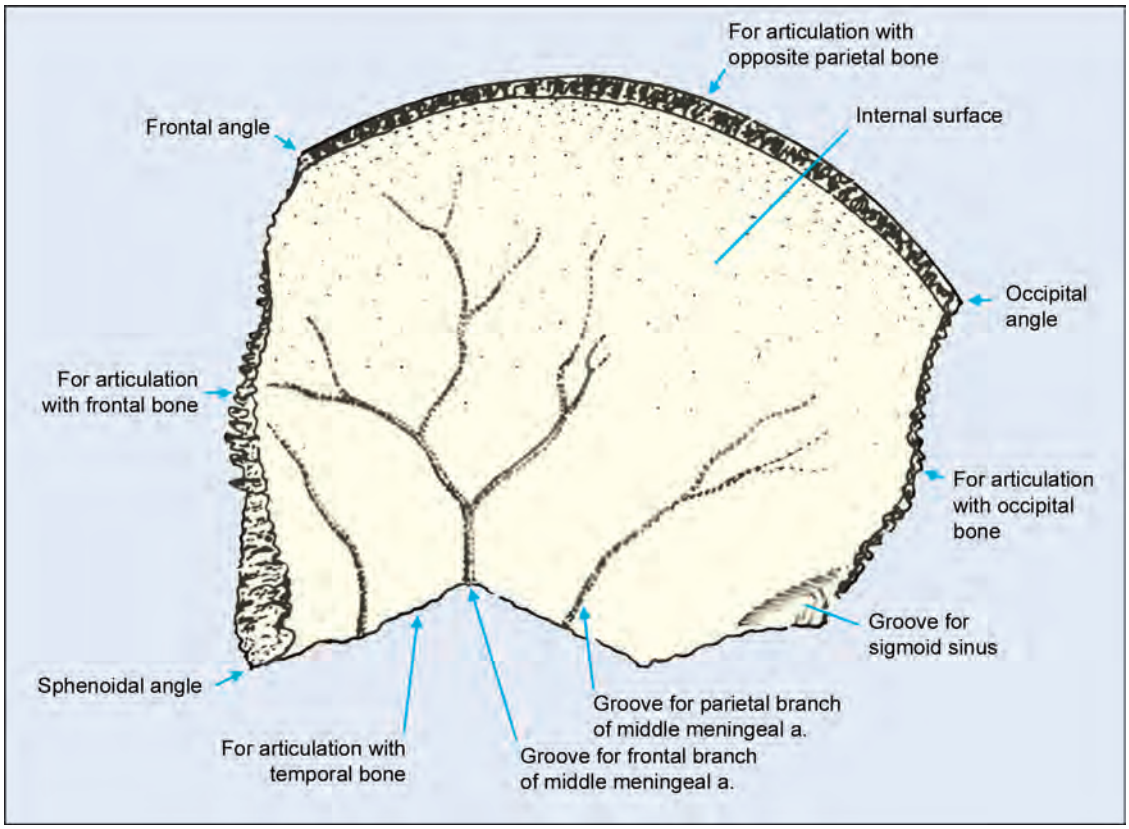


Fig. 3.18: Right parietal bone, medial aspect

2. The posterior aspect can be distinguished because the posteroinferior angle bears a groove (for the sigmoid sinus).
3. The medial surface is concave, while the lateral surface is convex.

THE OCCIPITAL BONE

The occipital bone is unpaired. It lies in the posterior part of the skull (Figs 3.5 to 3.7, 3.12, 3.14 to 3.17, 3.19 to 3.21).

The bone is pierced by the foramen magnum. The part behind the foramen magnum is the squamous part; the part anterior to the foramen magnum is the basilar part; and the parts on either side of the foramen are the lateral or condylar parts.

Squamous Part

The squamous part contributes to the posterior wall of the vault of the skull. It has external and internal surfaces. The features to be seen on the external surface have been examined (Figs 3.16 and 3.19). These are the external occipital protuberance; the external occipital crest, and the highest, superior and inferior nuchal lines. The internal surface of the squamous part is marked by four deep fossae (Fig. 3.12). The area where the fossae meet is raised to form the internal occipital protuberance. Above the protuberance there a wide median groove for the superior sagittal sinus; and on either side of the protuberance there is an equally wide groove for the transverse

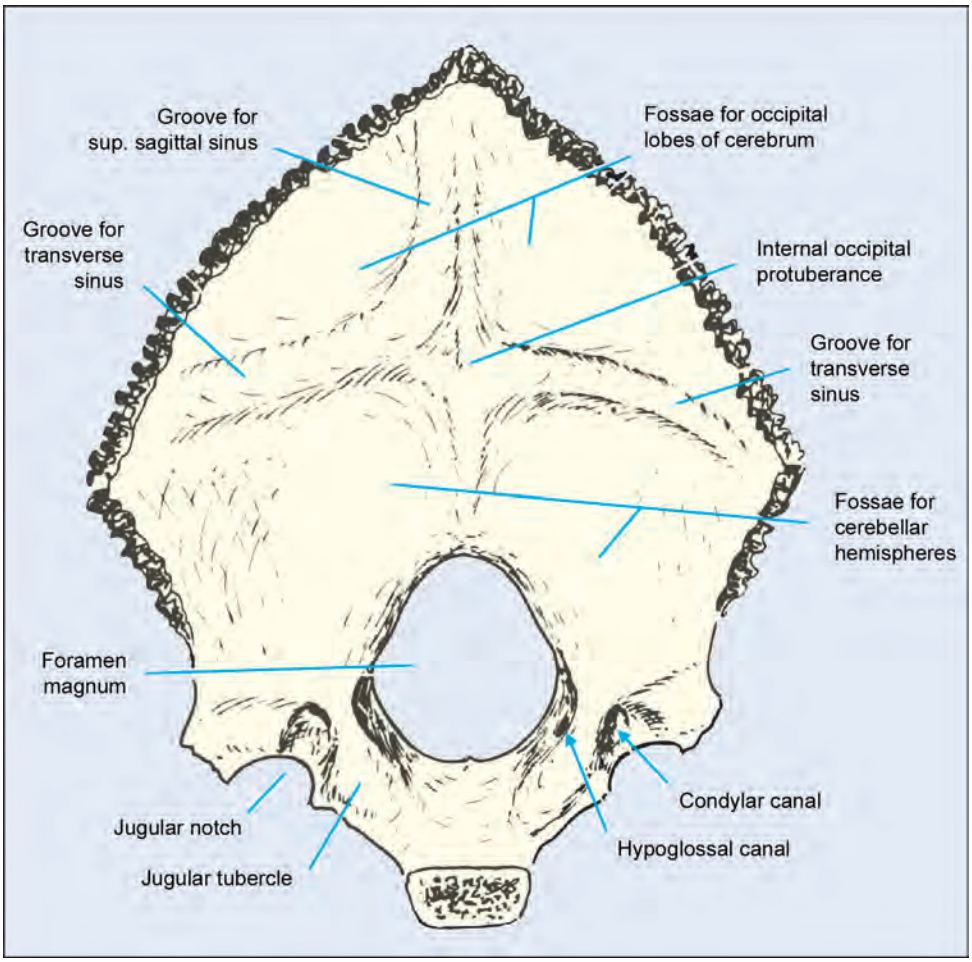


Fig. 3.19: Occipital bone, anterosuperior view

sinus. These grooves have prominent lips. Inferior to the protuberance the internal surface bears a median ridge called the internal occipital crest.

The Basilar Part

The basilar part of the occipital bone lies in front of the foramen magnum. In the adult it is directly continuous with the body of the sphenoid, but in the young the two are separated by a plate of cartilage. The inferior surface of the basilar part bears a small prominence called the pharyngeal tubercle (Fig. 3.20). The superior surface of the basilar part forms the sloping median portion of the anterior wall of the posterior cranial fossa clivus (Fig. 3.21).

The Lateral Part

The lateral parts of the occipital bone have superior and inferior surfaces. The features to be seen on the inferior surface have been examined (Fig. 3.20). They include the occipital condyles, the hypoglossal canal, the condylar fossa, the condylar canal, the jugular process, the jugular fossa and the jugular foramen. The superior surface of the lateral part

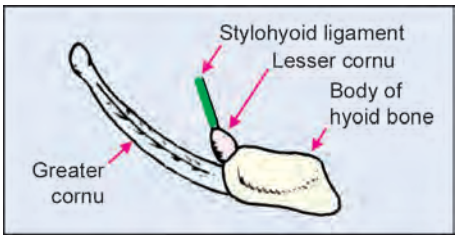


Fig. 3.20: Hyoid bone, seen from the lateral side

of the occipital bone forms part of the floor of the posterior cranial fossa (Fig. 3.21). It bears an elevation, the jugular tubercle. The superior aspect of the jugular process bears a deep groove for the lower part of the sigmoid sinus. The groove is continuous with the jugular foramen.

Articulations

The squamous part articulates (on each side) with the corresponding parietal bone at the lambdoid suture; and with the corresponding mastoid temporal bone at the occipitomastoid suture. The anterior margin of the lateral part of the bone meets the petrous temporal, the two being partially separated by the jugular fossa. Anteriorly, the basilar part is separated from the apex of the petrous temporal bone by the foramen lacerum.

THE TEMPORAL BONE

Each temporal bone (right or left) is made up of squamous, petrous, mastoid, tympanic and styloid

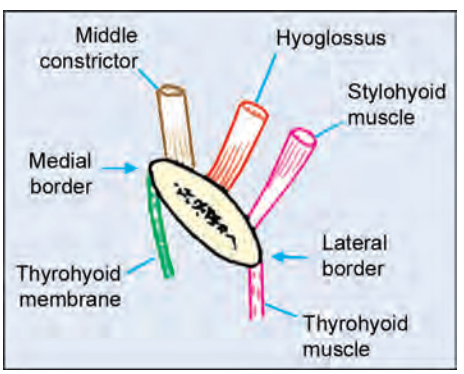


Fig. 3.21: Schematic vertical section through a greater cornu of the hyoid bone to show the arrangement of structures attached

parts (Figs 3.5 to 3.7, 3.13, 3.14, 3.16 to 3.24). Its lateral aspect is marked by a prominent zygomatic process and by the external acoustic meatus.

The Squamous Part

The squamous part contributes to the lateral wall of the skull. It also forms part of the base of the skull, and part of the floor of the middle cranial fossa. It has external (or temporal) and internal (or cerebral) surfaces. Arising from its external aspect there is the zygomatic process that joins the temporal process of the zygomatic bone to form the zygomatic arch (or zygoma). Inferiorly, the squamous part bears the mandibular fossa for articulation with the head of the mandible.

Some features to be seen on the lateral aspect of the squamous temporal bone have been described (Figs 3.14, 3,17 to 3.19). These include the temporal lines, the supramastoid crest, the anterior and posterior roots of the zygomatic process, the tubercle of the root of the zygoma, the postglenoid tubercle and the suprameatal triangle. When we examine the inferior aspect of the squamous temporal bone we see the infratemporal surface, the mandibular fossa and the articular tubercle (Figs 3.20 and 3.24).

The cerebral surface of the squamous part forms the lateral portion of the floor, and the lateral wall, of the middle cranial fossa. This surface shows vascular grooves (Fig. 3.21).

The Mastoid Part

The mastoid part of the temporal bone lies behind the external acoustic meatus. It shows a large downward projection called the mastoid process (Figs 3.17, 3.18 and 3.20). Medial to the mastoid process there is a deep mastoid notch. Near the anterior end of the notch we see the stylomastoid foramen. Medial to the mastoid notch there is a groove for the occipital artery. Posteriorly, the mastoid part of the temporal bone meets the occipital bone at the occipitomastoid suture. A mastoid foramen is present on or near this suture.

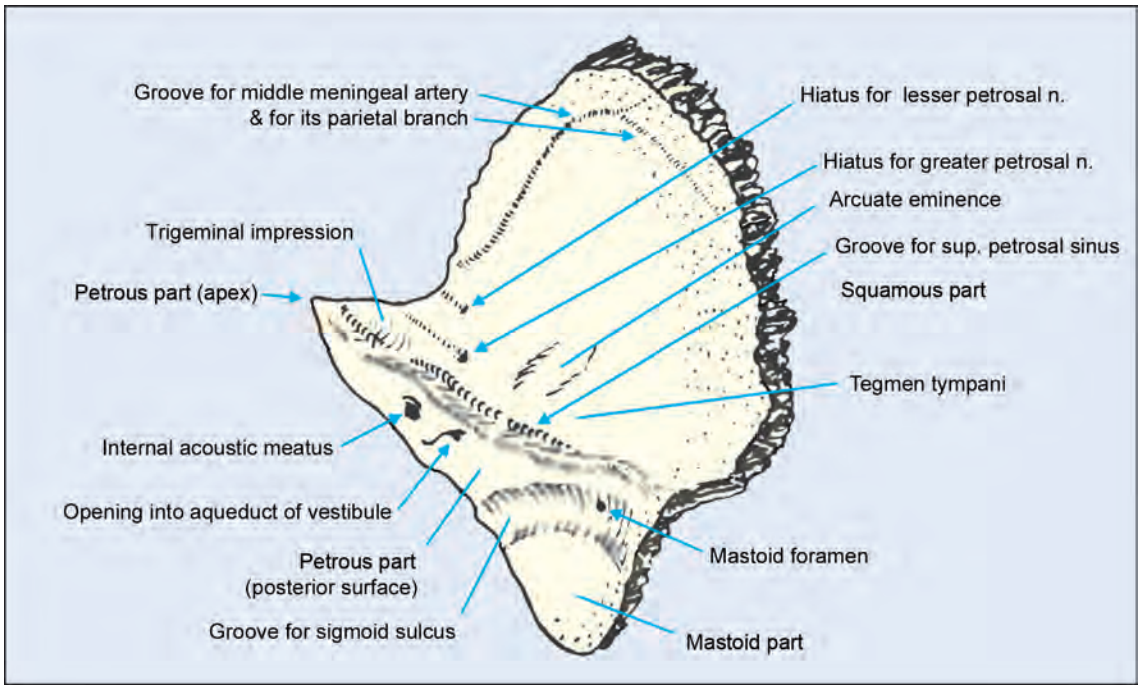


Fig. 3.22: Right temporal bone cranial aspect

The internal surface of the mastoid temporal is seen in the lateral part of the floor of the posterior cranial fossa (Fig. 3.21). It is marked by the groove for the sigmoid sinus, and by the internal opening of the mastoid foramen.

Within its substance the mastoid temporal bone contains several air filled spaces called the mastoid air cells. The largest of these is the mastoid antrum, which is closely related to the middle ear.

The Petrous Part

The petrous part of the temporal bone lies in the base of the skull in between the sphenoid bone, anteriorly, and the occipital bone, posteriorly. It is seen when the skull is viewed from below, and also in the floor of the middle and posterior cranial fossae. It has anterior, posterior, and inferior surfaces, and an apex which points forwards and medially.

The apex lies in the angle between the basilar part of the occipital bone (posteromedially) and the greater wing of the sphenoid (anterolaterally). It forms the posterior margin of the foramen lacerum. This foramen separates the apex from the body of the sphenoid bone, and from the basilar part of the occipital bone.

The anterior surface forms the sloping posterior part of the floor of the middle cranial fossa. The features to be seen on this surface have been examined (Fig. 3.21). They include the trigeminal impression, the hiatus for the greater petrosal nerve, the hiatus for the lesser petrosal nerve, the arcuate eminence and the tegmen tympani.

The posterior surface of the petrous temporal forms the lateral part of the sloping anterior wall of the posterior cranial fossa. This surface presents the opening of the internal acoustic meatus. Posterolateral to this opening a slit in the bone leads into a canal called the aqueduct of the vestibule.

The anterior and posterior surfaces are separated by a sharp superior border. This border separates the middle and posterior cranial fossae. The border is grooved by the superior petrosal sinus.

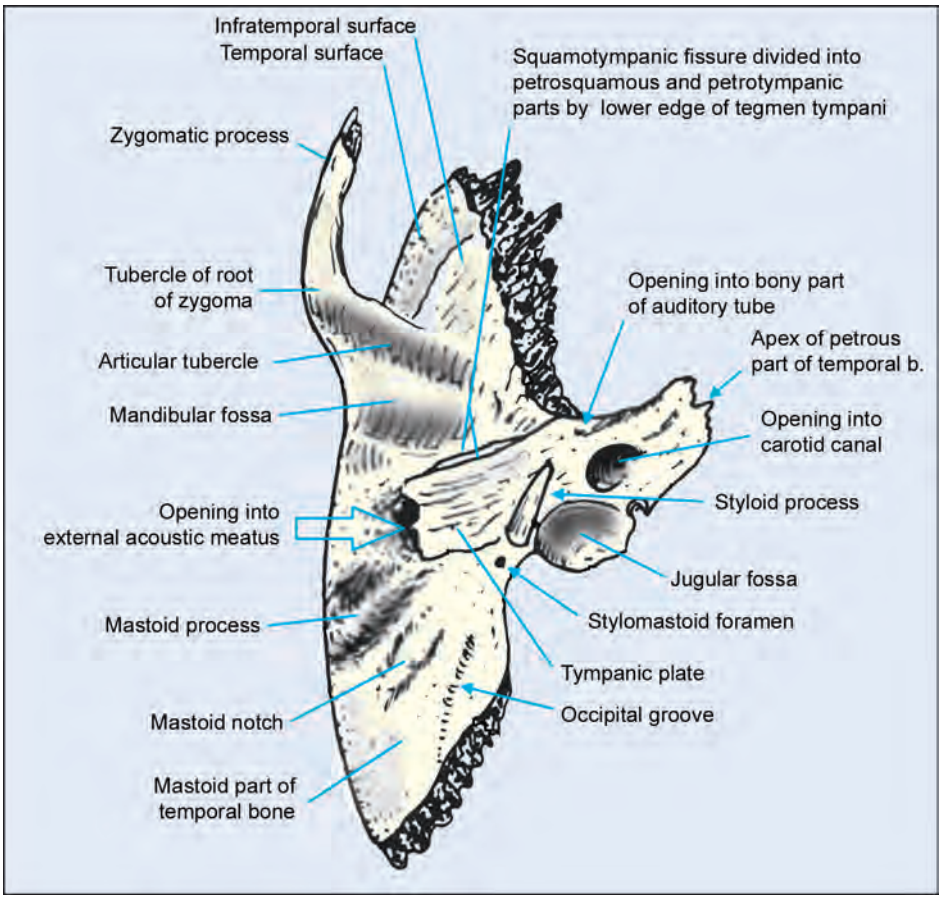


Fig. 3.23: Right temporal bone, seen from below

The inferior surface of the petrous temporal bone presents the lower opening of the carotid canal. The canal passes medially through the substance of the petrous temporal bone to open into the posterior wall of the foramen lacerum. Behind the opening of the carotid canal the petrous temporal forms the anterior wall of the jugular fossa, and of the jugular foramen. On the ridge between the opening of the carotid canal and the jugular fossa we see a small opening that leads into the canaliculus for the tympanic nerve. On the lateral wall of the jugular fossa there is the opening of the mastoid canaliculus.

The middle ear, and the internal ear, lie within the substance of the petrous part of the temporal bone. Associated with the middle ear there is the bony auditory tube, and the canal for the tensor tympani.

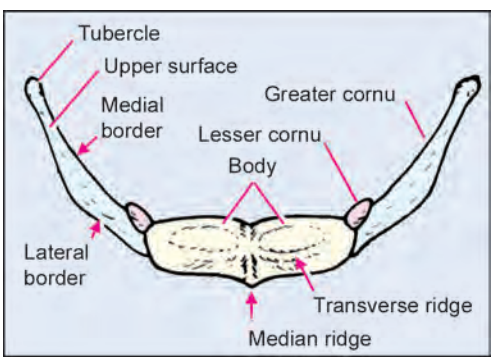


Fig. 3.24: Hyoid bone, seen from the front

The Tympanic Part

The tympanic part of the temporal bone is in the form of a plate of bone called the tympanic plate (Fig. 3.18). This plate lies between the mandibular fossa and the external acoustic meatus. It forms the anterior wall, the inferior wall, and the lower part of the posterior wall of the external acoustic meatus. The plate has a rough lateral margin which gives attachment to the cartilaginous part of the meatus. Posteriorly, the tympanic plate forms a sheath for the base of the styloid process.

The Styloid Process

The styloid process is attached to the inferior aspect of the temporal bone. It is thin and pointed, and variable in length (usually about 2.5 cm) (Figs 3.18 and 3.21). It is directed downwards and forwards. Its base is ensheathed by the tympanic plate. The stylomastoid foramen lies just behind the base of the styloid process.

Articulations of the Temporal Bone

The articular tubercle and the mandibular fossa articulate with the head of the mandible to form the temporomandibular joint. The zygomatic process articulates with the temporal process of the zygomatic bone.

Anteriorly, the squamous and petrous parts of the bone articulate with the greater wing of the sphenoid. Posteriorly, the petrous and mastoid parts articulate with the occipital bone. Superiorly, the squamous part articulates with the corresponding parietal bone.

Determination of Side

The side to which a given temporal bone belongs can be found by remembering that:

1. The zygomatic process is on the lateral side of the bone and points forwards.
2. The mastoid and styloid processes point downwards.

THE SPHENOID BONE

The sphenoid bone is unpaired. It forms the middle part of the base of the skull. Parts of it extend into the lateral wall of the vault, and into the orbit (Figs. 3.6, 3.7, 3.12, 3.14, 3.17 to 3.19, 3.21, 3.23, 3,25 to 3.28).

The sphenoid consists of a median part, the body, right and left greater wings, right and left lesser wings, and right and left pterygoid processes.

The Body

The body of the sphenoid bone has superior, inferior, anterior, posterior, and right and left lateral surfaces.

The inferior surface of the body lies in the roof of the posterior part of the nasal cavity and in the roof of the nasopharynx. Projecting downwards from the body there is a median ridge called the rostrum (which fits into the gap between the alae of the vomer (Fig. 3.25).

The superior surface of the body forms the median part of the floor of the (posterior part of the) anterior cranial fossa, and of the median part of the middle cranial fossa. The features to be seen here have been examined (Figs 3.27 and 3.28). They include the jugum sphenoidale, the sulcus chiasmaticus, the tuberculum sellae, the hypophyseal fossa, and the dorsum sellae with the posterior clinoid processes.

The lateral surfaces of the body of the sphenoid are also seen in the floor of the middle cranial fossa. Each lateral surface is marked by the carotid groove.

Posteroinferiorly, the body of the sphenoid is continuous with the basilar part of the occipital bone. Along with the latter it forms the median part of the sloping anterior wall (clivus) of the posterior cranial fossa.

The anterior surface of the body of the sphenoid takes part in forming the roof of the nasal cavity. This surface can be seen only in the disarticulated bone (Fig. 3.25). It bears a median sphenoidal crest on either side of which there is the opening of the

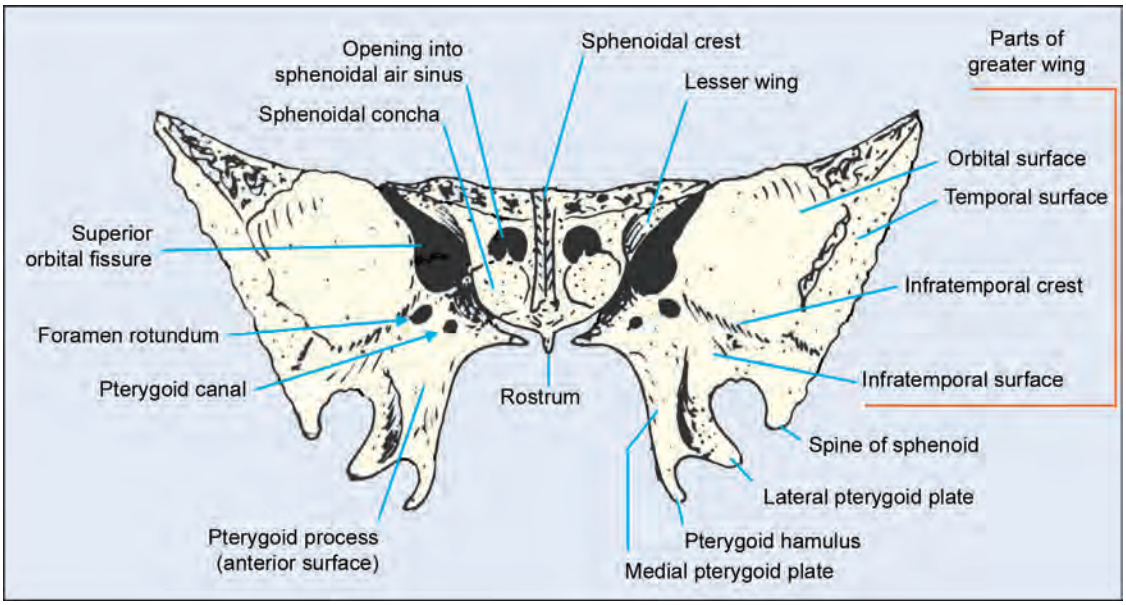


Fig. 3.25: Sphenoid bone, anterior aspect

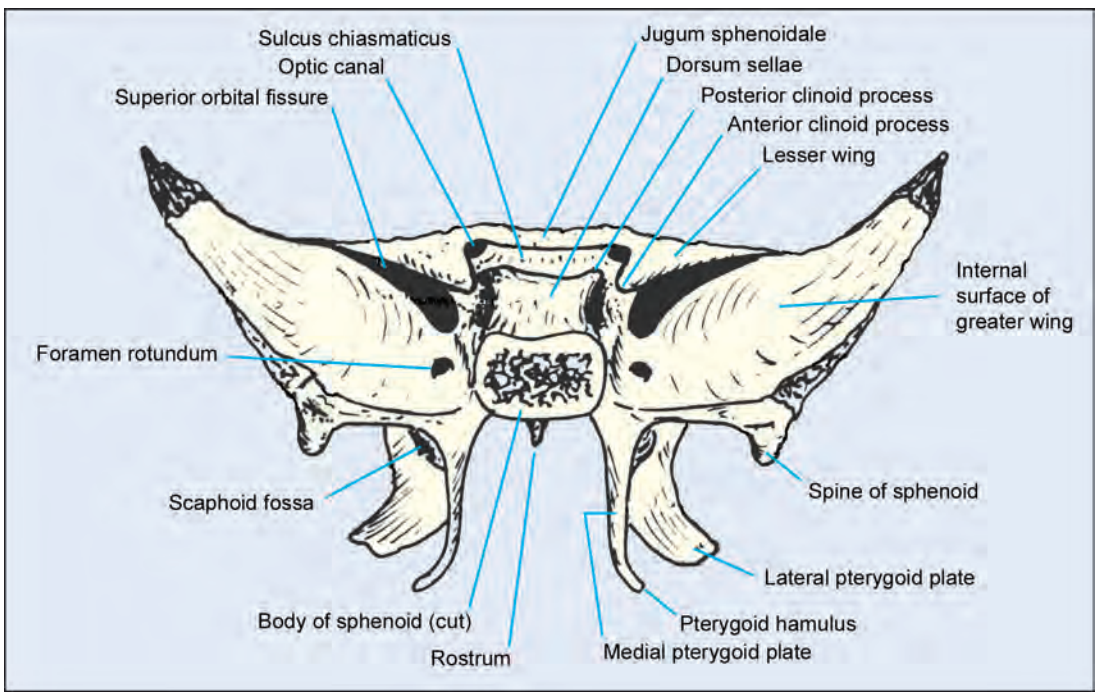


Fig. 3.26: Sphenoid bone, posterior aspect

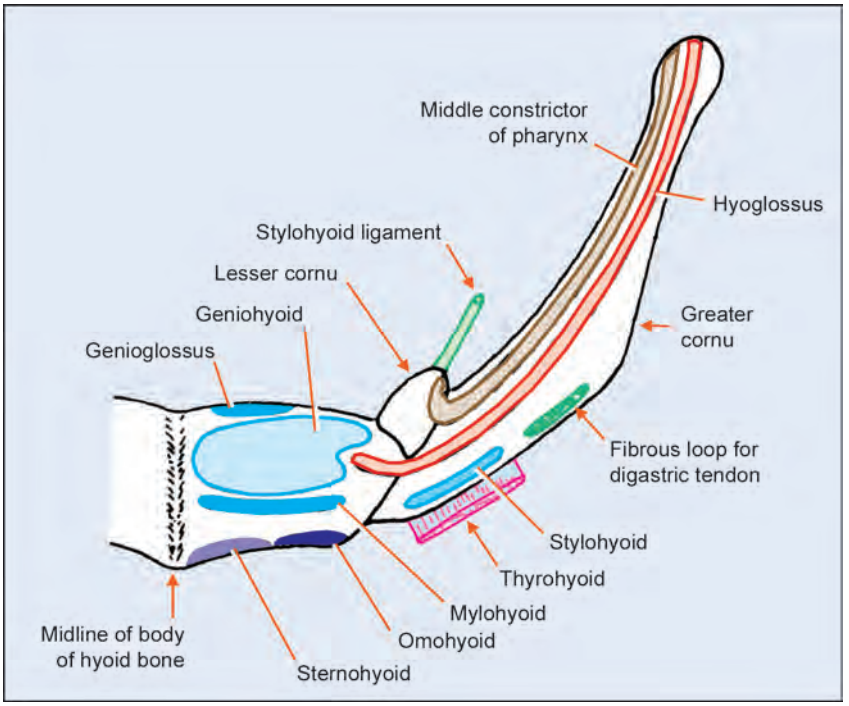


Fig. 3.27: Attachments on the hyoid bone, anterosuperior aspect

corresponding sphenoidal air sinus. The lower margin of each opening is formed by a thin plate of bone called the sphenoidal concha.

The sphenoidal air sinuses lie within the body of the sphenoid.

The Greater Wings

The greater wings of the sphenoid extend laterally and upwards from each side of the body. Each greater wing has cerebral, lateral and orbital surfaces.

The cerebral surface is concave. It forms part of the floor of the middle cranial fossa (Figs 3.27 and 3.28). Anteriorly and medially this surface has a sharp edge which is separated from the lesser wing by the superior orbital fissure. Just below the medial end of the fissure we see the foramen rotundum. Posteromedially, the greater wing is separated from the apex of the petrous temporal bone by the foramen lacerum. Near the posterior margin of the cerebral surface of the greater wing we see three or four foramina. These are the foramen ovale, the foramen spinosum, the emissary sphenoidal foramen, and sometimes the canaliculus innominatus.

The lateral surface of the greater wing is convex. It is divisible into an upper part, the temporal

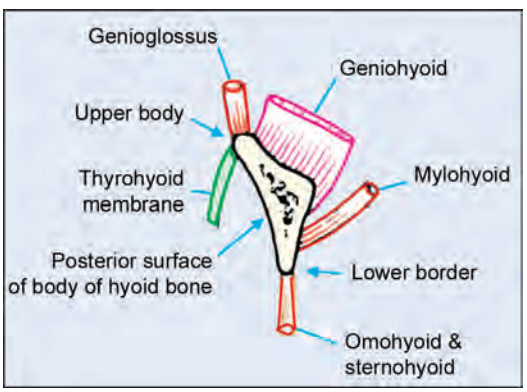


Fig. 3.28: Sphenoid bone, anterior aspect

surface; and a lower part, the infratemporal surface by the infratemporal crest. The features to be seen on the infratemporal surface have been described (Figs 3.12 and 3.24). They include the foramen ovale, the foramen spinosum, the emissary sphenoid foramen, the canaliculus innominatus, the spine of the sphenoid, and the groove for the auditory tube.

When viewed from the front the greater wing presents an orbital surface. We have seen that this surface forms the posterior part of the lateral wall of the orbit (Fig. 3.11). Medially, it has a free edge that forms the inferolateral margin of the superior orbital fissure. Inferiorly, it forms the upper boundary of the inferior orbital fissure.

The Lesser Wings

The lesser wings of the sphenoid pass laterally from the anterior and upper part of the body. Each wing is attached to the body of the sphenoid by two roots (anterior and posterior). The optic canal lies between these roots and the body of the sphenoid. The medial part of the lesser wing bears a backward projection called the anterior clinoid process.

The lesser wing has superior and inferior surfaces. The superior surface forms part of the floor of the anterior cranial fossa (including its sharp posterior edge) (Fig. 3.28). The inferior surface forms the posterior part of the roof of the orbit (Fig. 3.11). It forms the upper boundary of the superior orbital fissure.

The Pterygoid Processes

Each pterygoid process projects downwards from the junction of the body and greater wing of the sphenoid (Figs 3.12, 3.18, 3.19, 3.26 and 3.29). The process consists of medial and lateral pterygoid plates. In the Figure 3.25 note that the upper part of the pterygoid process has an anterior surface, which forms the posterior wall of the pterygopalatine fossa. On this surface we see the anterior opening of the pterygoid canal. (The posterior opening of the pterygoid canal is located just above the scaphoid fossa, in the anterior wall of the foramen lacerum). A little above and lateral to this opening we see the anterior opening of the foramen rotundum.

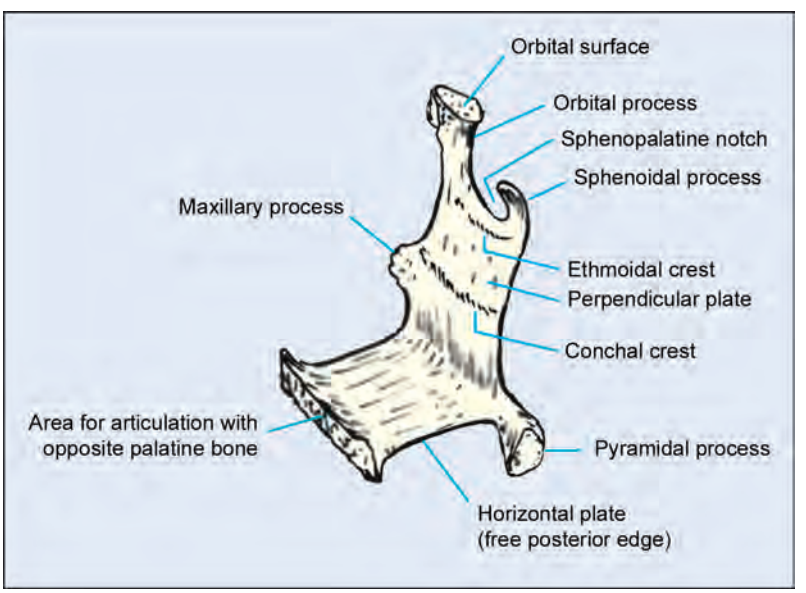


Fig. 3.29: Right palatine bone, posteromedial aspect

Articulations of the Sphenoid Bone

The body of the sphenoid is continuous posteroinferiorly with the basilar part of the occipital bone. Anteriorly, it articulates with the ethmoid bone. The sphenoidal crest articulates with the perpendicular plate of the ethmoid and forms a small part of the nasal septum.

Each greater wing articulates, posteriorly, with the petrous temporal; posterolaterally, with the squamous temporal; anteromedially with the frontal bone; anteriorly and laterally with the zygomatic bone; and superiorly with the anteroinferior angle of the parietal bone (Figs 3.11 and 3.14).

The lesser wing articulates anteriorly with the orbital plate of the frontal bone.

The lower part of the pterygoid process articulates, anteriorly, with the maxilla. The anterior margin of the medial pterygoid plate articulates with the perpendicular plate of the palatine bone. The pyramidal process of the palatine bone fits into the interval between the lower ends of the medial and lateral pterygoid plates. The vaginal plate (arising from the medial side of the pterygoid process) articulates anteriorly with the sphenoidal process of the palatine bone, and medially with the ala of the vomer (Fig. 3.25).

THE PALATINE BONES

Each palatine bone is made up mainly of two plates, one perpendicular and the other horizontal (Figs 3.6, 3.12, 3.23 to 3.25, 3.29, 2.37, 2.38). The horizontal plate forms the posterior part of the bony palate. Its lateral margin joins the lower end of the perpendicular plate. The perpendicular plate lies in the posterior part of the lateral wall of the nasal cavity. In addition to these two plates the palatine bone has three processes —pyramidal, orbital and sphenoidal.

The Horizontal Plate

The horizontal plate has superior and inferior surfaces. The inferior surface has been examined when the anterior part of the skull was viewed from below (Figs 3.6, 3.23 and 3.24). Note that each horizontal plate meets the plate of the opposite side at the interpalatine suture. Anteriorly, it meets the palatine process of the maxilla. The posterior edge of the plate is free: it provides attachment to the soft palate. In the midline the posterior edges of the right and left horizontal plates project backwards to form the posterior nasal spine. A little in front of the posterior margin the inferior surface of the horizontal plate shows a raised palatine crest.

The superior surface of the horizontal plate forms the floor of the posterior part of the nasal cavity. In the midline (where the two horizontal plates meet) there is an elevation called the nasal crest. This crest articulates with the vomer and contributes to the nasal septum.

The Perpendicular Plate

The perpendicular plate of the palatine bone lies in the lateral wall of the nasal cavity (Figs 3.13, 3.29 and 2.37).

Anteriorly, it articulates with the maxilla and posteriorly with the medial pterygoid plate. The perpendicular plate has medial and lateral surfaces. The lateral surface articulates with the maxilla converting the greater palatine groove on the latter into the greater palatine canal. The perpendicular plate overlaps the posterior part of the maxillary hiatus. Superiorly, it forms the medial wall of the pterygopalatine fossa.

The medial surface of the perpendicular plate forms part of the lateral wall of the nasal cavity. Inferiorly, this surface has a conchal crest that gives attachment to the inferior nasal concha; and superiorly it has an ethmoidal crest to which the middle nasal concha is attached (Fig. 2.37).

The upper border of the perpendicular plate has a notch which forms the lower part of the sphenopalatine foramen. (The foramen is bounded above by the body of the sphenoid) (Figs 3.13, 2.37 and 3.29).

The Pyramidal Process

The pyramidal process of the palatine bone (Figs 3.12, 3.23, 3.24 and 3.29) passes backwards and laterally from the posterolateral angle of the horizontal plate. It is wedged between the maxillary tuberosity (anteriorly) and the pterygoid process (posteriorly) and occupies the interval between the lower ends of the medial and lateral pterygoid plates. The lesser palatine foramina are seen on the inferior aspect of the pyramidal process.

The Orbital Process

The orbital process of the palatine bone (Figs 3.11 and 3.29) arises from the anterosuperior angle of the perpendicular plate. It forms a small part of the floor of the orbit.

The Sphenoidal Process

The sphenoidal process (Figs 3.25 and 3.29) arises from the posterosuperior angle of the perpendicular plate. It meets the vaginal plate of the sphenoid bone and helps to form the palatovaginal canal.

THE ETHMOID BONE

The ethmoid bone has a complicated configuration that is explained schematically in the Figure 2.42. It consists of a median vertical plate, and right and left labyrinths (Figs 3.7 to 3.9, 3.11, 3.27, 2.38 to 2.40, 2.42).

The median plate can be subdivided into a small part the crista galli which is seen in the floor of the anterior cranial fossa (Figs. 3.7 and 3.27), and the perpendicular plate which forms a considerable part of the nasal septum (Fig. 2.39).

The labyrinth consists of a number of ethmoidal air sinuses (Figs 2.40 and 2.42) that are enclosed in thin plates of bone. Laterally, the labyrinth is bounded by the orbital plate (which forms a considerable part of the medial wall of the orbit—Fig. 3.11) and medially it is bounded by the medial plate which lies in the lateral wall of the nasal cavity. Passing medially into the nasal cavity from the medial plate there are curved plates of bone that form the superior and middle nasal conchae (Figs 2.38 and 2.42).

Each labyrinth is connected to the median plate by a narrow horizontal plate that passes laterally from the junction of the crista galli with the perpendicular plate. This horizontal plate has numerous perforations and is, therefore, called the cribriform (= sieve like) plate. The cribriform plate forms part of the floor of the anterior cranial fossa and part of the roof of the nasal cavity (Figs 3.7 and 3.27).

The walls of many ethmoidal air cells are incomplete. In the intact skull they are completed by parts of the maxilla and of the frontal, lacrimal, sphenoid and palatine bones.

Articulations

The perpendicular plate of the ethmoid articulates anteroinferiorly with the septal cartilage of the nose, posteroinferiorly with the vomer, anteriorly with the frontal and nasal bones, and posteriorly with the sphenoid (Fig. 2.39). The cribriform plate articulates laterally with the orbital plate of the frontal bone, and posteriorly with the sphenoid (Fig. 3.27).

The labyrinth articulates above with the frontal bone, posteriorly with the sphenoid, and laterally with the maxilla, the palatine bone and the lacrimal bone. The medial aspect of the labyrinth gives attachment to part of the inferior nasal concha.

SOME SMALL BONES

The Lacrimal Bones

Each lacrimal bone is a small thin plate placed in relation to the anterior part of the medial wall of the orbit (Figs 3.4 and 2.37). It has a lateral surface, seen in the orbit; and a medial surface that helps to form the lateral wall of the nose.

The lateral surface is marked by a vertical lacrimal crest in front of which there is a vertical

groove. This groove meets a similar groove on the frontal process of the maxilla to form the groove for the lacrimal sac.

Inferiorly, the lacrimal groove is continuous with the nasolacrimal canal. A descending process from the lacrimal bone helps to complete the medial wall of the canal (along with the lacrimal process of the inferior nasal concha). A curved spicule of bone called the lacrimal hamulus lies in the lateral wall of the upper end of the nasolacrimal canal.

Articulations

The lacrimal bone articulates, anteriorly, with the frontal process of the maxilla; posteriorly, with the ethmoid; superiorly, with the frontal bone; and inferiorly, with the maxilla.

The Nasal Bones

The right and left nasal bones form the bridge of the nose (Figs 3.4, 3.6, 3.8, 3.9, 3.23, 3.25 and 2.39). Each bone articulates medially with the bone of the opposite side, laterally with the frontal process of the maxilla, and superiorly (and by its posterior surface) with the nasal part of the frontal bone. The inferior margin of the bone gives attachment to the lateral nasal cartilage.

The posterior surface of the bone is grooved and takes part in forming the anterior part of the roof of the nasal cavity. The medial margins of the two nasal bones are thickened (on this aspect) and project into the nasal cavity as a crest which contributes to the nasal septum.

The Vomer

The vomer is a flat plate of bone that forms the posteroinferior part of the nasal septum (Figs 3.4, 3.6, 3.8, 3.9, 3.23, 3.25 and 3.28). It articulates antero-superiorly with the perpendicular plate of the ethmoid. Posterosuperiorly the vomer articulates with the body of the sphenoid. Here the vomer has two alae; the rostrum of the sphenoid fits into the interval between the alae. Inferiorly, the vomer is attached to the palatine processes of the maxillae, and to the horizontal plates of the palatine bones. Anteriorly, the vomer gives attachment to the septal cartilage of the nasal septum.

The Inferior Nasal Concha

This is a thin curved plate of bone lying in relation to the lateral wall of the nasal cavity (Figs 3.4, 3.8, 2.37 and 2.38). The plate is free inferiorly. Its superior margin is attached to the maxilla (conchal crest) anteriorly, and to the conchal crest on the perpendicular plate of the palatine bone posteriorly. In between these it is attached to the lacrimal bone (through a lacrimal process), and along with the latter it forms the medial boundary of the nasolacrimal groove.

THE HYOID BONE

The hyoid bone is not a part of the skull, but is considered here for sake of convenience.

The hyoid bone is present in the front of the upper part of the neck. It is not attached to any other bone directly; but is held in place by muscles and ligaments which are attached to it. The most important of these are the stylohyoid ligaments by which it is suspended from the base of the skull.

The bone consists of a central part called the body, and of two cornua—greater and lesser—on either side (Figs 3.20, 3.21, 3.24, 3.27, 3.29 and 3.30). The body is roughly quadrilateral. It has an anterior surface directed forwards and upwards, and a posterior surface directed backwards and downwards. The anterior surface is divided into upper and lower parts by a transverse ridge, and into right and left halves by a median vertical ridge. The posterior surface is smooth.

The greater cornua are attached to the lateral part of the body, from which they project backwards and laterally. They are flattened and have upper and lower surfaces; and medial and lateral borders. The posterior end of each cornu is enlarged to form a tubercle.

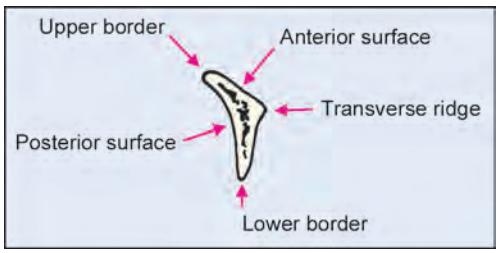


Fig. 3.30: Median section through the hyoid bone

The lesser cornua are small and conical. They project upwards and laterally from the junction of the body and the greater cornua.

The union between the body and greater cornua is cartilaginous in the young, but they fuse in later life. The lesser cornua are attached by fibrous tissue (but sometimes there may be synovial joints between them and the greater cornua).

Attachments on the Hyoid Bone

A. The muscles attached to the hyoid bone are as follows (Figs 3.21 and 3.27):
   a. The lowest fibres of the genioglossus are inserted into the upper border of the body.
   b. The geniohyoid is inserted on the anterior surface of the body.
   c. The mylohyoid is inserted on the anterior surface of the body below the insertion of the geniohyoid.
   d. The sternohyoid is inserted into the medial part of the inferior border of the body.
   e. The superior belly of the omohyoid is attached to the lateral part of the inferior border of the body.
   f. The middle constrictor of the pharynx arises from the upper surface of the greater cornu, and from the posterolateral aspect of the lesser cornu.
   g. The hyoglossus arises from the upper surface of the greater cornu (lateral to the origin of the middle constrictor), and from the lateral part of the body.
   h. The stylohyoid muscle is inserted into the upper surface of the greater cornu near its junction with the body.
   i. The thyrohyoid muscle is inserted into the anterior part of the lateral border of the greater cornu.

B. Other structures attached to the hyoid bone are as follows:
   a. The stylohyoid ligament is attached to the apex of the lesser cornu.
   b. The thyrohyoid membrane is attached to the medial border of the greater cornu, and to the upper border of the body.
   c. The fibrous loop for the tendon of the digastric is attached to the lateral part of the upper surface of the greater cornu, behind the insertion of the stylohyoid muscle.

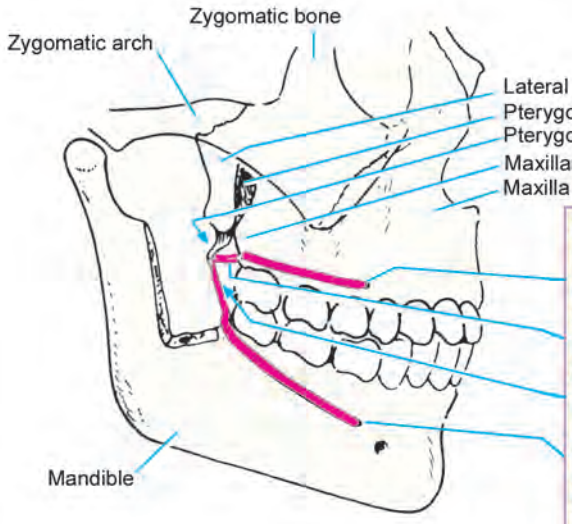
Development and Ossification of the Hyoid Bone

The upper half of the body, and the lesser cornua of the hyoid bone are derived from the cartilages of the second pharyngeal arches. The lower half of the body, and the greater cornua are derivatives of the cartilages of the third pharyngeal arches.

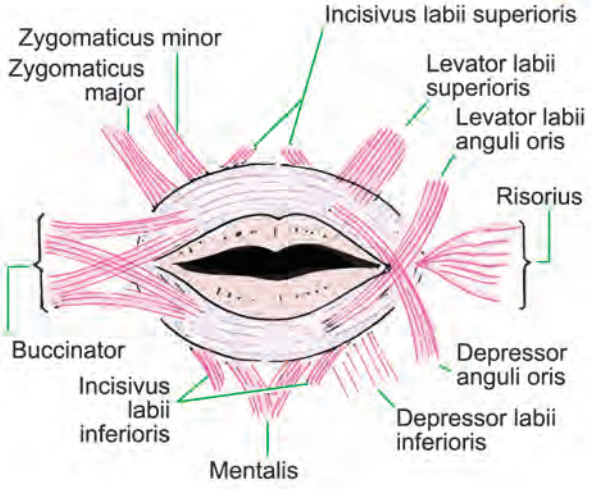
The hyoid bone ossifies from six centres. One centre appears in each greater cornua towards the end of foetal life. Two centres appear in the body at about the time of birth. Two centres appear in the lesser cornua only at about the age of puberty.

4 Some Muscles of Head and Neck

BUCCINATOR



ORIGIN: The buccinator has a 'C' shaped line of origin from :
(a) the outer aspect of the maxilla just above the three molar teeth;
(b) a tendinous arch connecting the maxillary tuberosity to the pterygoid hamulus;
(c) the pterygomandibular raphe (see below); and
(d) the outer surface of the body of the mandible just below the molar teeth. At its posterior end the line of origin from the mandible passes behind the 3rd molar tooth to reach the medial side.



The pterygomandibular raphe is made up of interlacing tendinous fibres. It is attached above to the pterygoid hamulus (at the lower end of the medial pterygoid plate), and below to the posterior end of the mylohyoid line of the mandible. The raphe gives attachment anteriorly to fibres of the buccinator, and posteriorly to fibres of the superior constrictor of the pharynx.

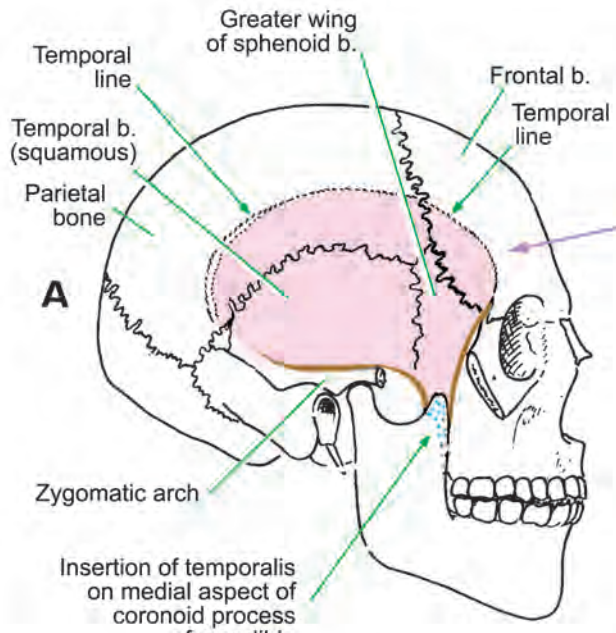
INSERTION: The fibres of the buccinator run forwards where they are continuous with the orbicularis oris).

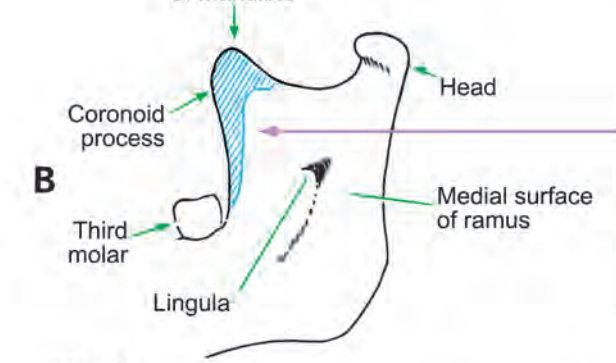
NERVE SUPPLY: The muscle is supplied by the lower buccal branches of the facial nerve.

ACTIONS: The buccinator aids mastication by pushing food between the teeth. The muscle increases air pressure within the mouth as in blowing. (Laterally, the word buccinator means one who blows a trumpet).

Important Relations: The muscle is lined on the inside by the mucous membrane of the mouth. It is related on its outer aspect to the parotid duct which pierces it opposite the third upper molar tooth; to the superficial muscles inserted into the angle of the mouth; to the facial artery and vein; and to branches of the facial and buccal nerves.

TEMPORALIS





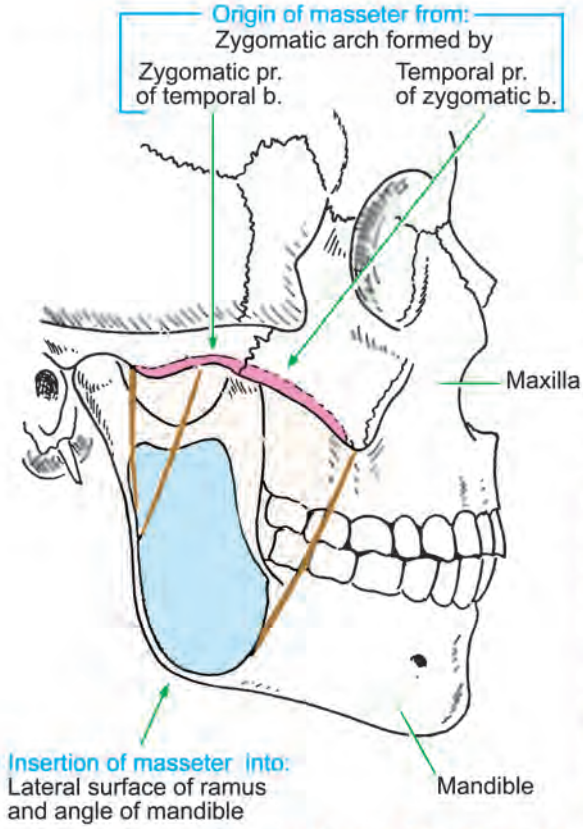
ORIGIN:
The temporalis arises from the temporal fossa on the lateral aspect of the skull. The area is bounded above by the temporal line, and below by the zygomatic arch. It includes parts of the frontal, parietal, and squamous temporal and of the greater wing of the sphenoid bone.
The anterior fibres of the muscle run vertically downwards; the posterior fibres run horizontally forwards; while the intermediate fibres run obliquely to converge in a tendon. The tendon passes deep to the zygomatic arch.

INSERTION:
The muscle is inserted into the coronoid process of the mandible. The region of insertion covers the entire medial aspect of the coronoid process (including its apex, anterior and posterior borders). Some fibres are inserted into the anterior border of the ramus.

NERVE SUPPLY:
The temporalis is supplied by the deep temporal branches of the mandibular nerve.

ACTIONS:
The temporalis helps to close the mouth by elevating the mandible.
The movements of elevation and depression of the mandible have two components. Firstly, there is a hinge like movement between the condyle of the mandible and the inferior surface of the articular disc of the temporomandibular joint. The second component is a gliding movement of the disc (along with the head of the mandible). In wide opening of the mouth the disc glides forward so that the head of the mandible comes to lie below the articular eminence.
In closing the mouth the posterior horizontal fibres of the temporalis pull the mandible backwards (along with the intra-articular disc), whereas the anterior vertical fibres produce the angular hinge-like movement.

Temporal fascia:
The temporalis is covered by a thick temporal fascia. The fascia is attached above to the (superior) temporal line, and below to the zygomatic arch.



MASSETER

NERVE SUPPLY:
The masseter is supplied by a branch of the anterior division of the mandibular nerve. The nerve reaches the muscle by passing through the notch between the coronoid process and neck of the mandible.

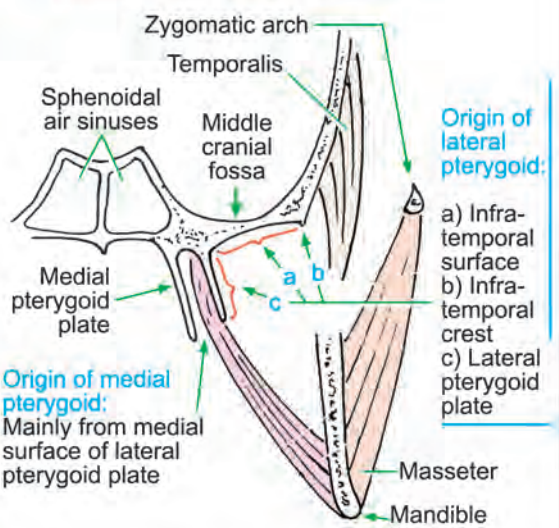
ACTIONS:
The masseter elevates the mandible to close the mouth. Its anterior fibres help in protraction (forward movement) of the jaw.

Important Relations:
Apart from the skin and some superficial muscles of the face the masseter is overlapped by the anterior part of the parotid gland, the parotid duct, the branches of the facial nerve and the transverse facial vessels. Deep to the masseter there are the ramus of the mandible, the lower part of the temporalis and the posterior part of the buccinator.

ORIGIN OF PTERYGOID MUSCLES

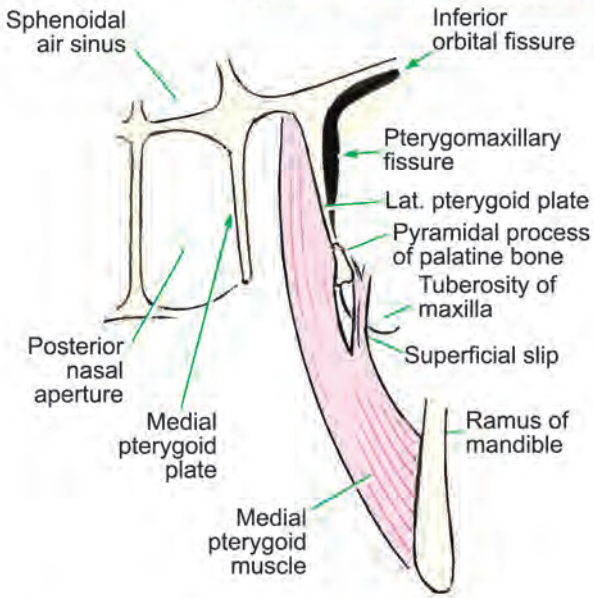
ORIGIN OF LATERAL PTERYGOID:
The upper head arises from:
(i) the infratemporal surface, and (ii) the infratemporal crest, of the greater wing of the sphenoid bone.
The lower head arises from the lateral surface of the lateral pterygoid plate.

ORIGIN OF MEDIAL PTERYGOID:
The medial pterygoid muscle takes origin from:
(a) the medial surface of the lateral pterygoid plate and
(b) the adjoining part of the palatine bone (pyramidal process).
(c) A superficial slip arises from the lateral aspect of the pyramidal process of the palatine bone and from the maxillary tuberosity (See next page also).



MEDIAL AND LATERAL PTERYGOID

(First see description of origins on previous page)

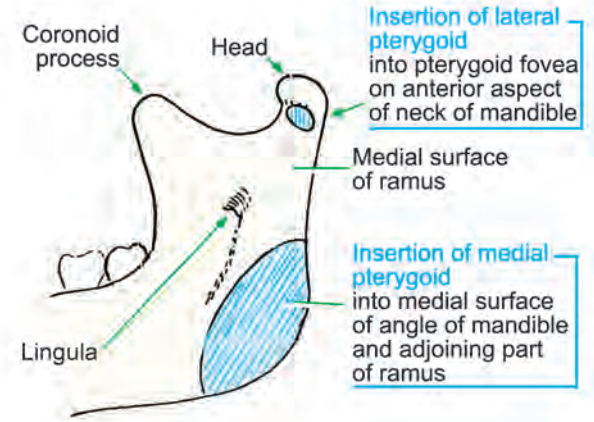


ACTIONS of Pterygoid Muscles:

(a) The medial and lateral pterygoids of both sides acting together protract the mandible.

(b) The medial and lateral pterygoids of one side acting together pull the mandibular condyle of that side forwards (and medially). As a result the chin moves forwards and to the opposite side. Alternate action of the muscles of the two sides results in side to side chewing movements.

(c) The two pterygoid muscles have opposite actions as far as opening and closing of the mouth is concerned. The medial pterygoid elevates the jaw. The lateral pterygoid helps in opening the mouth by pulling the head of the mandible forwards along with the intra-articular disc.

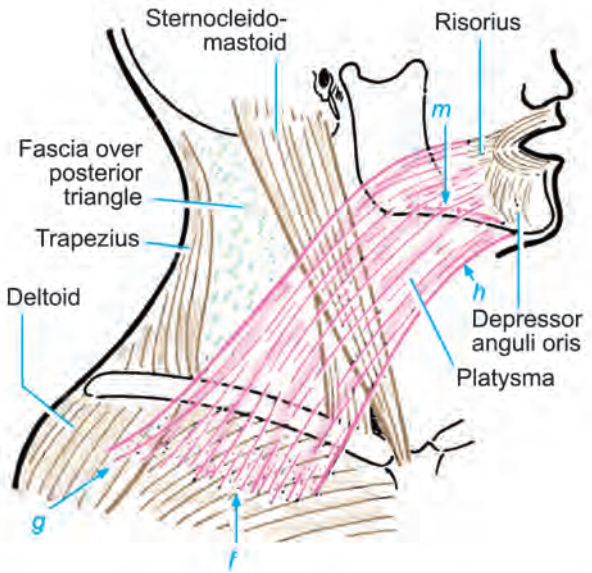


INSERTION OF LATERAL PTERYGOID:
The fibres of both heads run backwards and laterally to be inserted into a depression (pterygoid fovea) on the anterior aspect of the neck of the mandible. Some fibres are inserted into the intra-articular disc and some into the capsule of the temporomandibular joint.

INSERTION OF MEDIAL PTERYGOID:
The fibres of the muscle pass downwards, backwards and laterally to be inserted into the medial surface of the angle of the mandible and the adjoining part of its ramus.

NERVE SUPPLY OF MEDIAL AND LATERAL PTERYGOID MUSCLES:
Mandibular nerve.

PLATYSMA



This is the most superficial muscle in the neck. Like the muscles of the face it lies in the superficial fascia. It is a remnant of an extensive sheet of subcutaneous muscle (called the pannulus carnosus) to be seen in some animals.

Origin: The muscle arises from the deep fascia covering the upper part of the pectoralis major (f in figure) and the anterior part of the deltoid (g). The fibres form a broad thin sheet that passes upwards and forwards across the clavicle, and then across the sternocleidomastoid.

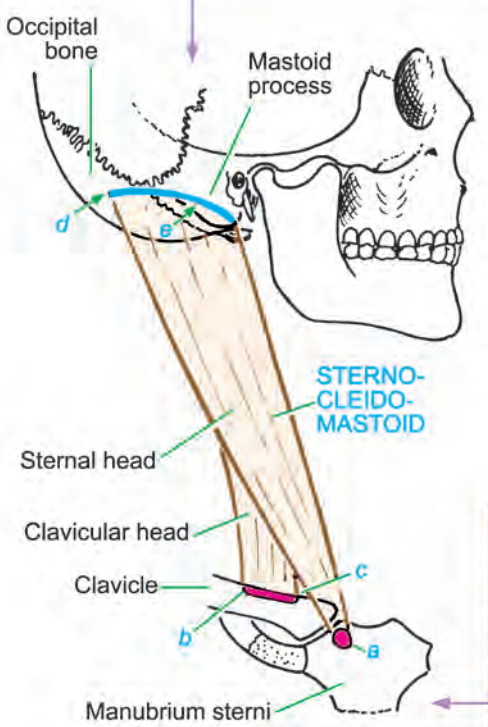
Insertion: The most anterior fibres end by interlacing with those of the opposite side below the chin (h). The remaining fibres cross the lower border of the mandible, some of them being attached to it (m). The fibres end by merging with muscles at the angle of the mouth (specially risorius and depressor anguli oris).

Nerve Supply: The muscles is supplied by the cervical branch of the facial nerve.

Action: The platysma produces wrinkles over the skin of the neck. [The much better developed subcutaneous sheet of muscle present in some animals, e.g., the horse, enables them to move their skin over underlying structures]

STERNOCLEIDOMASTOID

INSERTION:
The muscle is inserted into the:
(1) lateral half of the superior nuchal line (d); and
(2) the lateral surface of the mastoid process from its apex to the upper border (e).



NERVE SUPPLY:
The sternocleidomastoid is supplied by the accessory nerve (spinal part) and by branches from the ventral rami of spinal nerves C2, C3.

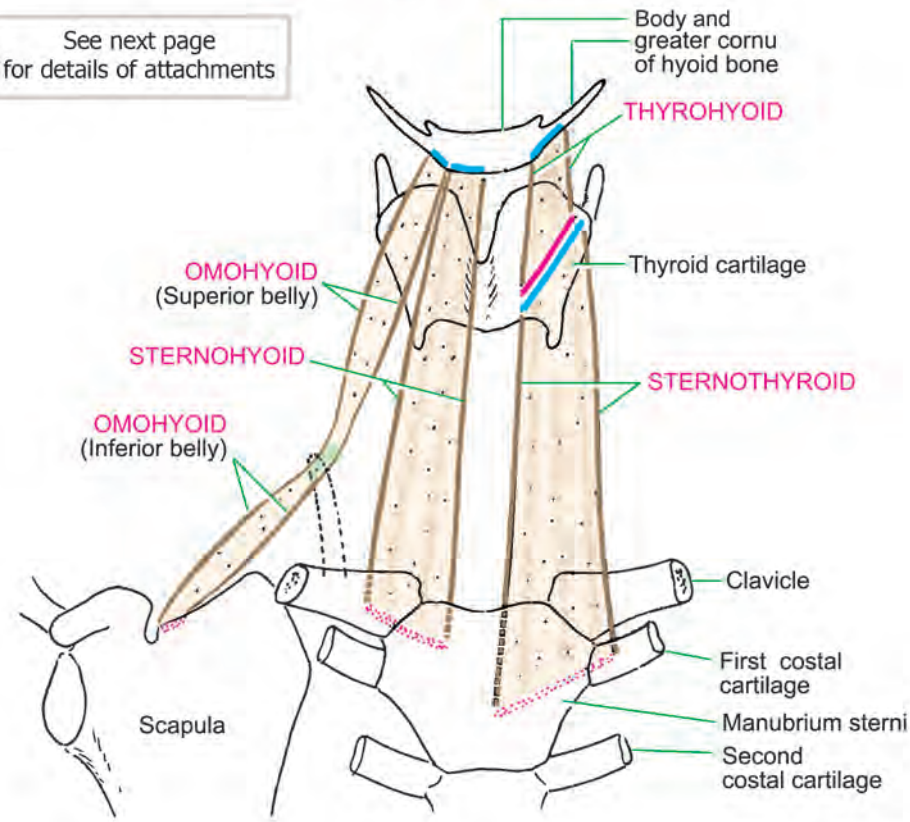
ACTIONS:
When the muscle of one side contracts the head is tilted to the same side, and the face is rotated to the opposite side. When the muscles of both sides act together the head and neck are flexed.

ORIGIN:
The muscle arises by two heads.
(1) The sternal head arises from the anterior surface of the manubrium sterni (a).
(2) The clavicular head arises from the upper surface of the medial part of the clavicle (b).
The two heads are separated at their origin by a triangular interval (c). Higher up the clavicular head blends with the deep aspect of the sternal head.

Relations:
The sternocleidomastoid forms an important landmark in the neck, and divides it into anterior and posterior triangles.

INFRAHYOID MUSCLES

See next page
for details of attachments



These are the sternohyoid, the sternothyroid, the thyrohyoid and the omohyoid muscles. The sternohyoid passes from the sternum to the hyoid bone. The sternothyroid passes from the sternum to the thyroid cartilage (of the larynx). The thyrohyoid passes from the thyroid cartilage to the hyoid bone. The omohyoid is made up of upper and lower bellies united by an intermediate tendon. The lower belly is attached to the scapula, and the upper belly to the hyoid bone.
For details of attachments see next page.

NERVE SUPPLY of infrahyoid muscles:
All the foregoing infrahyoid muscles are supplied by branches from the ansa cervicalis except the thyrohyoid which is supplied by fibres of the first cervical nerve that travel through the hypoglossal nerve.

ACTIONS of infrahyoid muscles:
The sternohyoid, the omohyoid and the thyrohyoid depress the hyoid bone. The sternothyroid pulls the larynx downwards, whereas the thyrohyoid can raise it when the hyoid bone is fixed.

INFRAHYOID MUSCLES (Continued)
Details of attachments

STERNOHYOID
The sternohyoid takes origin from:
(a) the posterior aspect of the manubrium sterni (upper part);
(b) the medial end of the clavicle (posterior aspect); and
(c) the capsule of the sternoclavicular joint.
The fibres of the muscle pass upwards and somewhat medially to be inserted into the body of the hyoid bone (lower border) .

THYROHYOID
The thyrohyoid muscle takes origin from the oblique line on the lamina of the thyroid cartilage.
It is inserted into the lower border of the greater cornu of the hyoid bone.

STERNOTHYROID
The sternothyroid takes origin from the posterior surface of the manubrium sterni below the sternohyoid, and from the medial end of the first costal cartilage.
It is inserted into the oblique line on the lamina of the thyroid cartilage just below the origin of the thyrohyoid.
Observe that the insertion of the sternothyroid corresponds to the origin of the thyrohyoid.

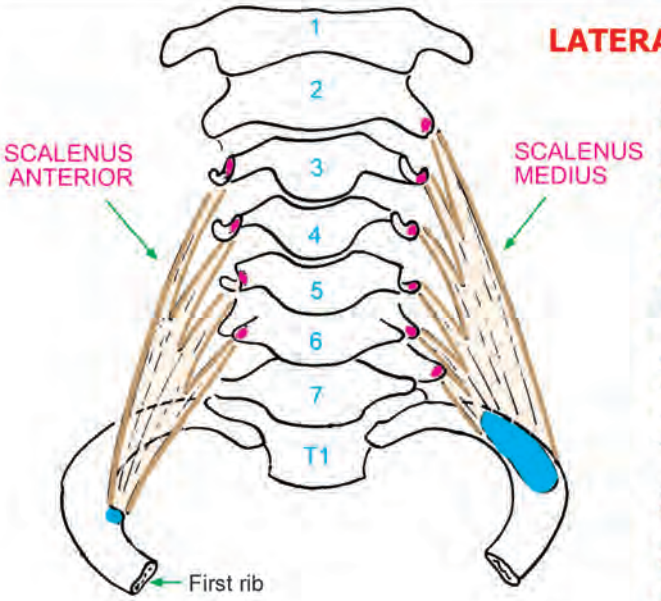
OMOHYOID
The omohyoid has two bellies, superior and inferior, joined by an intermediate tendon.

The inferior belly takes origin from a small area on the upper border of the scapula (near the scapular notch). From here the inferior belly passes forwards, upwards and medially across the floor of the posterior triangle.
It ends deep to the sternocleidomastoid by joining the intermediate tendon.

The superior belly arises from the intermediate tendon and passes upwards (and somewhat medially). to reach the hyoid bone.
It is inserted on the hyoid bone (lower border of the body, lateral to the sternohyoid).

The intermediate tendon is kept in place by a band of deep fascia which stretches from the tendon to the clavicle.

LATERAL VERTEBRAL MUSCLES



Scalenus Anterior

The scalenus anterior arises from the anterior tubercles of the transverse processes of vertebrae C3 to C6. It passes downward and laterally to be inserted into the inner border of the first rib (scalene tubercle) and to a ridge on its upper surface.

Nerve supply and action

It is supplied by the ventral rami of spinal nerves C4, C5, and C6. It bends the neck forward and laterally and rotate it so that the face turns to the opposite side.

Scalenus Medius

The scalenus medius takes origin from the transverse process of the axis, and from the transverse processes (posterior tubercles) of vertebrae C3 to C7.

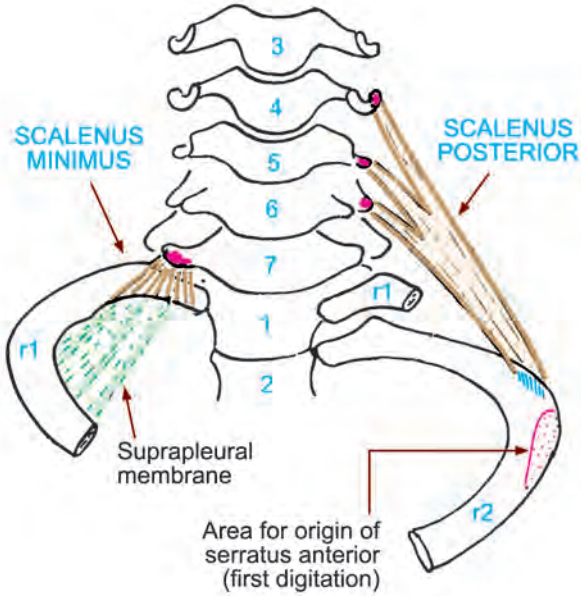
The muscle passes downwards and laterally to be inserted into the upper surface of the first rib between its tubercle and the groove for the subclavian artery.

Nerve supply

The scalenus medius is supplied by ventral rami of spinal nerves C3 to C8.

Action

The muscle bends the cervical spine to its own side. It can raise the rib during forced inspiration.



Scalenus Posterior

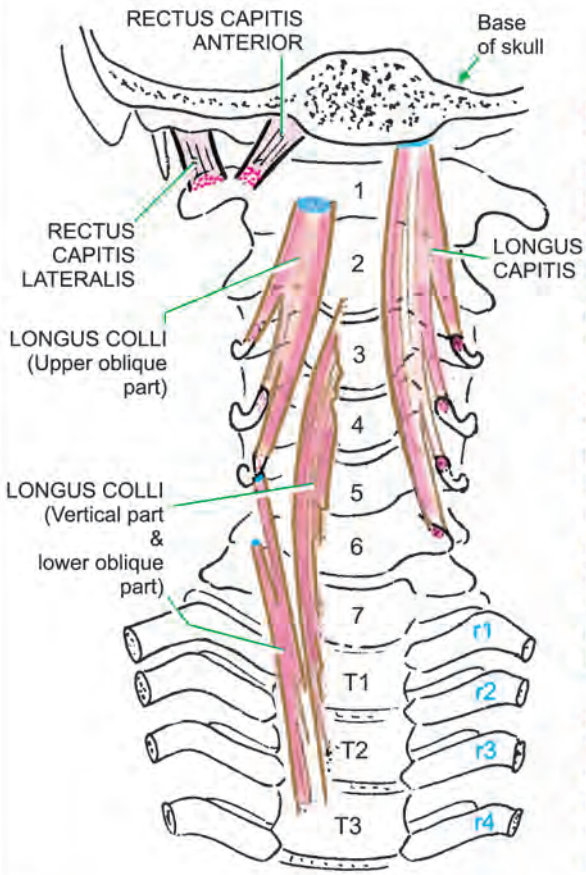
The scalenus posterior takes origin from the posterior tubercles of the transverse processes of vertebrae C4, C5, C6. Its fibres pass downwards and laterally to be inserted into the outer surface of the second rib (behind the attachment of the serratus anterior).

Nerve supply and action

The scalenus posterior is supplied by the ventral rami of spinal nerves C6, C7, C8. It bends the cervical spine to the same side. It can elevate the second rib.

Scalenus minimus

The scalenus minimus is a small muscle arising from the transverse process of the seventh cervical vertebra. The fibres of the muscle spread out to be inserted into the inner border of the first rib in its posterior part. Some of its fibres are continuous with the suprapleural membrane, which is sometimes considered to be an expansion of the muscle.



ANTERIOR VERTEBRAL MUSCLES

Rectus Capitis Anterior

The rectus capitis anterior arises from the atlas vertebra (lateral mass and root of transverse process).
It runs upward to gain insertion into the basilar part of the occipital bone.
The rectus capitis anterior is supplied by the ventral rami of spinal nerves C1 and C2.
It is a flexor of the head.

Rectus Capitis Lateralis

The rectus capitis lateralis arises from the transverse process of the atlas.
It runs upward to the base of the skull where it is inserted into the jugular process of the occipital bone (just behind jugular fossa).
It is supplied by the ventral rami of spinal nerves C1 and C2. It bends the head to its own side.

Longus Colli

The longus colli is placed in front of the vertebral column. It extends vertically from the atlas above, to the third thoracic vertebra below. It consists of an upper oblique part, a middle vertical part, and a lower oblique part.

The upper oblique part runs upward and medially from the transverse processes (anterior tubercles) of vertebrae C3, C4, and C5 to the anterior arch of the atlas.
The vertical part arises from the bodies of vertebrae C5, C6, C7 and T1, T2, T3. It runs upward to be inserted into the bodies of vertebrae C2, C3, C4.
The inferior oblique part arises from the bodies of upper thoracic vertebrae and passes upward and laterally to the transverse processes (anterior tubercles) of vertebrae C5 and C6.
The longus colli is supplied by the ventral rami of cervical nerves C2 to C6. It is a flexor of the neck. It can help in lateral flexion and in rotation of the neck.

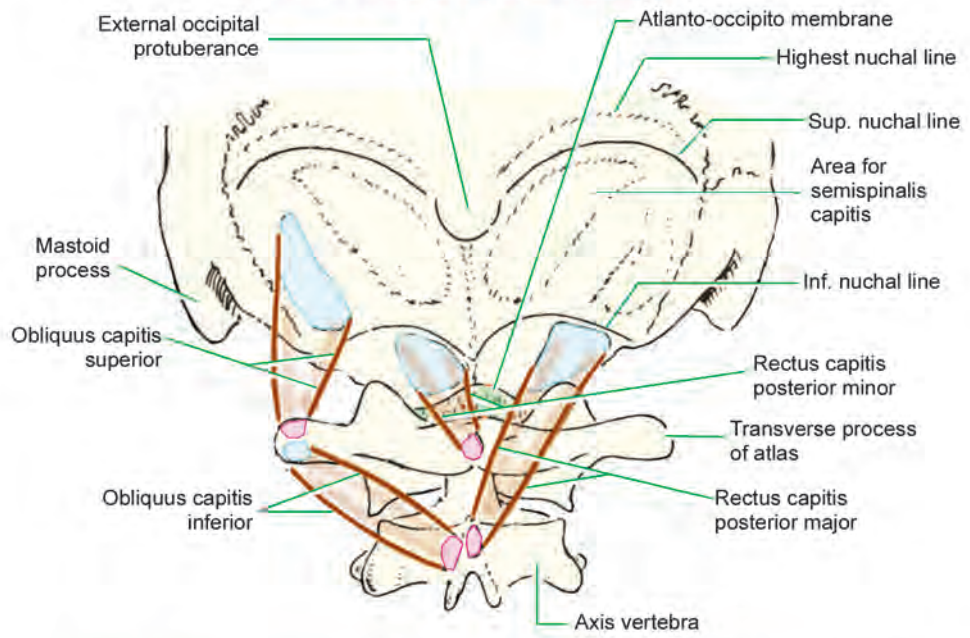
Longus Capitis

The longus capitis arises from the transverse processes (anterior tubercles) of cervical vertebrae (C3 to C6) and runs upwards and medially to be inserted into the base of the skull, on the basilar part of the occipital bone.

Nerve supply and action

The longus capitis is supplied by the ventral rami of spinal nerves C1, C2 and C3. It is a flexor of the head.

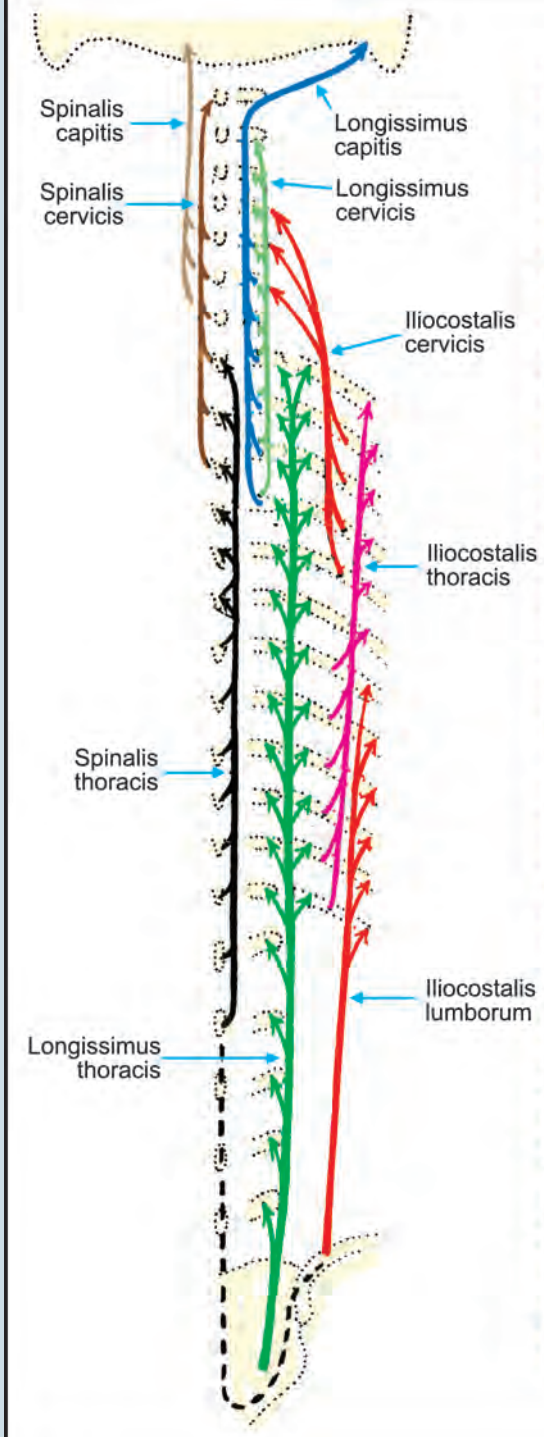
SUBOCCIPITAL MUSCLES



This is a group of small muscles placed in the uppermost part of the back of the neck, deep to the semispinalis capitis. They form the boundaries of the suboccipital triangle.

The **rectus capitis posterior minor** arises from the posterior arch of the atlas. Its fibres pass upwards to be inserted into the occipital bone in the medial part of the area below the inferior nuchal line (i.e., between the line and the foramen magnum).
The **rectus capitis posterior major** arises from the spine of the axis vertebra. Its fibres pass upwards and laterally to be inserted into the lateral part of the area below the inferior nuchal line.
The **obliquus capitis inferior** arises from the spine of the axis vertebra. Its fibres pass laterally and somewhat upwards to be inserted into the transverse process of the atlas vertebra.
The **obliquus capitis superior** arises from the transverse process of the atlas. Its fibres pass upwards (and somewhat medially) to be inserted into the lateral part of the area between the superior and inferior nuchal lines.

NERVE SUPPLY and ACTIONS:
The suboccipital muscles are supplied by the dorsal ramus of the first cervical nerve.
The main action of the suboccipital muscles is to maintain the posture of the head. Note that the head tends to fall forwards due to gravity. This is resisted by the two recti and the superior oblique which extend it. The obliquus capitis inferior rotates the head at the atlantoaxial joint turning the face to its own side. The rectus capitis posterior major can also produce slight rotation of the face to its own side. The superior oblique tilts the head laterally to its own side.



ERECTOR SPINAE

The erector spinae is deep to the splenius group and superficial to the semispinalis group. It consists of a lateral part, the iliocosto-cervicalis; an intermediate part called the longissimus; and a small medial part, the spinalis.

ORIGIN:

The main origin of the muscle is from the back of the sacrum through a U-shaped tendon attached to the median and lateral sacral crests. The medial limb of the 'U' extends upwards to the lumbar and lower thoracic spines. The lateral limb extends on to the dorsal part of the iliac crest and the sacrotuberous and sacroiliac ligaments. (The origin is indicated by thick interrupted line in the lower part of figure).

The muscle mass passes upwards and divides into three main parts.

The **spinalis** part is most medial and least developed. Its fibres pass from spines to spines. It is subdivided into the following:

(a) The spinalis thoracis
(b) The spinalis cervicis
(c) The spinalis capitis

The **longissimus** is the largest division of the erector spinae. It is subdivided into the following:

(a) The longissimus thoracis
(b) The longissimus cervicis
(c) The longissimus capitis

The **iliocostocervicalis** lies lateral to the longissimus and consists of:

(a) the iliocostalis lumborum
(b) the iliocostalis thoracis
(c) the iliocostalis cervicis

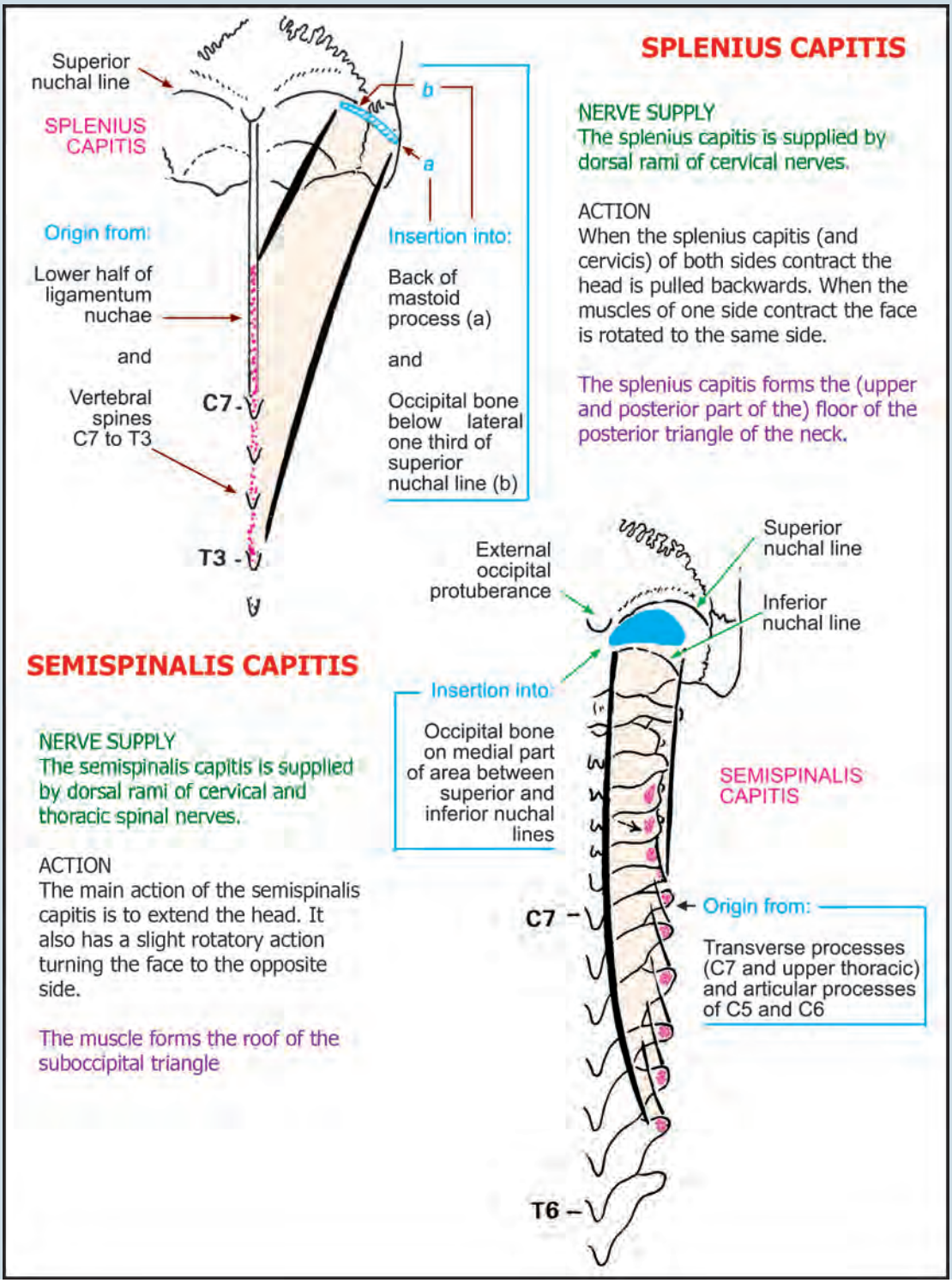
Note that out of the large muscle mass of the erector spinae only three slender slips (namely the iliocostalis cervicis, longissimus cervicis and longissimus capitis) reach the neck.

Nerve Supply and Actions of Erector Spinae:

The erector spinae is supplied by dorsal primary rami of spinal nerves.

As a whole the erector spinae is an extensor and lateral flexor of the vertebral column. The longissimus capitis turns the face to its own side.

The erector spinae is a very important postural muscle. In persons who lead a sedentary life, and with old age, the muscle becomes weak. The vertebral column then tends to bend forwards. This puts excessive strain on ligaments of the vertebral column and also predisposes to prolapse of intervertebral discs. These are common causes of backache. Tone in the erector spinae can be maintained by exercises and also by brisk walking.


Superior nuchal line
SPLENIUS CAPITIS
Origin from:
Lower half of ligamentum nuchae
and
Vertebral spines C7 to T3
C7
T3
b
a
Insertion into:
Back of mastoid process (a)
and
Occipital bone below lateral one third of superior nuchal line (b)
SPLENIUS CAPITIS
NERVE SUPPLY
The splenius capitis is supplied by dorsal rami of cervical nerves.
ACTION
When the splenius capitis (and cervicis) of both sides contract the head is pulled backwards. When the muscles of one side contract the face is rotated to the same side.
The splenius capitis forms the (upper and posterior part of the) floor of the posterior triangle of the neck.
SEMISPINALIS CAPITIS
NERVE SUPPLY
The semispinalis capitis is supplied by dorsal rami of cervical and thoracic spinal nerves.
ACTION
The main action of the semispinalis capitis is to extend the head. It also has a slight rotatory action turning the face to the opposite side.
The muscle forms the roof of the suboccipital triangle
External occipital protuberance
Superior nuchal line
Inferior nuchal line
Insertion into:
Occipital bone on medial part of area between superior and inferior nuchal lines
SEMISPINALIS CAPITIS
C7
T6
Origin from:
Transverse processes (C7 and upper thoracic) and articular processes of C5 and C6

5 The Vertebral Column

STRUCTURE OF A TYPICAL VERTEBRA

The parts of a typical vertebra are best seen by examining a vertebra from the mid-thoracic region. Such a vertebra is seen from above in Figure 5.1 and from behind in Figure 5.2. A lateral view of two such vertebrae is shown in Figure 5.3. The following parts can be distinguished.

1. The body lies anteriorly. It is shaped like a short cylinder, being rounded from side to side, and having flat upper and lower surfaces that are attached to those of adjoining vertebrae through intervertebral discs (Fig. 5.3).
2. The pedicles (right and left) are short rounded bars that project backwards, and somewhat laterally, from the posterior part of the body.
3. Each pedicle is continuous, posteromedially, with a vertical plate of bone called the *lamina*. The laminae of the two sides pass backwards and medially to meet in the middle line. The pedicles and laminae together constitute the vertebral arch.
4. Bounded anteriorly by the posterior aspect of the body, on the sides by the pedicles, and behind by the laminae, there is a large vertebral foramen. Each vertebral foramen forms a short segment of the vertebral canal that runs through the whole length of the vertebral column and transmits the spinal cord.
5. Passing backwards (and usually downwards) from the junction of the two laminae, there is the spine (or spinous process).
6. Passing laterally (and usually somewhat downwards) from the junction of each pedicle and

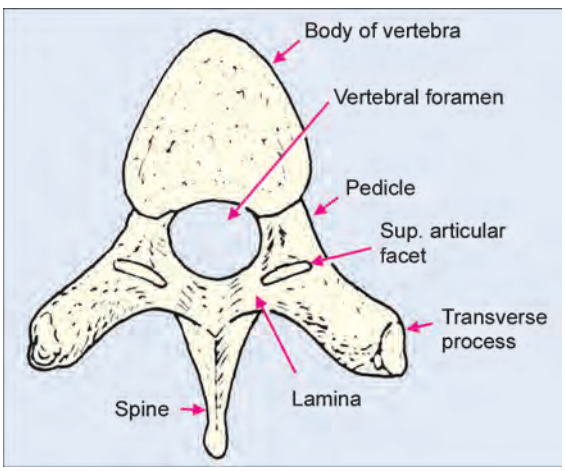


Fig. 5.1: Typical vertebra seen from above

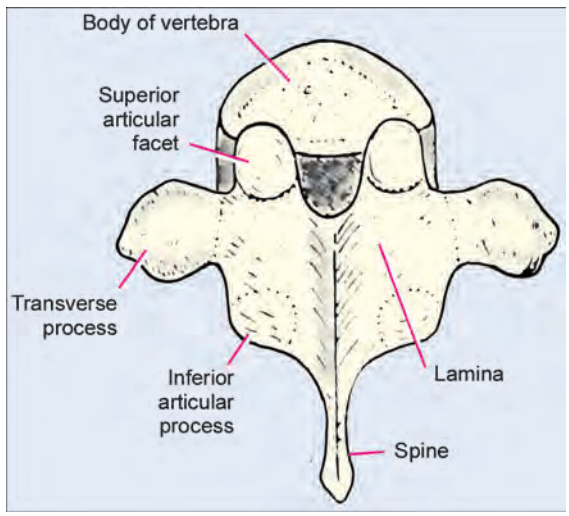


Fig. 5.2: Typical vertebra seen from behind

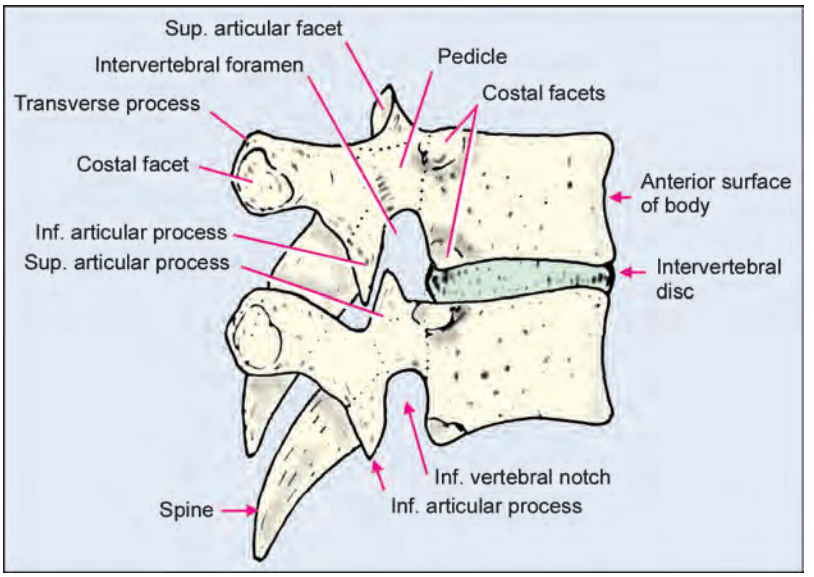


Fig. 5.3: Typical vertebrae seen from the lateral side. (Costal facets, for ribs, are shown on the bodies and transverse processes: they are present only in the thoracic region)

the corresponding lamina there is a transverse process. The spinous and transverse processes serve as levers for muscles acting on the vertebral column.

When the vertebrae are viewed from the lateral side (Fig. 5.3) we see certain additional features.

7. Projecting upwards from the junction of the pedicle and the laminae there is, on either side, a superior articular process; and projecting downwards there is an inferior articular process. Each process bears a smooth articular facet: the superior facet is directed posteriorly and somewhat laterally, and the inferior facet is directed forwards and somewhat medially.

   The superior facet of one vertebra articulates with the inferior facet of the vertebra above it. Two adjoining vertebrae, therefore, articulate at three joints: two between the right and left articular processes and one between the bodies of the vertebrae (through the intervertebral disc).
8. In Figure 5.3 note that the pedicle is much narrower than the body (in vertical diameter) and is attached nearer its upper border. As a result there is a large inferior vertebral notch below the pedicle. The notch is bounded in front by the posterior surface of the body of the vertebra, and behind by the inferior articular process. Above the pedicle there is a much shallower superior vertebral notch. The superior and inferior notches of adjoining vertebrae join to form the intervertebral foramina which give passage to spinal nerves emerging from the spinal cord.

Distinguishing Features of Typical Cervical, Thoracic and Lumbar Vertebrae

The cervical, thoracic and lumbar vertebrae can be easily distinguished from one another because of the following characteristics.

a. The transverse process of a cervical vertebra is pierced by a foramen called the *foramen transversarium* (Fig. 5.4).
b. The thoracic vertebrae bear costal facets for articulation with ribs. These are present on the sides of the vertebral bodies and on the transverse processes (Fig. 5.3).
c. A lumbar vertebra (Fig. 5.5) can be distinguished by the fact that it neither has foramina transversaria nor does it bear facets for ribs. It is also recognized by the large size of its body.

We may now consider additional differences between cervical, thoracic and lumbar vertebrae.

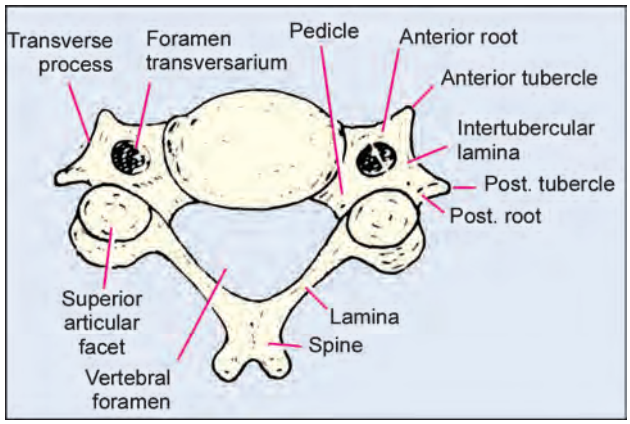


Fig. 5.4: Typical cervical vertebra seen from above

1. The vertebral bodies progressively increase in size from above downwards. They are, therefore, smallest in the cervical vertebrae and largest in the lumbar vertebrae. In shape the body is oval in the cervical and lumbar regions and triangular or heart shaped in the thoracic region.

   The upper and lower surfaces of the bodies are more or less flat in the thoracic and lumbar region. In cervical vertebrae the upper surface of the body is concave from side-to-side (Fig. 5.6): the posterolateral parts of its edge are raised to form distinct lips. As a result of this the superior vertebral notch is prominent in cervical vertebrae, but is barely perceptible in thoracic vertebrae (Fig. 5.3).

   In the thoracic region the head of a typical rib articulates with the sides of the bodies of two vertebrae (Fig. 5.7). For this purpose each side of the body of a typical thoracic vertebra bears two costal facets, upper and lower, adjoining its upper and lower borders (Fig. 5.3). Each of these is really only half a facet (demifacet), the other half being on the adjoining vertebra. The upper facet is large and articulates with the numerically corresponding rib. The lower, smaller facet articulates with the next lower rib.

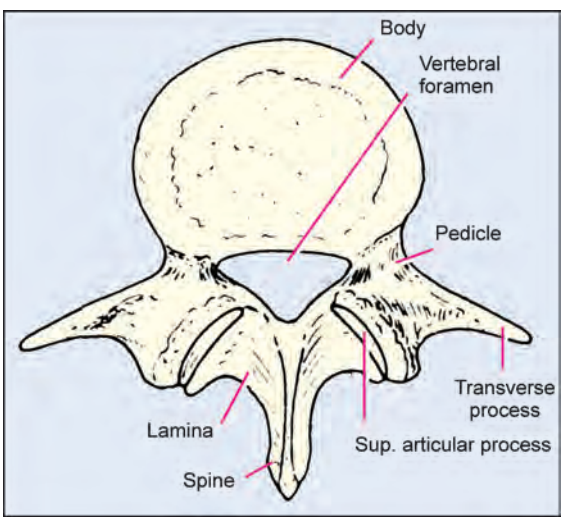


Fig. 5.5: Typical lumbar vertebra seen from above

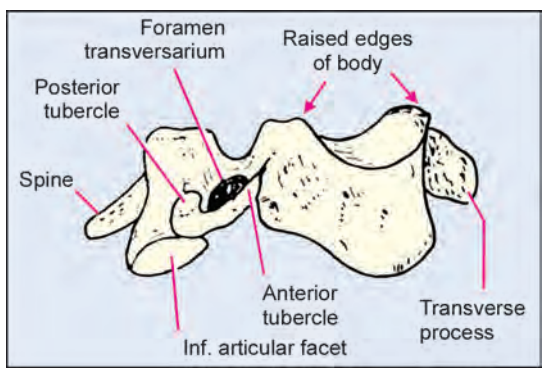


Fig. 5.6: Typical cervical vertebra seen from the anterolateral side

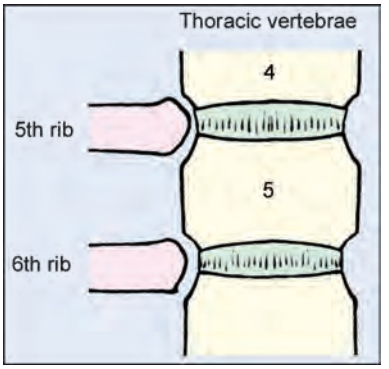


Fig. 5.7: Scheme showing the numerical relationship of thoracic vertebrae to ribs

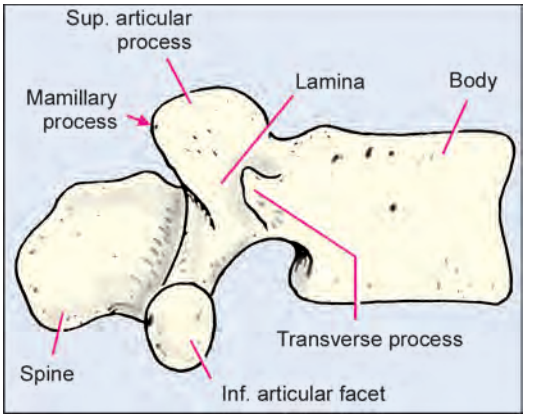


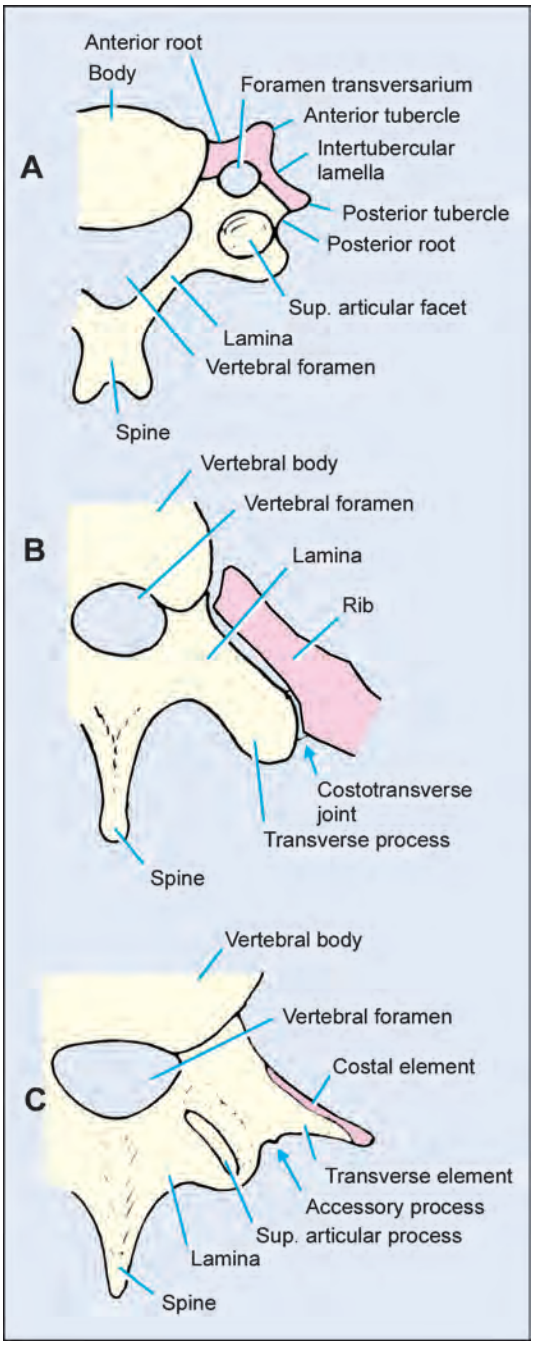
Fig. 5.8: Typical lumbar vertebra seen from the lateral side

2. The vertebral foramen is triangular and large in cervical vertebrae (Fig. 5.4). In the lumbar vertebrae also it is triangular (Fig. 5.5), but in thoracic vertebrae it is small and circular or oval (Fig. 5.1). These variations in size correspond with those of the spinal cord which is largest (in diameter) in the cervical region.
3. The pedicles are long and directed backwards and laterally in the cervical region (Fig. 5.4). In the thoracic region they pass almost directly backwards (Fig. 5.1). They are thick and short in the lumbar region and are directed backwards and somewhat laterally (Fig. 5.5).
4. The laminae of cervical vertebrae are long (transversely) and narrow (vertically) (Fig. 5.4). In the thoracic region they are short (transversely) and so broad (vertically) that the laminae of adjacent vertebrae overlap (Figs 5.1 and 5.2). In the lumbar region also they are short and broad, but do not overlap (Fig. 5.5).
5. The spinous processes are short and bifid in a typical cervical vertebra (Fig. 5.4). They are long and project downwards in the thoracic region (Fig. 5.3). In lumbar vertebrae they are large and quadrangular: they are more or less horizontal and have a thick posterior edge (Fig. 5.8).
6. The transverse processes of typical cervical vertebrae (Fig. 5.9A) are relatively short and, as mentioned earlier, they are pierced by foramina transversaria. The part of the process in front of the foramen is called the *anterior root*; and the part behind it is called the *posterior root*. The part lateral to the foramen is usually called the costotransverse bar, but it is more correct to call it the *intertubercular bar*. The anterior and posterior roots end in thickenings called the *anterior and posterior tubercles* respectively. When viewed from the lateral side the transverse process is seen to be grooved (Fig. 5.6). The cervical nerves lie in these grooves after they pass out of the intervertebral foramina.

   The transverse processes of a typical thoracic vertebra are large with solid blunt ends (Figs 5.1, 5.3 and 5.9B). They are directed backwards and laterally. Each process lies just behind the corresponding rib and bears a prominent facet for articulation with the rib.

   The lumbar transverse processes are relatively small and often have tapering ends (Fig. 5.9C). The posteroinferior aspect of the root of each transverse process bears an elevation called the *accessory process*.

   Although proper ribs are formed only in the thoracic region, rudimentary ribs are formed in the cervical and lumbar regions during foetal life. These become fused with the true



Figs 5.9A to C: Transverse processes showing the parts derived from the costal elements (red shading). (A) Cervical; (B) Thoracic; (C) Lumbar;

transverse processes. The part of the transverse process derived from the rudimentary rib is called the *costal element*. In the cervical region (Fig. 5.9A) the costal element forms the anterior root, the costotransverse bar and both the anterior and posterior tubercles.

In the lumbar region (Figs 5.9C and 5.10) the costal element forms a strip along the anterior margin of the transverse process.

7. The direction of the articular facets is variable. It is shown diagramatically in Figures 5.11 to 5.13.

In the cervical region, the facets are flat. The superior facets are directed equally backwards and upwards (Also see Fig. 5.4). The inferior facets are directed forwards and downwards (Also see Fig. 5.6).

In the thoracic region again (Fig. 5.12) the facets are flat, and here they are almost vertical. The superior facets face backwards, slightly upwards and slightly laterally (Also see Fig. 5.2). The

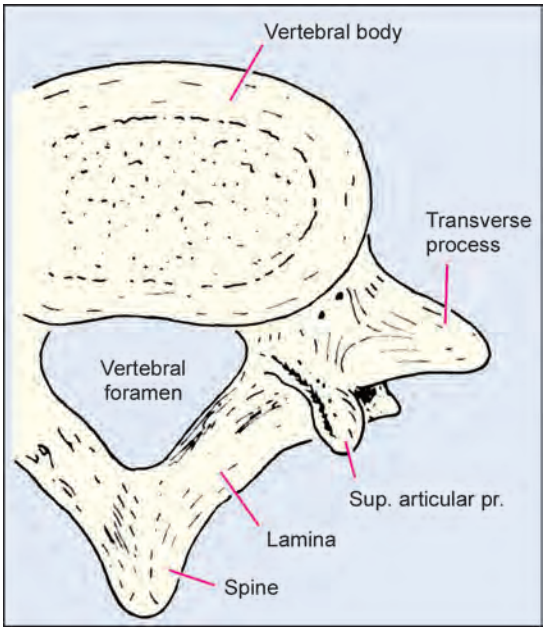


Fig. 5.10: Fifth lumbar vertebra seen from above

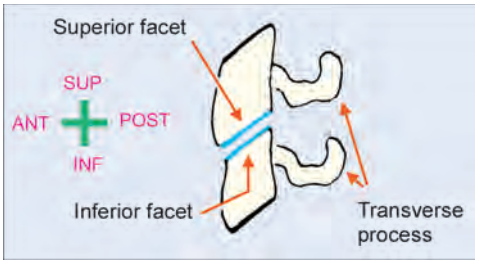


Fig. 5.11: Scheme to show the orientation of the articular facets of cervical vertebrae (lateral view)

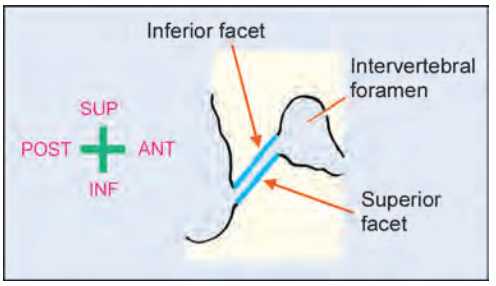


Fig. 5.12: Scheme to show the orientation of the articular facets of thoracic vertebrae (lateral view)

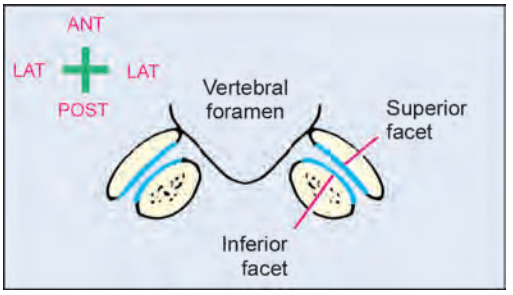


Fig. 5.13: Scheme to show the orientation of the articular facets of lumbar vertebrae. The facets are seen from above. The inferior processes are cut across

inferior facets face forwards, slightly downwards and slightly medially.

In the lumbar region the facets are vertical. They are curved from side-to-side (Fig. 5.13). The superior facets are slightly concave (Also see Fig. 5.5) and are directed equally backwards and medially. The inferior facets are slightly convex, and are directed equally forwards and laterally (Also see Fig. 5.8). Each superior articular process of a lumbar vertebra bears a rough projection called the mamillary process, on its posterior border.

In the cervical region the superior and inferior articular processes form a solid articular pillar that helps to transmit some weight from one vertebra to the next lower one. This is not so in the thoracic and lumbar regions.

Attachments on Vertebrae

Vertebrae give attachment to numerous muscles and ligaments. The muscles attached to vertebrae vary from vertebra to vertebra, and no useful purpose is served by trying to list them. The ligaments concerned are those that hold adjoining vertebrae together. Adjoining vertebrae are connected to each other at three joints. There is one median joint between the vertebral bodies, and two joints (one right and one left) between the articular processes.

1. Adjoining vertebral bodies are connected to each other by intervertebral discs, made up of fibrocartilage. Each disc has an outer fibrous part called the annulus fibrosus, and an inner soft part called the nucleus pulposus.
2. The joints between the articular processes are synovial joints. The capsules of these joints are attached along the margins of articular facets.
3. Apart from the intervertebral discs and the capsular ligaments, adjoining vertebrae are connected to one another by a series of ligaments that are shown schematically in Figure 5.14.

These ligaments are as follows:

a. The anterior longitudinal ligament passes from the anterior surface of the body of one vertebra to another. Its upper end reaches the basilar part of the occipital bone.
b. The posterior longitudinal ligament is present on the posterior surface of the vertebral bodies (within the vertebral canal). Its upper end reaches the body of the axis beyond which it is continuous with the membrana tectoria.
c. The intertransverse ligaments connect adjacent transverse processes.

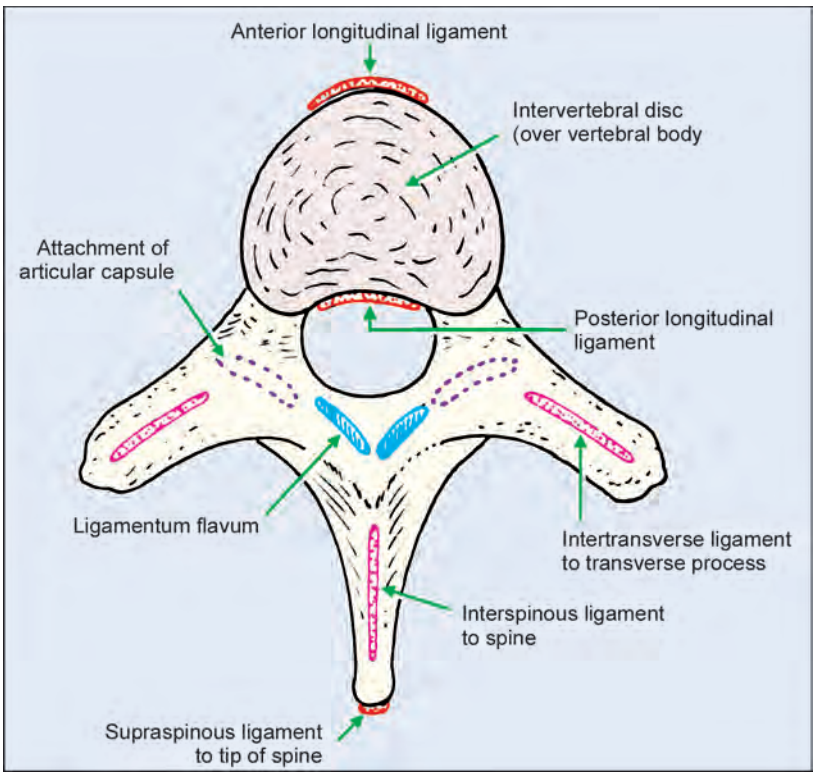


Fig. 5.14: Scheme to show the position of various ligaments interconnecting adjoining vertebrae

d. The interspinous ligaments connect adjacent spinous processes.
e. The supraspinous ligaments connect the tips of the spines of vertebrae from the 7th cervical to the sacrum. (In the neck they are replaced by the ligamentum nuchae).
f. The ligamenta flava (singular = ligamentum flavum) connect the laminae of adjacent vertebrae. The right and left ligaments meet in the middle line.

A TYPICAL CERVICAL VERTEBRAE

The Atlas (First Cervical) Vertebra

The first cervical vertebra is called the atlas. It looks very different from a typical cervical vertebra as it has no body, and no spine (Figs 5.15 and 5.16).

It consists of two lateral masses joined anteriorly by a short anterior arch, and posteriorly by a much longer posterior arch. The arches give the atlas a ring-like appearance. A large transverse process, pierced by a foramen transversarium, projects laterally from the lateral mass. The superior aspect of each lateral mass shows an elongated concave facet which articulates with the corresponding condyle of the occipital bone (to form an atlanto-occipital joint). The long axis of the facet runs forwards and medially. The facet may be constricted at its middle or may even be divided into two. Nodding and lateral movements of the head take place at the two (right and left) atlanto-occipital joints. The inferior aspect of each lateral mass (Fig. 5.16) shows a large oval (almost circular) facet for articulation with the corresponding superior articular facet of the axis (second cervical vertebra) to form a lateral atlantoaxial joint. The facet is more or less flat and is directed downwards and medially and somewhat backwards. The medial side of the lateral mass

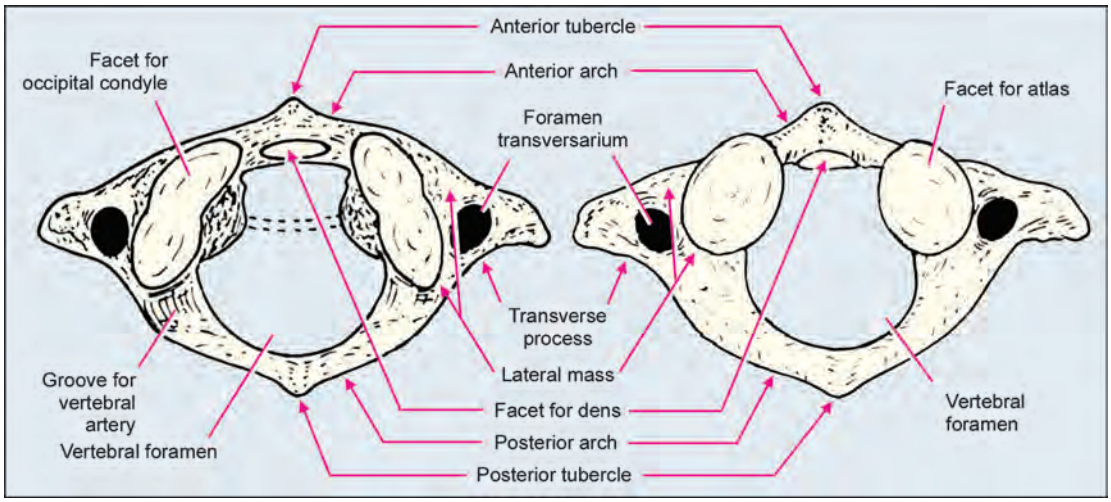


Fig. 5.15: The atlas (first cervical vertebra) seen from above

Fig. 5.16: The atlas (first cervical vertebra) seen from below

shows a tubercle which gives attachment to the transverse ligament of the atlas (shown in dotted line in Fig. 5.15). This ligament divides the large foramen (bounded by the lateral masses and the arches) into anterior and posterior parts. The posterior part corresponds to the vertebral foramen of a typical vertebra: the spinal cord passes through it. The anterior part is occupied by the dens (which is an upward projection from the body of the axis). The dens articulates with the posterior aspect of the anterior arch, which bears a circular facet for it. The dens also articulates with the transverse ligament, these two articulations collectively forming the median atlanto-occipital joint. In side-to-side movements of the head the atlas moves with the skull around the pivot formed by the dens.

The anterior arch bears a small midline projection called the *anterior tubercle*. The posterior arch bears a similar projection, the posterior tubercle, which may be regarded as a rudimentary spine. The upper surface of the posterior arch is grooved by the vertebral artery. The groove is continuous laterally with the foramen transversarium.

The transverse processes are large. Their tips are believed to correspond to the posterior tubercles of the transverse processes of a typical cervical vertebra.

Attachments and Relations of the Atlas

1. The vertebral artery passes upwards through the foramen transversarium and then runs medially on the groove over the posterior arch. It is accompanied by the vertebral vein (which is in the form of a plexus), and by a plexus of sympathetic nerve fibres (Fig. 5.17).
2. The first cervical nerve crosses the posterior arch deep to the vertebral artery and divides here into anterior and posterior primary rami.
3. Structures passing through the vertebral canal include the spinal cord, the meninges, the spinal part of the accessory nerve, and the anterior and posterior spinal arteries.
4. The ligaments attached to the atlas are as follows:
   a. The capsules of the atlanto-occipital joints, and those of the atlantoaxial joints are attached along the margins of the corresponding facets.
   b. The anterior and the posterior atlanto-occipital membranes are attached to the upper margins of the corresponding arches of the atlas.
   c. The transverse ligament is attached to the medial side of the lateral mass.

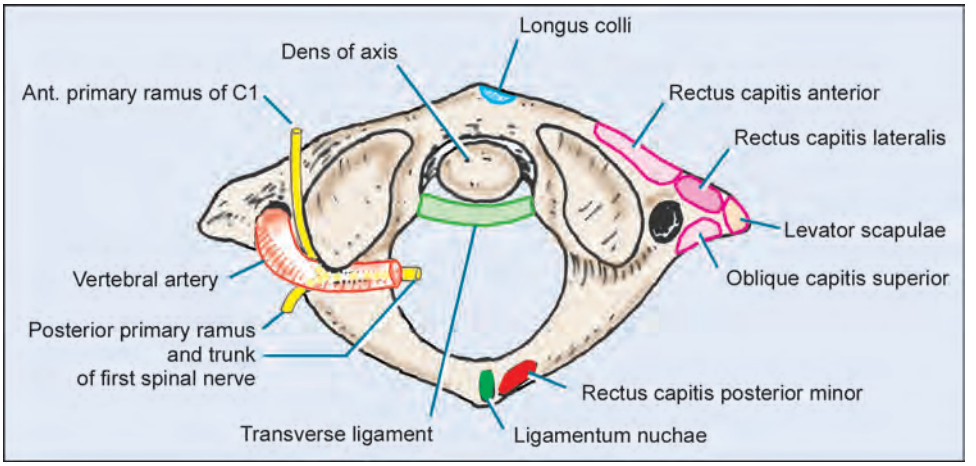


Fig. 5.17: Some structures attached/related to the atlas

d. The ligamentum nuchae is attached to the tip of the posterior tubercle.
e. The atlas is attached to the axis by ligaments similar to those between typical cervical vertebrae.

5. The muscles attached to the atlas are as follows:
   a. The rectus capitis anterior arises from the front of the lateral mass and from the root of the transverse process.
   b. The rectus capitis lateralis arises from the anterior part of the upper surface of the transverse process.
   c. The rectus capitis posterior minor arises from the posterior tubercle.
   d. The obliquus capitis superior arises from the posterior part of the upper surface of the transverse process.
   e. The obliquus capitis inferior, and the splenius cervicis are inserted into the inferior aspect of the transverse process.
   f. The levator scapulae arises from the lateral margin of the transverse process.
   g. Some fibres of the upper oblique part of the longus colli are inserted on the anterior tubercle.

The Axis (Second Cervical) Vertebra

The most conspicuous feature of the axis, which distinguishes it from all other vertebrae, is the presence of a thick finger-like projection arising from the upper part of the body. This projection is called the *dens*, or *odontoid process*. We have already seen that the dens fits into the space between the anterior arch of the atlas and its transverse ligament to form the median atlanto-occipital joint. The anterior aspect of the dens bears a convex oval facet (Fig. 5.18) for articulation with the anterior arch.

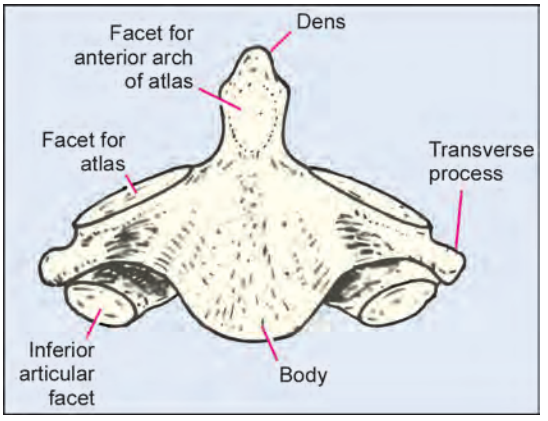


Fig. 5.18: The atlas (first cervical vertebra) seen from above

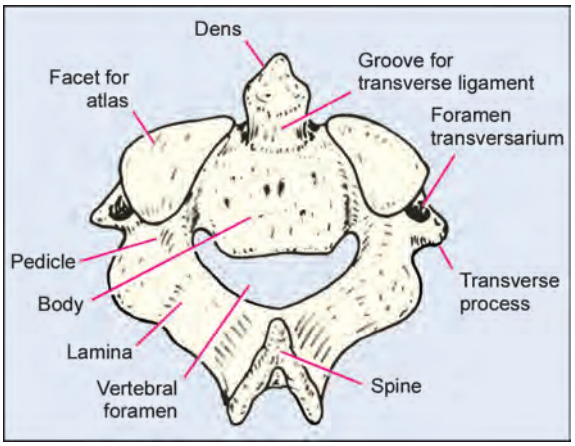


Fig. 5.19: The atlas (first cervical vertebra) seen from below

Its posterior aspect shows a transverse groove for the transverse ligament.

On either side of the dens the axis vertebra bears a large oval facet for articulation with the corresponding facet on the inferior aspect of the atlas (Fig. 5.19). The transverse process of the axis lies lateral to this facet. It is small and ends in a single tubercle corresponding to the posterior tubercle of a typical cervical vertebra. The transverse process is pierced by a foramen transversarium which runs upwards and laterally (to correspond with the lateral direction of the vertebral artery as it passes from the axis to the atlas).

The pedicles, laminae and spine are thick and strong. The inferior articular facets are placed below the junction of the pedicles and the laminae. They are orientated as in a typical cervical vertebra.

Attachments and Relations

1. The ligaments attached to the axis are as follows (Fig. 5.20):
   a. The apical ligament is attached to the apex of the dens.
   b. The right and left alar ligaments are attached to the dens on depressions just below and lateral to the apex.
   c. The lower end of the membrana tectoria is attached to the posterior surface of the body.

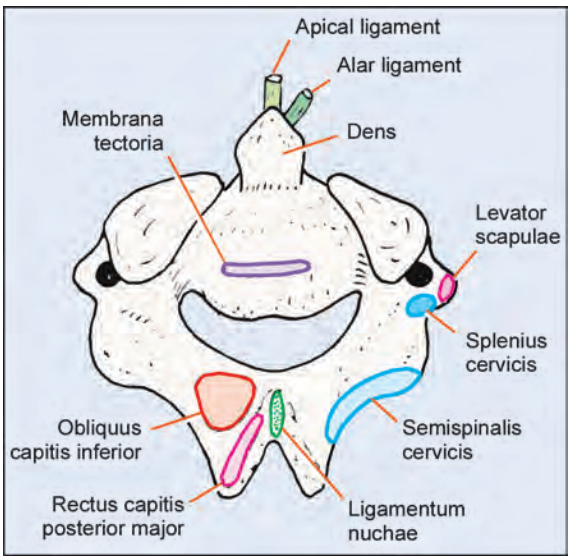


Fig. 5.20: Some structures attached to the axis. The vertebra is viewed from above and behind

   d. The ligamentum nuchae is attached to the tip of the spine.
   e. The axis is connected to the atlas and to the third cervical vertebra through ligaments similar to those between typical vertebrae.
2. The muscles attached to the axis are as follows:
   a. The rectus capitis posterior major arises from the thick posterior edge of the spine.
   b. The obliquus capitis inferior arises from the side of the spine.
   c. The scalenus medius (not shown in the figure) arises from the anterior aspect of the transverse process.
   d. The levator scapulae arises from the lateral aspect of the transverse process.
   e. The splenius cervicis is inserted into the posterior aspect of the transverse process.
   f. The semispinalis cervicis is inserted into the lower part of the spine and of the lamina.
   g. The vertical part of the longus colli (not seen in the figure) is attached to the anterior aspect of the body.
   h. Other muscles attached to the spine (but not shown) are the multifidus, the spinalis cervicis and the interspinalis.

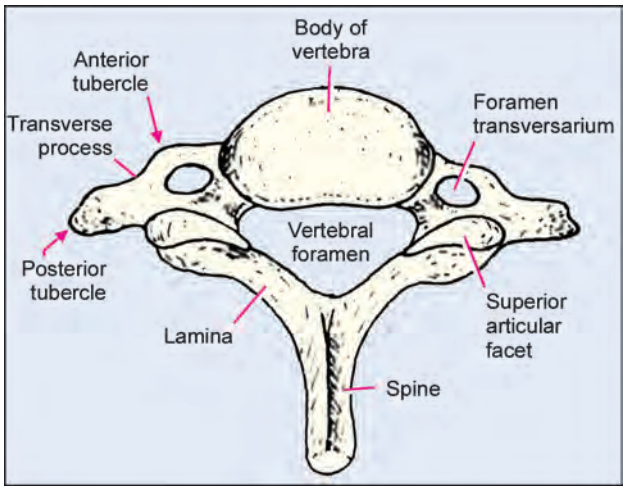


Fig. 5.21: Seventh cervical vertebra seen from above

The Seventh Cervical Vertebra

The seventh cervical vertebra differs from a typical vertebra in having a long thick spinous process which ends in a single tubercle (Fig. 5.21). The tip of the process forms a prominent surface landmark. Because of this fact this vertebra is referred to as the vertebra prominens. The transverse processes are also large and have prominent posterior tubercles.

Note that the vertebral artery and vein do not traverse the foramen transversarium of this vertebra. An accessory vertebral vein passes through the foramen.

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