

Neuroscience of Human Movement
Department of Multidisciplinary
Indian Institute of Technology, Madras

Lecture – 56
Cerebellum Part – 5

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Neuroscience of Human Movement

Cerebellum
Part - 5.



So, welcome to this class on Neuroscience of Human Movement we will continue our discussion on cerebellum. So, this is part 5 of our discussion on Cerebellum.

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In this class...

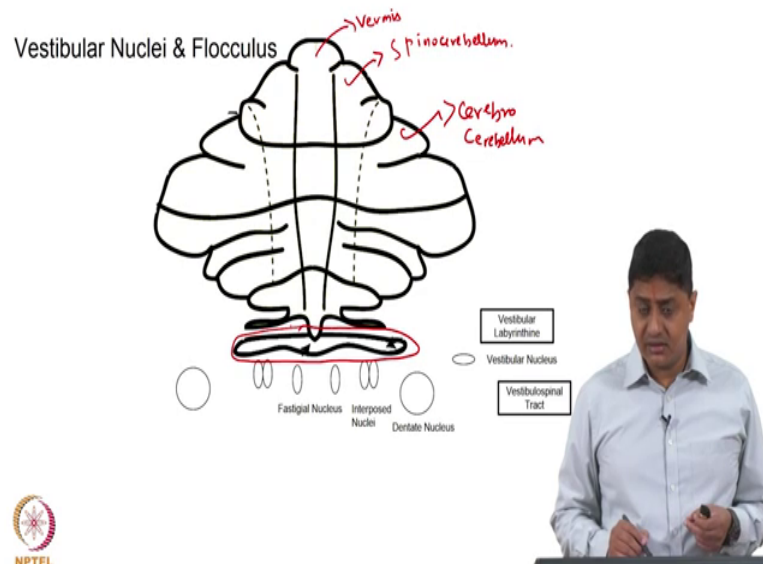
1. Vestibular Nuclei & Flocculus
2. Balance and eye movement
3. Vestibular-Ocular reflexes
4. Nature of vestibulocerebellum as the early cerebellum



So, in this class we will be discussing the vestibulocerebellum or flocculus and nodules or the flocculonodular lobe. And how flocculus and nodules receive input from the vestibular nuclei and how they output to the vestibular nucleus. A unique feature of the vestibulocerebellum and how the vestibulocerebellum contributes to balance and eye movements and how vestibular ocular reflexes are modulated in the presence of lesion for example are how they are controlled in healthy cases in by the vestibulocerebellum.

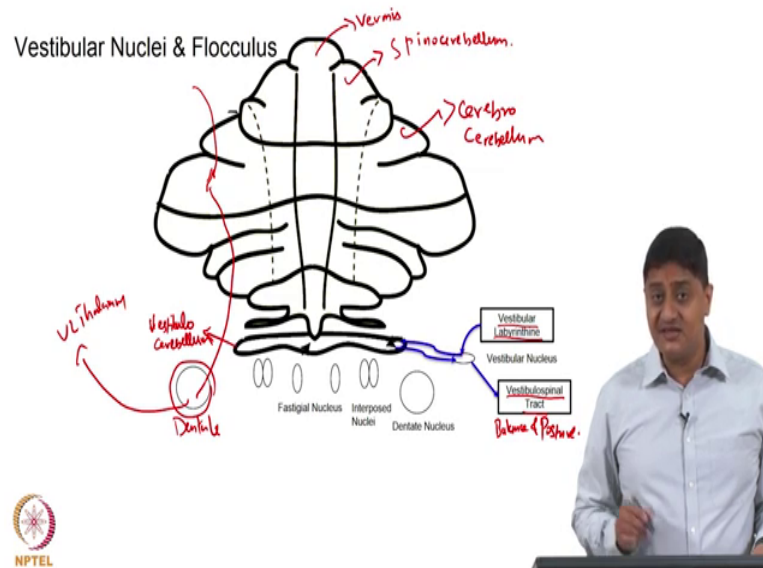
The vestibulocerebellum is the early cerebellum or the archicerebellum and so, we will discuss that in today's class.

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So, this is an outline of the cerebellum we know that is the cerebro cerebellum. The more medial regions of course, the most medial region is called vermis. Vermis and paravermal area together constitute the spinocerebellum, then where is the vestibulocerebellum. This is called as the flocculonodular lobe and that is also called as the vestibulocerebellum right, so that is the vestibulocerebellum.

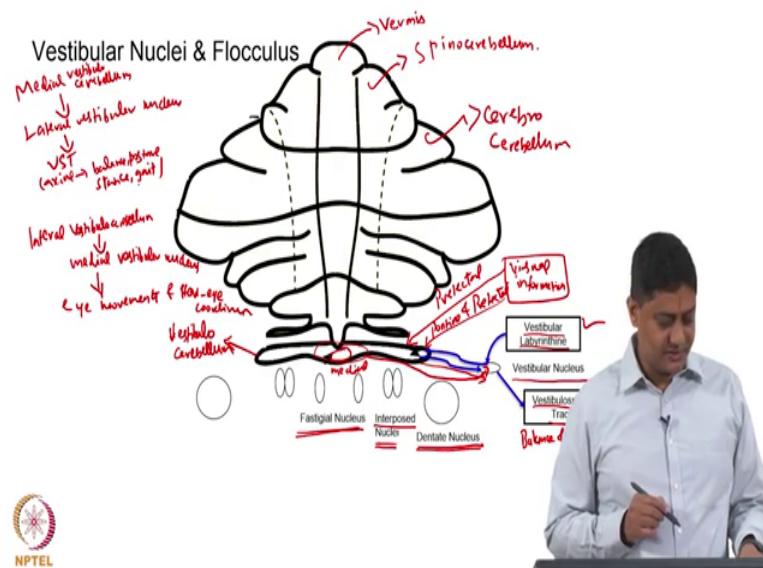
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So, it turns out that the vestibulocerebellum receives input from the vestibular labyrinth, and are the otolith organs within the vestibular system. And from there they project to the so that information is from the vestibular nucleus to the lateral vestibulocerebellum. For example, in this case it is demonstrated as lateral vestibulocerebellum, say the vestibulo cerebellum. And then it projects back to the vestibular nucleus, but what is it going to do? The vestibular nucleus actually has projections to the vestibulo spinal tract. So, the vestibulo spinal tract means it projects to motor neurons and the spinal cord through the vestibular system that means, movements can be controlled by this tract right.

So, what are the functions that are controlled balance and posture? So, important functions that are controlled by the vestibulo spinal tract and the vestibular nucleus; note unlike other cases where for example, if it if the input is coming into the cerebro cerebellum. Then it is processed in the cerebellar cortex or in the lateral cerebellar cortex in the cerebro cerebellum. Then it outputs why are the dentate nucleus that is the dentate nucleus and from the dentate nucleus to VL thalamus etcetera right.

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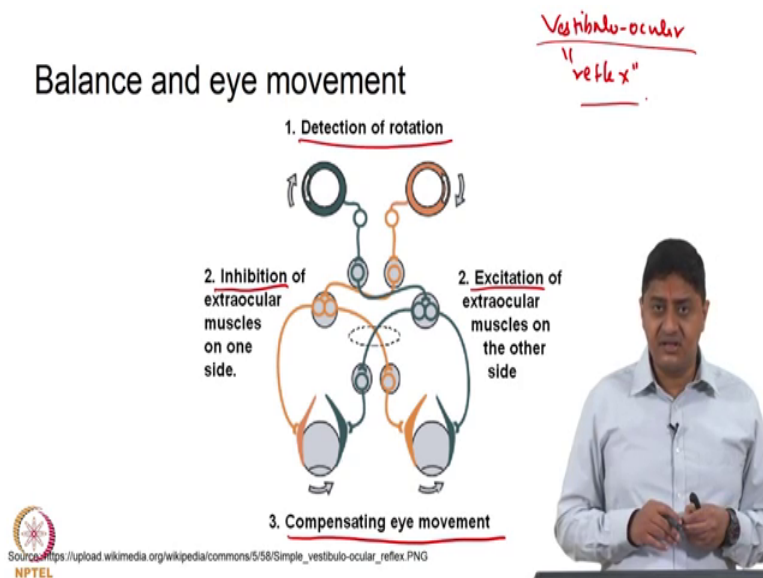
Note dentate nucleus is actually a nucleus within the cerebellum, it has been drawn outside the cerebellum for convenience in this picture, in this schematic, but actually all this fastigial nucleus, interposed nuclei and dentate nucleus are all deep cerebellar nuclei, these are nuclei that are present within the cerebellum, but in the case of vestibulocerebellum, flocculonodular lobe acts as the cortex, acts similar to the cortex, but it does not project to an output nucleus that is within the cerebellum, but rather it projects to the vestibular nucleus itself.

So, the vestibular nucleus is unique in a sense, because it also performs or it mimics the function of these of the deep cerebellar nucleus. In the vestibular nucleus is also considered as an output nucleus of the cerebellum right; so in that sense this is a very unique right. What is the nature of information that is received by the vestibular cerebellum? Well there are multiple information, one source of information is of course, the vestibular system that sends information about position and orientation of the head, a very sophisticated gyroscope so to speak.

Other information not shown in this picture or from the visual information, this is coming where two pathways, two separate pathways; one is the pretectal pathway, the other is information that comes from the primary and secondary visual cortex, and that reaches by pontine, nucleus, and the pretectal context on the pretectal nuclei. So, information is received both about the head position and orientation and visual

information. So both of this are in some sense combined; so that must give us an idea of what is probably the function of this particular nucleus. And important function of this nucleus is in the regulation or control of vestibulo-ocular reflexes, what are these?

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It turns out that, when you rotate your head in a particular direction say for example, if I am rotating my head to the right, suppose I am doing that right; if I have no need to fix at or look at an object as I am rotating to the right, then my eyes will move along with the head or the eyes will not move relative to the head, there will be no relative movement between the head and the or the eyes will not move in the opposite direction at least. But suppose I have to look at the camera and I have to rotate my head, I am doing that now.

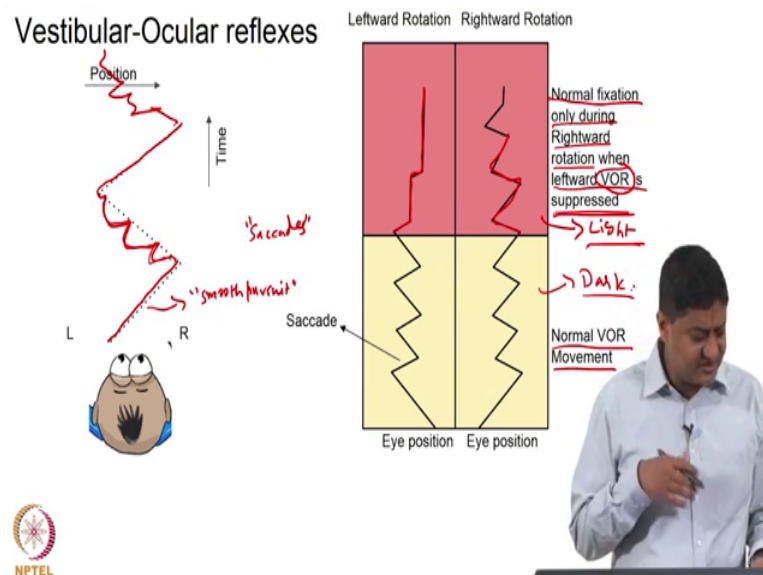
For example, now I am looking at the camera and I am rotating my head to the right; that means what? For me to maintain fixation at the camera or say this objects. Now, I have to maintain my vision or I had to fix at on this object, and I have to rotate my head on the right suppose; I have to do that, I am able to do that right. How is this accomplished? Simple by rotating when I have to rotate my head to the right, it is necessary for me to rotate the eyes to the left right, this is done very naturally without much conscious that is actually considered to be reflex. Actually, this also works in relatively fast head movements, which is called as the vestibulo ocular reflex.

So, depending on the nature of the head rotation depending on whether I am rotating to the right or left, depending on how fast I am rotating, depending on the magnitude of

rotation, the reflex will change. It is actually very easy, very possible for healthy individuals to fixate on objects or to perform smooth pursuit actions, while they are moving their head this is a very normal thing.

So, how is this accomplished? By performing you know compensatory eye movements through relative inhibition/excitation of the extraocular muscles on either side ok. So, this is called as this is called as the vestibulo-ocular reflexes right. So, how is this performed in, how is this accomplished by the vestibulocerebellum or what is vestibulocerebellum's role in performing this action; well that becomes apparent, when there are lesions of the vestibulocerebellum when that happens.

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Actually, for example here is a case of an individual, who has had left vestibulo cerebellar lesion. So, the lesion of the vestibulocerebellum is on the left side. We have seen in the previous classes that cerebellum controls or coordinates functions and the same side of the body or ipsilateral.

So, if the lesion is on the left side of the body, then the left side function is going to be compromised. And so suppose you have to perform sinusoidal movements right, suppose you have to do that while moving from left to right, you see that there is relative smooth movements; whereas while moving from right to left, there are jumps are what are called as saccades. Instead of smooth pursuit, so there are different kinds of this eye movement, so these are technical terms I am using without definition, so please do check this.

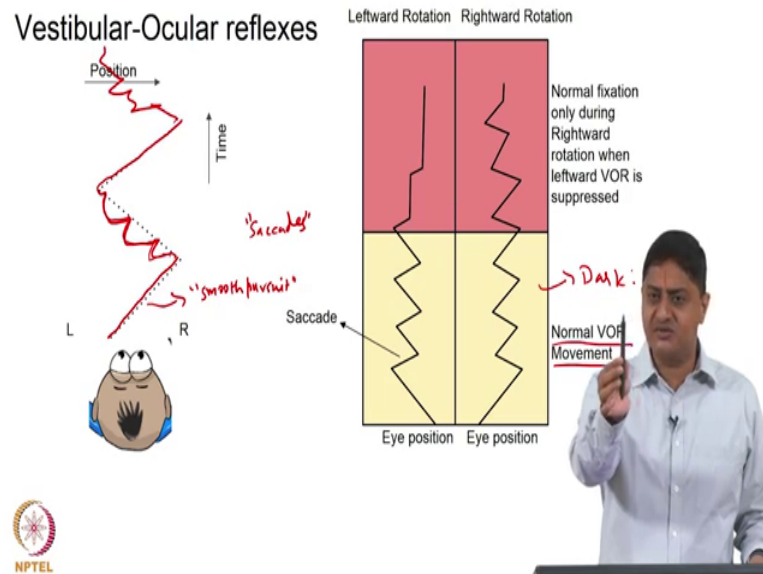
Saccades are relatively fast movements right. So, these are saccades that cause jumps in the moment of the eye. Whereas, once again from moving from left to right there is relatively smooth movements, while moving from right to left there is going to be jumps right; so that means that this person is able to perform eye movements to the right or while moving to the right. There is relatively smoother performance, also there is smooth pursuit is possible while moving from left to right, but while moving from right to left there is not smooth pursuit, but movement of the eye is predominant with only saccades right.

Now, what happens when this person is asked to fixate on an object that is moving along with his head rotation. Say for example, left side lesion of the vestibule cerebellum for example, is the case when vestibulo-ocular reflex is relatively normal in the dark right; this is in the dark actually. So, in the dark when you ask a person to rotate, the head to the right, the and fixate on an object for example, so I have to fixate on that object and rotate to the right, the person can do it; and rotate to the left, the person can do it.

And they can do it in the dark and eye movements are relatively normal in the dark and when you ask them to fixate. When the person's head is rotating and an object is also moving along with the head rotation. And your requirement is to fixate and the moving object, when would this be possible; the example of this is for example, you have a chair and you are rotating it is a it is a rotating chair; and you are you are rotating on the chair.

And suppose an object is attached to the chair, there is no relative movement of this object with respect to the chair. Suppose there is such an object, suppose I have a stick that is somehow suspended, somehow held in place relative to the movement of the chair. So, as the chair is moving, the stick is also moving. The person who is sitting in the chair is required to fixate on that say for example, this pen that is moving along.

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In the earlier cases, I said the pen is fixed and I am fixating, but suppose the pen is moving as I am moving right, suppose that is the situation. Suppose, I am having the pen like that and I have to fixate on at the tip for example, and the pen is moving, as I am moving suppose such that is the situation. Then people with the left lesion, left side lesion will not be able to perform; when leftward movement is there, because there is a normal fixation only during rightward rotation. Actually this is happening through saccades so you fixate through saccades.

Actually, what happens in this case is the vestibulo-ocular reflex is suppressed right for a brief time, but that is not possible during the left side rotation leading to specific deficits. Note that this is happening, only when the person has to do it in the presence of light, but not in dark.

So, critical to note is which part of the vestibulocerebellum is responsible for this kind of function. So, within the vestibulocerebellum the more medial regions, the more medial regions, these are the more medial regions. They project to the lateral vestibular nucleus. And further to the vestibulo spinal tract to control axial or more medial limb muscles and or limb extensors into control balance or stance or gait right.

The more lateral regions of the vestibulocerebellum, they project to the more medial regions. So, the lateral vestibulocerebellum projects to the medial vestibulo nucleus, vestibulo nucleus is the nucleus located outside the cerebellum right that is responsible

for vestibulo function. And this is responsible for eye movements and head, eye coordination. Whereas the medial vestibulocerebellum projects to the lateral vestibulo nucleus to the vestibulo spinal tract to control the axial musculature, balance, posture, stance, gait, etcetera right.

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Nature of vestibulocerebellum as the early cerebellum

Vestibulocerebellum is found in fishes - it is the "early cerebellum" or the "archicerebellum"

Paleocerebellum → Spinocerebellum
Neocerebellum → Cerebrocerebellum



So, and also we have seen what happens with due to lesion. And also remember that vestibulocerebellum is the early cerebellum, it is the archicerebellum, it is present in fishes and other such lower animal. So, the further development of after the development of vestibulocerebellum for the development led to the paleocerebellum, we know what this is paleocerebellum is also the spinocerebellum, is it not.

And then we have the neocerebellum, this is basically the cerebrocerebellum, this gives us some insight on the function, it turns out that vestibulocerebellum as the early cerebellum is important for the most primitive or the more basic functions such as balance, head and eye coordination fundamental functions. Actually, head and eye coordination for example, this is considered as a some more advanced feature. So, for whatever reason this has been co-opted along with the more basic function such as balance ok.

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Summary

- Vestibular Nuclei & Flocculus - nodulus
- Balance and eye movement
- Vestibular-Ocular reflexes
- Nature of vestibulocerebellum as the early cerebellum
archicerebellum:



So, with this we come to the end of this class, we will so continue this in future classes. So, what we have discussed in today's class; we have discussed how vestibulo nucleus and flocculonodular lobe function together. And how vestibulocerebellum contributes to balance and the control of eye movements, and vestibulo-ocular reflexes and vestibulocerebellum is the early cerebellum or the archicerebellum.

So, thank you very much for your attention.