Neural Science for Engineers
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Lecture - 17
Skull Demonstration

So, in the previous session we discussed something about the various constituents apart from the brain which exists in relation to the skull and I highlighted the importance of each of these structures and why we need to know a little more about this. Sometime during the course of several discussions downstream, I might quote these particular things.

So, say something about CSF or something about ventricles and there is some necessity of discussing this further. So, the focus of this session is to understand a little more about skull anatomy, it looks a bit tedious, but it is necessary to at least understand, what is where, may not be necessary to remember terminologies, I am making no effort to make slides out of this and show the terminologies.

What I would like to understand is placement of the various entities it is easy to get these photographs from anywhere online. So, what I would want you to keep your focus on is the anatomy as it is being described. I would take you through the process of understanding skull anatomy and then we will go ahead from that.

(Refer Slide Time: 01:38)

So, the skull I think you have been familiar from my first class and which I promised to showcase in greater detail. So, this part of the skull which is the outer part, is the calvarium. It is the cut section and you can see the inside.

(Refer Slide Time: 01:59)

So, lot of complex structures around, we will start with what is very obvious and we will proceed on from there. So, what is obvious and what can be easily recognized are the orbits which is the two eye sockets. The eye sockets contain the eye; obviously, this is the nasal cavity.

So, this is the nasal cavity and this is the bony nasal cavity. So, there are lot of other structures which are there, and which constitutes the nose this is just about here. So, the jaw is removed, this is the upper part maxilla which is the bone. I am not again detailing any of these things, but what is necessary to focus is this two structures over here.

(Refer Slide Time: 02:59)

So, this thing is the something called as the superior orbital fissure. So, this is the superior orbital fissure over here.

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Maybe I think I should show in this camera.

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So, this would be the superior orbital fissure, and this is the optic canal So, optic canal is through where the nerve comes into the optic nerve comes into the eye.

(Refer Slide Time: 03:42)

So, that is the place and if you look at it from inside you can see. So, that is where the optic nerve comes into the eye. And the eye socket is designed such that there is a bony covering and there is a lot of musculature which surrounds the eye and which controls the eye movement.

So, basically muscles need some fixed attachment against which they contract, I explained to you the process of muscle contraction sometime earlier to some detail. So, when there is electrical activity in the muscle, the muscle contracts and by that leverage there is some functional movement happening within the eye.

So, there are various muscles which are connected to the different parts of the socket and then that is how the eye moves in the orbit so, cardinal four directions and rotatory movements. So, these are the kinds of motions which the eye can can work with. So, this is the orbit, nose again to revise.

(Refer Slide Time: 04:54)

So, inside of the skull the calvarium is basically lined by dura. So, dura is the outermost covering of the brain which I told you its firm and thick. I would be showing somewhere in the operative videos how dura actually looks like.

(Refer Slide Time: 05:11)

But here for the process of understanding you should remember that this entire surface which is just the skull bone has a covering of dura in when in all of us. So, the covering is smooth in most areas and it fits into the contours of the skull. So, each of these ridges would be reflected as dural reflections in the same.

Dural reflections in the sense that there is a bend over here, there is a bend over here and it is in this dural reflections many a times the sinuses go through. I spoke to you about venous sinuses in the prior class, so, all the blood which is coming out from the brain goes into distinct entities called venous sinuses. So, these are the outmarks of the venous sinuses.

So, this is something called as the superior sagittal sinus, this is in the upper part then you got the transverse sinus both sides going all the way down into the jugular bulb. So, the jugular bulb comes down outside of the skull and then goes into the heart. So, this is the jugular bulb from the outside, a jugular bulb goes into the heart. So, this is the front of the skull.

(Refer Slide Time: 06:29)

So, when we take out the front of the skull from the front you have this marking where the superior sagittal sinus goes.

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Superior sagittal sinus goes into two transverse sinuses. So, transverse sinuses take the venous blood through its sinus and then it goes to the sigmoid sinus sigmoid because its s shaped over here.

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So then that would go out of the skull through the jugular bulb into the jugular vein. There are venous sinuses over here this is the other important sinus so, this is the cavernous sinus, there would be superior petrosal sinus and inferior petrosal sinus. These names are not for remembering, but at least you should have an idea that these things exist so, that us the point of explaining the venous sinuses.

Now, two entities which you should be aware of when the discussion is of anatomy is happening is something called as a dural reflections. So, there are two important dural reflections; one is reflection over here. So, this part is covered by a dural reflection it is somewhat like this.

(Refer Slide Time: 07:54)

So, you would have the dural reflection like this, now that dural reflection its thick, it is not like the paper here it's very thick and the brain actually passes through this opening which is called as a tentorial incisura. So, why this is important is because it compartmentalizes the skull into two halves.

So, this being the covering here and this being the opening this is the covering, this is the opening here and this thing actually gets attached over here it is much more anterior. So, it gets attached over here, it is attached over here this is the opening of the tentorium. So, this structure is called as the tentorium divides the skull cavity into two compartments.

This is the supra that is above tentorium, this is the infra that is below the tentorium, supratentorial compartment and the infratentorial compartment. These have several kinds of implications, one especially if you are looking at biomechanical stuff say head injuries and things like that you should understand that there are a lot of its a firm stuff unlike the brain which is very semi solid and as I told you earlier this is firm stuff.

So, in spite of CSF you can have trauma when the brain impinges on any of these surfaces. So, this is a surface as such although I have put it as a paper, this is a surface and then the brain cannot push through this membrane. In the same context it is necessary to understand that something which I have to I am not yet discussed is the closed nature of this entire cavity.

(Refer Slide Time: 09:42)

So, you have this skull which is completely closed, it is a completely sealed chamber. So, as to say and there are very few openings you can notice. So, the largest opening here is the foramen magnum so, foramen magnum I have to show in the other direction.

(Refer Slide Time: 10:02)

So, this is the foramen magnum where this spinal cord comes out of the brain. So, the spinal cord continues into the neck spine, the cervical spine and the spinal cord and some blood vessels come out through here. So, there is another membrane which I have to explain before going into some other issue of foramen mandrocally doctrine.

(Refer Slide Time: 10:33)

So, the next membrane is something called as the falx. So, the falx cerebri is somewhat like this. So, I should have made it in more firmer material which I think I should do it later on, in my next series of classes hopefully. So, I was explaining the falx cerebri, a falx cerebri is a knife like structure which is which starts from the tentorium which I explained.

Then divides the upper part of the supratentorium this is above the tentorium. So, this is this tentorium, this is supratentorium and the supratantorial compartment into right and left halves now as you can notice it is not a complete division and there is a space below the falx through which the brain communicates with each other two halves of the brain communicate with each other. So, these are two important structures which are part of the dura matter which I explained in my last class.

(Refer Slide Time: 11:34)

So, dural reflections separate the skull into the one right and left halves incompletely which is the falx; the falx attaches from here and comes somewhere up to here. So, anteriorly this is the attachment of the falx.

(Refer Slide Time: 11:54)

So, this is the knife-like outer part of the skull and then there is an inner part over here. So, the inner part attaches from here to the tentorial edge. Tentorial edge, there is a incisura in this area incisura is the opening from the tentorium which is the membrane over here which splits into supratentorium and infratentorium.

So, that is the classification of various compartments within the head. Now I have spoken so far about veins if you notice and I have not spoken anything at all about the arteries so, arteries and veins will be dealing with it little more detail subsequently. So, suffice to say that there are two sets of arteries which one would need to be one of them is on either side and there is another set of arteries behind.

Now, we would classify that into two parts so, that would be called anterior circulation, and something called as posterior circulation. So, anterior circulation refers to the blood which is supplying almost the entire part of the supratentorium here are exceptions I would not want you to know the exceptions but suffice to say that the anterior circulation supplies the most part of the brain of the supratentorium.

(Refer Slide Time: 13:22)

The posterior circulation is something which supplies brain tissue below the tentorium, just keeping the tentorium back for your reference. So, the tentorium is important not only for that purpose that it's an anatomical structure, it also has functional significance; functional significance in terms of arterial blood supply, where blood supply to the brain below the tentorium is from different set of blood vessels when compared to the anterior circulation.

So, how those things form we will look at it later. The blood vessels on top have to come through this foramen which is called foramen lacerum.

(Refer Slide Time: 13:58)

No need to remember the name as such, but you just remember that this is the place where the blood vessel enters into the skull and then comes out through here comes in through here and then comes out through here and then goes into that so, this vessel is the internal carotid artery.

So, carotids if you would know from some place, the major blood vessels and carotid stroke is one of the most lethal strokes which can happen. So, the carotid artery comes into the brain through this foramen and then comes into here and then goes into the intracranial part which I will be describing later.

So, there are two carotid arteries one on right one on left posteriorly; posteriorly we had the tentorium, but the vessels are actually over here. So, there is something called vertebral artery which would come in, no that is the hypoglossal foramen. So, it would come in through here and then form something called as the basilar artery, the basilar artery would be situated over here.

So, that is about the artery. So, two carotid arteries basilar artery, two vertebral arteries which come through the foramen magnum through the dura of course. So, that is about the blood vessels. A bigger focus which I would want to why I wanted to showcase the skull is the presence of cranial nerves.

Now, in the introductory class on brain architecture I had listed that not only do we study brain and the spinal cord, but there are also nerves by which the communication between the brain and the periphery is undertaken.

So, those are through distinct entities called nerves; nerves basically are axonal fibers which can be output or input. So, there are output nerves which are called motor nerves; motor because activity related. So, motor nerves start from the brain and go outside sensory nerves start from the outside and come back to the brain. So, that is the logic motor and sensory nerves and some of them are mixed nerves.

So, most of the nerves which are there in the limbs are mixed nerves in which you know both output and input is mediated through the same bundle, but in the skull there is some differences in which some nerves are exclusive motor nerves some are exclusively sensory nerves and that needs some highlighting to be done.

Now, the number of nerves within the cranium is 12 so, we will list each one of those nerves and see how they go out through the skull. So, that is the actual point of highlighting. So, you would need to know where these nerves are and at least the names and some notion about where they exist from the skull.

It is pretty easy if you understand the concept of how they go out of the skull and the nomenclature thereof. Now the first nerve is olfactory. So, nose, olfaction. So, what is closest to the nose and the inside of the head is these two things. So, the olfactory tract so, the olfactory nerves are the shortest of nerves.

(Refer Slide Time: 17:39)

They are there only between the nose over here, inside of the nose and then instead of the skull.

(Refer Slide Time: 17:41)

So, the olfactory tract on both the sides so, this is the midline right and left so, right olfactory tract, left olfactory tract; olfaction means smell. So, the nerves and the connections come out through this particular area. So, come into the skull through this particular area and that is the olfactory grew in the skull.

Now, that will be obviously the first nerve, the second nerve is behind olfactory. So, that is this part. So, this part is where I showed you earlier so, what happens is, this is the optic canal so, that is the second nerve optic nerve.

(Refer Slide Time: 18:26)

Now, optic nerve is purely sensory so, it just mediates the light signals which are captured from the eye and transfers it to the brain. So, it does not do any further, you know the movement of the eye is definitely not controlled by that. So, that is something which you have to remember. The second nerve only is a pure sensory nerve it takes in light information from the eye into the brain. Now third, fourth and sixth nerves so, it is like that so, you have third, fourth and sixth nerve coming from here to here.

So, third, fourth and sixth actually come in through this other opening within the in the back of the eye. So, that is the superior orbital fissure. So, this is the second nerve, third, fourth and sixth come in through here. That is the exit out of the cranium through here so, 1, 2, 3 sorry 3, 4 and 6 so, that is the; that is the arrangement.

(Refer Slide Time: 19:43)

Now, why there is a gap between fourth and sixth which is coming to the eye is because of the fifth nerve. The fifth nerve yeah sorry I did not complete that. So, third, fourth and sixth basically are for the control of eye muscles.

(Refer Slide Time: 20:01)

So, they control the muscles of one eye one, third, fourth, sixth with one, third, fourth, sixth on the opposite side. So, individual eyes are controlled by individual nerves which are on either side of the skull, but obviously, all of us know that eyes move

synchronously and the synchrony is actually maintained somewhere else within the brain.

So, the how synchrony is maintained and how movements are synchronized and made smooth would be topics of separate discussion which we will handle later. There are common principles between all of those. So, third so, we have covered 1, 2, 3, 4, 6. The fifth nerve comes out from the brain stem and then comes over here. So, this thing is called meckels cave which contains the fifth nerve, there is a nucleus of the fifth nerve and the fifth nerve divides into 3.

So, one goes again out through the superior orbital fissure. So, it would come out somewhere over here then the second division goes out through here.

(Refer Slide Time: 21:20)

So, the second division goes out through here and the third division goes out through here.

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So, these two come out of the skull and the fifth nerve functions has both functions, it has both sensory components and motor components. Fifth nerve is important because it supplies the entire dura which I told you over here and is responsible for many of the pain symptoms which you have its it senses pain.

(Refer Slide Time: 21:59)

So, fifth nerve also supplies the face and as I told you there are three divisions. So, the first division is from the top of the skull to somewhere over here second division and

third division for the jaw in very broad terms; very broad terms. It also manipulates chewing.

So, the jaw muscles are activated by the fifth nerve so, fifth is trigeminal nerve. So, three that is the tri and trigeminal nerve goes into orbital fissure, foramen ovale and foramen lacerum no sorry foramen ovale, rotundum; rotundum and ovale. So, ovale is for v 2 rotundum is for v 3, v 3 is the third division.

(Refer Slide Time: 22:56)

So, there are three divisions that is how the calculations are. Now that is fifth, sixth is actually here. So, it exits out of the skull over here which is below the marking for the fifth nerve. So, that is the logic between the sixth, but I did include 3, 4, 6 because they form a different organization the 3, 4, 6 are for eye movements the fifth is for sensation and chewing functions.

So, that is fifth, sixth is for the moving movement of the eye. The specific functions we will discuss later. Then comes the seventh nerve so, seventh nerve is here sixth is here seventh is here eighth is here. So, seventh and eighth nerves are for hearing and musculature of the face.

So, the seventh nerve moves the various parts of the face for all kinds of facial emotions, facial muscle activity, closure of the eye and it also helps a little bit on chewing, it also

mediates taste from the mouth, part of the taste from the mouth is taken care of by the seventh nerve.

(Refer Slide Time: 24:15)

The eighth nerve is the nerve of hearing so, this is the ear canal on the skull. So, what you see as the outside ear goes into the skull as the ear canal over here and this is the area where the apparatus related to hearing and balance are there. So, the eighth nerve contains both, its a mixed nerve so, it is vestibulocochlear nerve.

Vestibular is for the balance sensation of the body there are two of them, it's a very interesting mechanism which I will discuss later, and cochlear which is the hearing part of the story. So, vestibulocochlear nerve and goes out through the internal acoustic meatus. This is the external acoustic meatus, internal acoustic meatus over here.

Ninth, tenth and eleventh are together through the jugular foramen. Now jugular foramen is something which I discussed for the vein over here ,which is the transverse sinus which comes out through here goes across the sigmoid sinus and exits through the jugular foramen. So, that is the place where it gets out.

So, ninth, tenth and eleventh nerves go through here yeah it is just to have a notion of where these things come out. So, ninth, tenth and eleventh is through here twelfth is here, just about the rim of the foramen magnum so, that is the twelfth nerve on the other side. So, that is the gross architecture. So, twelfth nerve is responsible for tongue movements.

So, interestingly there are combinations of nerves which are responsible for activity. So, one combination is third, fourth and sixth which is for eye movements and in combination with the second nerve for the whole of the visual apparatus. So, there is a lot of integration which actually has to happen.

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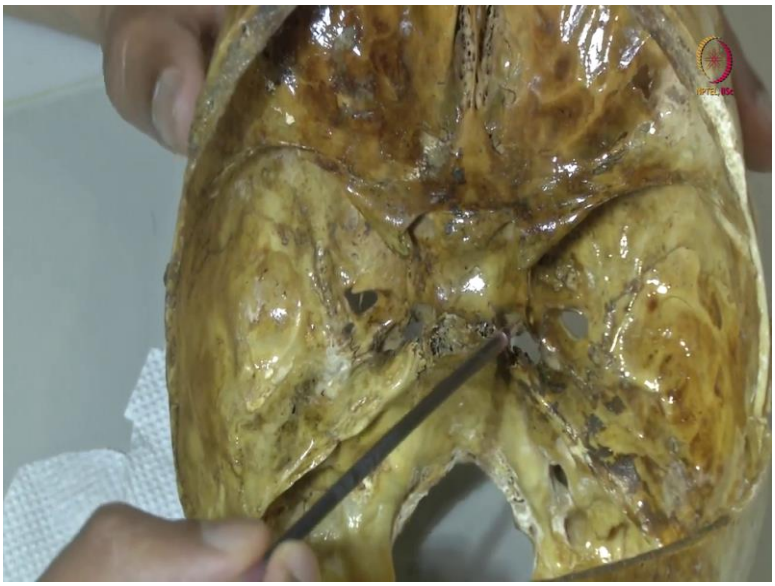

Because what you see with in terms of light is actually determined a lot by where the eye is looking at. So, third, fourth and sixth have to ensure that the eye is focused on your target object, but the actual image which is generated and processed then you know you infer stuff is through the second nerve which is a completely different nerve so, that is one level of integration.

Now, another set of integration which happens is in this ninth, tenth, eleventh along with seventh nerve, they are all responsible for speech. So, ninth and tenth are responsible for the throat part of the story. So, where the where actual air is modulated through the vocal cords and how the vocal cords, you know the various loudness, the intensity are manipulated and the seventh nerve modulates the nature of the speech as such.

So, the seventh nerve actually takes care of different kinds of verbalizations, diction and things like that. The twelfth nerve also combines with that because the tongue is responsible for a lot of the speech. So, speech in turn is divided into linguals gutturals and there is one more thing I have forgotten that.

So, the linguals are the words or the syllables which are which are manipulated by the tongue or generated by the tongue. So, the speech comes out through the throat gets manipulated by the tongue and those are the lingual words, lingual syllables and that is actually manipulated through the twelfth nerve.

So, combinations of cranial nerves are responsible for different functions. So, the fifth nerve also contributes to some because it has to move the jaw it also takes in sensation from all over the skull and the face. So, this is the architecture of several of the relevant structures.

Now, to reiterate and revise the whole thing first nerve, second nerve, third, fourth, sixth, third, fourth, third, fourth, sixth, fifth then seventh and eighth over here seventh and eighth over here nine ten eleven is down nine, ten, eleven is down and twelfth nerve is here twelfth nerve is the bottom.

So, the organization of the cranial nerves is like that. So, one to twelve in serial order of their exit from the skull, see that is a very tricky term because the sixth nerve exits from here it, is going through the cavernous sinus which is considered as outside of the skull it is in the it is in the membrane over here, it's not considered inside of it. So, that is how sixth comes below and fifth comes on top. So, fifth nerve exits earlier than the sixth nerve 1, 2, 3, 4 ok.

(Refer Slide Time: 29:28)

1, 2, 3, 4, 5, 6, 7 and 8, 9, 10, 11 and 12 so, that is the idea of having twelve cranial nerves in various parts of the skull and that is all. So, if you look at the organization of the skull you can see that you can divide it into three independent parts on the base of the skull. So, one part would be this part this is incidentally the sphenoid ridge, the clinoid process and there are so many other structures you would not want to know all of that. So, the anterior cranial fossa is this part middle cranial fossa is this part middle cranial fossa and the posterior fossa is this part.

So, that is something about terminologies anterior middle and posterior cranial fossa and that is the division. So, this is a very fast quick lecture on making you understand the basis of divisions within the skull and how these things are organized. We would use a lot of these things when we discuss about the brain and the structure.

So, please do remember the calvarium to revise in brief again calvarium the entire skull base skull base divided into anterior, middle and posterior fossa. The foramen magnum which is the exit the major exit of the skull there are several other foramina in the skull; foramina means basically opening.

So, each of these openings have multitudes of structure it is not just that the spinal cord comes through the foramen magnum it is also the vertebral arteries the cranial nerve 11 there is one small branch which comes from below. So, there are a lot of structures and I do not think I would want to bore you with those details.

Anterior cranial fossa smell vision on the other side so, the anterior cranial fossa this is the eye on the inside eye on the inside eye on the inside nose on the inside. So, eye nose is in relation to the anterior cranial fossa this is something called temporal lobe which I have not yet described this is something called cavernous sinus which you would not need to know in great detail.

So, a lot of structures, the artery, the internal carotid artery fifth nerve the cavernous sinus 2, 3, fourth now are all close to each other. So, it is very compact which is why I am saying skull anatomy is one of the most difficult to understand. So, there are mixes of these things, one advantage of having a video is that you can always run back and check things if you have not understood or understood any part of the discussion.

So, arteries, veins, the containment of various structures, the divisions within the tentorium and these falxes. Then the temporal lobe so, this is where the cerebellum is situated. So, these two marks are for both sides cerebellum both sides the brain stem is situated between from here to here.

So, that is the brainstem cerebellum, cerebrum, cerebrum; that is the organization which anyway I will be dealing with in greater detail. So, cranial nerves, arteries, veins and sinuses, brain, dural reflections, tentorium falx, cerebri, these are the constituents of the skull.

(Refer Slide Time: 32:58)

So, there are multiple other things which you would not need to know. So, this is something called a stylomastoid process and the facial nerve comes out through here there are lot of other details. So, this is the ear canal on this side, external acoustic meatus internal acoustic, internal acoustic meatus; it is not the same.

So, the ear apparatus is here it communicates on the outside from here and on the inside from here, inside it is the nerves, outside is this sound and you have a membrane over here which actually translates the sound waves into this which we will again be looking in detail.

Ear apparatus sight apparatus then rest of the muscles are outside. So, that sort of completes my brief overview of the skull. These details may be necessary for the

subsequent discussion. So, it is with that I think we can break over here so, that we will come back for the brain. So, this is show and tell. I could not build a skull. We will see how to learn brain anatomy next.

Thank you.