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Fundamentals of Video Head Impulse Test: Lesson 1 – Principles and Mechanics

Presenter: Vishal Pawar, MD

It is now my pleasure to introduce our class for today. Fundamentals of Video Head Impulse Test Lesson one, Principles and Mechanics. Before I turn this over to Inventus and our presenter for today, I do need to run through just a few items. These are the risks and benefits associated with today's class. You can read through these at a later time by finding them in your handout that is located in in your audiology online account.

These are the learning outcomes that are also associated with today's course and what we hope that you will learn by the end of this course. If you would like to review these, please do so in the handout.

And now it is my pleasure to turn it over to Inventus and our presenter for today. Dear all, a warm welcome to Today's webinar, the first of three in our 2025 Invent Academia series dedicated to the Video Head Impulse test. We are honored to be joined Once again by Dr. Vishal Pawar, Specialist neurologist and fellow of the European Board of Neurology, who leads a dedicated vertigo clinic in Dubai and has extensive expertise in vestibular medicine and headache disord. Today's session will cover the principles and mechanics of the VHIT, exploring its vital role in vestibular assessment.

Thank you Dr. Pawar for your continued collaboration. As always, feel free to submit your questions via the question and answer box and don't forget to complete the feedback survey after the session. Your input. I highly appreciate it.

And now Dr. Pawar, the stage is yours. Enjoy the webinar and see you later.

Okay, so thank you Anna for that nice introduction and thank you for giving me this opportunity to present today. So, so we, what we are going to do is we are going to cover the fundamentals of Video Head Impulse Test. This is the first chapter that is Principles and mechanics. So we are going to cover two more. Like in two more lessons we are going to cover further aspects.

So today we will just deal with the basics of vestibul ocular reflex.

Now coming to the outline of my talk. So. Yeah, yes. So basically in this talk I'll just initially cover the introduction which includes the anatomy which gives foundation to this particular subject. Then I'll go with principles and methods of ocular recording, then measurement of head and eye movements and if possible, basic interpretative parameters of the V hit.

We will try to see how much we can. I can cover in an hour.

Now let us dive into the introduction. That is, I have divided into three parts, that is Anatomy and physiology of vestibular system, clinical helgi's test and which is also called bedside head impulse test. And there is video Hel Maris test that is vhit. So we are going to cover these three aspects in this particular, you know, introduction. Now coming to anatomy and physiology of vestibular system.

So let us start with very, very basics. That is, you know, the talk will start with lot of basic concepts and it will go into deeper. So bear with me because it's going to get little, you know, heavier later on. But let's dive into it. So for.

So we all know that we have five special senses. That is test hearing, vision, smell and touch. Okay? So unfortunately like the, the sense of equilibrium, the balance is not included in the five senses. And because it works in background, we hear people asking each other how is your hearing, how is your sight, how is your smell, how is your test?

But we, we don't inquire balance in normal physiology. But when it goes like there is a problem in this definitely everybody, everybody gets aware that there is something called vestibular system which maintains our balance. And it works in the background. And it is a sixth sense, sixth special sense which works in the background. And all the time it is working.

Even in, during sleep it is working. It has a pacemaker activity and it is a working behind the curtain. Now here if we look at ear, it has three parts. We know that it has three parts, that is external ear, middle ear and internal ear. And the internal ear is divided into cochlea and vestibule.

We know that this is this external ear, middle ear. And the cochlear part is related to the hearing and vestibule is related to the equilibrium. Is a very simple sentence to begin with. We'll start with this simple sentence and as we dive deeper, I will tell the different aspects of this vestibular system. So this is how the vestibular system is organized.

From here until here there is a peripheral and then the central vestibular system takes over. Then in the peripheral sense organ there, there is vestibule, that is three semicircular canals, utrical and saccule. Uh, then there is vestibular nerve with superior inferior branches with the Scarpa's ganglion. And then, uh, until the. Then there is a.

Once it enters the brain stem, there is a root entry zone and then it goes into the vestibular nuclear complex. And from here the sensations are distributed like for different aspects. Like for vestibular ocular reflex, cerebellum has a control. Then vestibulospinal reflex and many other reflex vestibule autonomic reflex and other. So the interpretation of the vestibular vestibular signals starts at the vestibular nuclear level.

And the it is like a part of central vestibular system. Now the peripheral sense organ is semicircular canal. And there are otolith organs as we know. There are three semicircular canals on one on each side, that is posterior anterior and the lateral semicircular canal. And two otolith organs, utrical and sacule.

And there is a sensory epithelium which includes which is nothing but semicircular canal, crista and utricular or secular macula. This, this is the sensory neuroepithelium which senses different aspects of the vestibular sensations and it helps in interpreting those signals in variety of structures in the brain. So the hair cell which is a basic unit of the the vestibular system or even cochlear system, they are basically mechano electrical transducers. Means the mechanical stimulus of deformation or rotations or translations is converted into electrical impulses in case of vestibular system or the sound which is a mechanical stimulus which convert into electrical stimulus in coch. So the hair cell function in the cochlea is hearing.

But when it comes to semicircular canals it helps in detecting the angular acceleration. And in utrical and sacule it helps in detecting the linear acceleration and gravity. So the, the function of hair cell changes as per the organ they are placed. So for example if they are placed in cochlea they will. They are just mechano electrical transducer.

They will convert that mechanical stimulus into electrical stimulus whether it is hearing or whether it is a angular or or linear acceleration. Now coming to. Yeah. So there are two types of hair cells. There are type one hair cells and type two hair cells.

And you must be wondering who are these two guys especially those countries where crick. All right, these are the. These are two Indian players cricket in the cricket team. He's Mr. Rahul Dravid.

He's a very good test player. The test is a cricket match which is played over five days. And you need lot of stamina and you know, patience. It's a game of patience. And he is Surya Kumar Yadav who is like one of the top batsman in T20 format which is played over a just three and a half hours.

320 match is played over just three and a half hours and it is a 20 over game and this is a five day game. So type one hair cells are basically like the T20 players, they have irregular responses, they play

the different kind of shots, unnatural shots they have to play during the match and they have rapid response. They are, you know, they are rapidly responding to the whatever stimulus is happening. And but in case of. If we look at the type 2 hair cells, they have regular and sustained response to head movement and and they are more involved in steady state detection of head position.

So both type 1 and type 2 hair cells play a different role. And why this is important with respect to vestibul ocular reflex. I'll explain. Type 1 are more involved in Det vor because they detect the rapid movements of the head. So and why this is clinically relevant why I'm telling about this type 1 type 2 hair cells which like, you know, it's a base very basic thing but it's clinically very relevant because in vestibular neuritis, which superior vestibular neuritis is very common and the superior vestibular nerve supplies the type 1 cells predominantly and they are strongly affected.

Therefore there is a vor loss in vestibular neuritis and type 2 are less affected in as opposed in Menier's disease. The type 2 cells are affected early because they are located at the base of the hair cell because of the pressure changes they are affected early as compared to the type 1 hair cells which are located at the top of the cupola. In aging press by vestibulopathy, the type 2 cells are commonly affected because of the metabolic processes are different in type 1 and type 2. Type 2 hair cells are more vulnerable to the age related degeneration as compared to the type 1 hair cells. And head trauma affects the type 1 hair cells as compared to the type 2 hair cells.

And autoimmune inner ear disease can. So in nutshell the V affection of the V which is rapid response to the head movement is detected by the type 1 cells is will get affected very commonly in case of vestibular neuritis head trauma or it it can get affected in autoimmune in a year disease as compared to the other pathologies. But of course many of disease when it is recurrent multiple episodes or it is very sever effect and then it will lead to even the affection of the type 1 hair cells. We have been like hearing about like you know from the our undergraduate days about the linear acceleration and angular acceleration detected by semicircular canal linear is detected by autoliths. This is oversimplification of you know like the AT which happens at the level of peripheral end organ.

But as these stimuli go inside through the vestibular nerve, and the interpretation happens in vestibular nucleus, and it sends the signals to the relevant areas, it becomes more and more complex. How it becomes more complex? I'll tell you. For example, let us look at, at the peripheral level, what happens when we are, you know, we start the car and we accelerate and then we are in constant velocity. And then after braking, what happens?

Let's see. So when we start the car and suppose there is acceleration, there is a deceleration. Like when we accelerate the car, we move backward because of the inertial movement. And from rest to movement, there is acceleration and there is in because of the inertia, there is movement of the kinocilium in this direction, opposite to the car movement. When there is a constant velocity, then it is stable.

There is no much movement. And when there is a breaking, there is a deceleration that is moving forward. Or in terms of kinocilium, there is a. Like it moves forwards. So then if we look at this analogy, you will see that the vestibular sense sensors detect changes in velocity as compared to the constant motion.

During the constant motion, it was. The hair cell was steady. But during the acceleration or deceleration, it moves. So that prevents the sensory overload on the brain. Because if all the time the vestibular system is active, like hyperactive, I mean, then the brain will undergo a lot of sensory overload.

That's why there is, during the constant speed, there is like less activation of the hair cells as compared to the acceleration and deceleration. So the fluid in the semicircular canal lags during acceleration and deceleration and thus stimulating the hair cells. So they are basically they are inertial sensors. Like whenever there is a change in rate of change of velocity will determine the how much movement will happen with respect to the hair cells.

So now let us look at a basic concept of this head movements. Like first I will talk about the translations and then we will go into the. Our very important thing, that is angular head movements. So in, in terms of head translations, we have three moments. So all of you, I would like to request to do these three head movements.

It's a very good exercise for the neck. So surge is nothing but the forward movement. Like all of you, I request you to move the head forward and backward. You can move it along with the body or just moving the head forward or backward, that is surge. Center of posterior movement of the head is surge.

Then there is another moment that is heave like the side to side head movement, it can be head on the body or just head moving on the body. That is heave moment and Bob is just moving up and down. The head is moving up and down, especially while walking. There is a bobbing moment which is detected by the saccule and surgeon heave is predominantly by the like utricle. So either this forward backward movement or the side to side is detected by the utricle and Bob is detected by, because it is vertically placed is mainly detected by the sacule.

So that is about head translation about the head rotation. We have three moment yaw. This is your right, this is your left. Okay. Then there is pitch forward and then pitch backward.

And there is a roll right. And there is a roll left. Okay, so these are the angular head movements. So the linear head movements are detected by the utrical and sacule which I discussed earlier. That is Serge, he and Bob.

So these linear head movements are detected by autolith organs. And the angular head movements, I.e. yaw, pitch and roll is predominantly detected by the semicircular canals. Okay, so that's about the head translations and rotations. And these are natural head movements which we have discussed just now.

These are the natural head movements we do. We. But of course, when it comes to the actual exact stimulation of particular canal, the, the, the. Those movements are different. Like the.

That movement should happen in particular plane. For example, this is suppose my right anterior canal, left posterior canal. This movement is right anterior and this moment is for left posterior stimulation. So those moments also we will discuss. But before that we will just see.

When we are doing the right ear movement, there is a right lateral canal stimulation and there is inhibition of the left lateral canal. When there is I move my head towards the left side, there is left lateral canal activation and right lateral canal inhibition. When there is left left anterior. When the left anterior, left posterior, right anterior, right posterior. So different canals are activated in different like you know, movements.

Like for example, this is your then pitch and roll. So different moments will lead to different canal pair activation. Because that's how it becomes complete. Like they are semicircular canals and they complement each other to complete that circle. Okay.

Just that circle of movement. When I move my head to the right, it is not just activation of right lateral canal but along with the inhibition of left side. But that happens when the movements are slow. I will go to that concept later. But first, when we are doing slow or medium pace movements, both the canals are important.

One is getting stimulated and one is getting inhibited. So there Are like co planner. They are working in coordination with each other. So there is LARP plane, RALP plane and horizontal plane in which these are the semicircular canal planes. Just now what we discussed was your right, your left pitch.

These are natural head movement. But if we look at the semicircular canal planes, they are as I was telling, this is LARP and this is RA lp and there is horizontal plane for the horizontal canal activation. So that is about the semicircular canal planes. Now some basics like orientation of canals. The interior canal is angulated 41 degree to the sagittal plane.

And the posterior canals are, you know, they are 56° to. To the sagittal plane, but they are closer to the coronal plane. The posterior canals and the anterior canals are closer to the sagittal plane. And that leads to change in nystagmus. And variety of, you know, things clinically relevant things are there because of this change in angulation, especially related to the BPPV part.

And the canals are nearly orthogonal. They are not exactly orthogonal. And that leads to certain like, you know, clinically relevant things. Like sometimes when you are doing dixalpike and the patient doesn't get nystagmus and when you are doing the head roll, the patient gets nystagmus of vertical canal. So there are certain variations, anatomical variations, and they are not exactly orthogonal, but near orthogonal to each other.

And this is a very important concept. I would like to. This is a little physi. It is more of a physics is involved in this concept. I will just talk about this.

That is vestibular system is described as a pendulum model with critical damping consisting of three elements. Now let us see which are these three elements. One is mass. So whenever there is a movement like of the head, the labyrinth moves along with the head because it is anatomical structure.

But the endolymph which is present inside the like the semicircular canals, it moves because of the mass.

It has a certain mass and it creates the force in the it go. It moves in the opposite direction of the head movement. It is something similar to water moving inside a bottle. When you shake it, when you shake the bottle, the. The water will move something similar like because of the mass of the water, it will move.

Similarly, the endolymph moves because of the mass. Then the second important component of this pendulum model is viscosity. Now let us like look at the viscosity part, the thickness of the flu, how quickly it settles down after the movement. Okay. If it is very like you know, less viscous, it will move faster and it will take more time to settle down.

But suppose it is a honey, like it is viscous, so it will settle down faster, it will move slowly and it will settle down faster as compared to water. So endolymph has certain viscosity which helps the endolymph to settle down after the movement. After the head movement, it helps to it to the settle down. So first we have seen is mass. Because of the mass it moves whenever there is head movement.

And because of the thickness it settles down after the movement. And the third important thing is the spring like property that helps the system to return to its normal position. That is bouncing back once after being stretched. So this is mainly like, you know, cupula has this particular capacity to bounce back to normal. Like, you know, it comes back to the normal position after the initial stimulation.

Okay, so these are the three physical properties. Mass, viscosity and elasticity.

Now again I would like to request all of you to look at, keep looking at this particular dot. And now I request everyone to move your head slowly, keep looking at this dot and do gentle movements of the head and keep looking at it. So this is slowly you are moving the head. Now do it little increase the velocity of the movement. That is medium velocity, that is the second stage.

And third is there there is different physics involved when you are moving the head at a slower pace versus moderate pace versus high speed. Now do one thing like just give a jerky movement to the head and keep looking at the dot and move your head to the right and left. Okay. So there is the physics which is involved. The physical properties of cupula are different in these three different movements.

How it is different, I will tell you. So whenever the head movement is happening at slow pace, the cupular behavior is mainly dependent on its elasticity because it is loose elastic. And it responds to this acceleration because it has because of this slow movement there is because of the elasticity, it will respond to that acceleration. And the response type is acceleration. As we discussed initially when the car is started, because of the elasticity, it will, it will respond by movement like acceleration.

So when you are moving the head in at a moderate pace, what happens is the, the cupular behavior is balanced by the viscosity and it helps to detect the speed. Like whenever there is a moderate pace movement, the viscosity comes into picture. And viscosity of the cupula helps in stabilizing it during the moderate movement. And it helps to detect that speed of the movement. And when we are moving Doing the fast movements, then the inertial forces dominate.

And then, then the cupula is most sensitive to the position, not to the speed, not to the acceleration. So the cupular sensitivity changes as per the head movement velocity. When the head movement velocity is slow, it responds to the acceleration. When the head movement velocity is moderate, it responds to the speed. And when the head movement is fast, gives the position like it, it, it helps to detect the position, it responds to the, it has more sensitivity to detect the position.

So let us now understand this concept. As I told, when you move the head to the right, the membranous labyrinth will move along with the head towards the right side because it's an anatomical structure. But the endolymph inside will move towards the left because because of the mass and inertia, it will move towards the left side when the head is moving to the right side. And that will lead to the cupular deflection. And that will move the eyes towards the left side.

So when the head is moved towards the right side, the eyes will move towards the left side. And when the head moves towards the left side, the eyes move towards the right side. So just if you look at these two things that when the eye movements are in synchrony with the endolymph movement, so you can predict the endolymph movement by just looking at the eyes. So I. Eyes are, that's why we have to look into the eyes of the patient, a vertigo patient is because the endolymph movement is, is predicted by the eye movement.

Okay. And then going to the next concept is these concepts are very important to understand because once we cover all these basic concepts, then it will be easier to understand the complexity of the vestibule ocular reflex. Now, now I will request all of you to look in the center at this plus sign and keeping attention on this plus sign, keep looking at, keep fixating at it and look at the clarity of your vision when you look at nine. If you, if you keep looking at that plus sign, your clarity of vision is good with when you look at nine. But keep fixating at that plus sign and just try to observe the clarity.

What is happening to the clarity of number 8, number 7, number 6, 5, 4, 3, 2, 1. So as you are this, when you are focusing on this plus sign, that is your macular vision. And the numbers are from 9 to 1 is going like, as you are going from 9 to 1, you are going into the periphery of the retina. So the peripheral vision, the visual acuity drops when you, when we start moving away from the macula when the image of any object is. It falls.

As it falls further from the macula, the visual acuity starts dropping further and further. So as early as you move from here to here, the visual acuity drops almost 50% and it progressively. It drops. So what is the purpose of this? So the, the central part, I.e.

macular vision is for clarity. And the peripheral part is for movement detection. Movements are detected very well in area. Peripheral vision is not for clarity. It is to detect movement.

For example, you keep looking at that plus sign and do some hand gestures in the peripheral vision. You will. It will detect because the peripheral vision is more sensitive to the movement. And it helps. It tells to the brain that there is some movement happening.

And then the foveal vision can be shifted here and there. So, so in nutshell we have foveal vision. Then there is para. There is a foveal vision which is very clear. Paraphernal vision is little less clear.

And if as we move further, the clarity of vision goes further down as we move away. So if we look at this, this is the macular, the area. This is. This is center of the macula, that is fovea where the visual acuity is highest. And as we are moving away from the macula, the visual acuity drops further and further.

And only most important is it is helpful for detection of movement. Now there are like functional classes of eye movement. Before going into vor, I will just mention about the other functional classes. The first is saccades. We know that it.

It bring images of the object of interest onto the fovea. For example, you are focusing in the center of. Suppose towards the center of screen. And some. Something happens in the periphery, some movement happens.

Then from here the. Your. The object of interest shifts. Suppose you decide to look at that object because of that movement. Then your eyes move from the center to that object.

So that is saccadic movement. And so for example, this particular stimulus. I can. I will do your second testing by doing moving this stimulus. So keep looking at this stimulus.

So you are doing right and left horizontal circuits. Okay. By looking at this and in the graphs, how in the VNG testing, how will it look? Is is right and left psychiatric eye movements. Now second is smooth pursuit movement.

I will test your smooth pursuit. Let's do your VNG in next five minutes. Circuits are over. Now you're doing the horizontal smooth pursuit. And it is.

We record the graphs like this. And the purpose of this movement is hold the image of a small moving target on the fovea, basically, you it's trying to keep that object on foveal fovea and trying to, you know, keep that target on the fovea. Then next is vestibul ocular reflex. Of course we are going to go in details, but here I will just cover the basic concept about vestibul ocular reflex is when there is a target and there is sudden head movement happens in one direction. Suppose the head moves towards the right and it reflexively the eyes will make equal and opposite movement towards the left.

So it is a reflex which in which there is equal and opposite eye movement to maintain the fixation. And suppose the object, the subject decides, chooses not to keep their head fixed on the target and chooses to move the eyes along with the head. Then the reflex can be suppressed. That is vor suppression. Okay, so these are two very important concept.

That is vor and vor suppression. There are pathways for vor. There are pathways for vor suppression. Now, just to complete the eye movements, the optokinetic reflex, when the stimulus moves left to right,

right to left, bottom to up or up to bottom. There are different kinds of nystagmus which, which are seen and which are recorded by the vng, which we have, you know, gone into details last year when I conducted a webinar series on vng.

And there is another eye movement that is Virgin's eye movement. When the eyes move, when the object moves closer to the eyes, there is a convergence of eyes. And when the object moves away, there is mild divergence. Physiologically, there is a mild divergent movements which are not appreciable. But convergence is very much appreciable because it involves a near object that is for depth perception.

And again, like, I would like to request all of you to look at the center this particular target. If you are looking at the target, you have to. Your brain is inhibiting the unwanted sackets, I.e. microsychadic movements of the eyes. So visual fixation is an active process.

It is not just a passive process. It is actively. We have to, you know, like fix on a target. So it involves inhibiting the unwanted sacates. So these are the functional classes.

So the. So let us see which eye movement helps in what aspect of the like functional class. That is eye movement, which helps to hold images of visual world steady on the retina during brief head rotations or translations is nothing but vor. Hold the images of stationary object on the fovea by minimizing the ocular drifts is visual fixation. Hold images of the visual World steady on the retina during sustained head rotations or translations is nothing but the optokinetic reflex.

And hold the images of a small moving target. On the fovea is smooth pursuit. And move the eyes in opposite direction. So that the images of a single objects are placed simultaneously on the fovea is nothing but the versions. And bring the images of object of interest.

On the fovea is nothing but the psychiatric movement. And testing all these types of eye movements is important. But specifically the VOR is assessed by the video head impulse and the bedside head impulse test. Now, if we look at the classification of these eye movements, VOR comes under gauge stabilizing. It helps to stabilize the gaze.

Despite of the head movement. We focus on the vor. It is a gaze stabilizing reflex. Then if we look at vor, it is a conjugate eye movement. So whenever I move my head to the right, there is a conjugate eye movement.

That is right eye moves like towards the left and the left eye. Both are doing conjugate movement. Right eye medial rectus and left either lateral rectus is moving. And it is a debatable. But it is a retinal type of reflex.

But it helps to maintain the clarity of vision. And whether we have ability to suppress all these is yes, we are as I told, there is a VOR suppression pathway. Also we can inhibit the vestibul ocular reflex. And we, if we look at the V, as name itself indicates, is it is a reflex. Vestibul ocular reflex and optokinetic reflex.

These are purely reflexive mechanisms. And the others are, you know, little mixture of these two things. And so V stands out of all the reflexes, all the, all the. These eye movement functional classes of eye movement. Because of its short latency that is less than 15 millisecond.

That's why it is fatigable because it is a very rapid response. And it is one of the fastest eye movement which happens. And the. As opposed to the other reflexes which are visually mediated. And they have longer latencies and less fatigueable as compared to the vestibular mediated reflexes.

So the. All these reflexes, whether it is vestibular mediated or visual mediated, they are, you know, you know, calculated in the brain. And they are the processing happens in the brain. And basically what they are trying to do is trying to maintain a clear vision. The clarity of vision is the most important thing.

What they are, you know, achieving by different classes of functional dysfunctional classes of eye movements. So if we look at the VOR despite of the head movement. It is trying to make the image more stable. So there is a image. It is.

It is one. It is a software in the brain which helps to meant give the clarity of vision despite of the head movement. And which is appreciable during the like. You know, whenever there is a pathology happens. Whenever there is a vestibulopathy.

Patient develops oscillopsia and blurring of vision when they do head movements. So as we know that we. We have been like. We keep discussing about vestibular system as integration. There is integration of vision proprioception and vestibular system to maintain the balance.

And how this is achieved is the vestibular input helps to stabilize the gaze by with the help of vestibulo ocular reflex. Like vestibular input is very important to stabilize stabilize the gaze. And the vestibulocolic reflex is important to stabilize the head. So the vestibular input helps to maintain the tone of the neck muscles through the vestibulocolic reflex to keep the head stable during the head movement. And there is vestibulo spinal reflex.

The vestibular input is. Is trying to maintain our posture by trying to with the help of vestibular spinal reflex. And of course there are other reflexes which are important. Like neck cervical ocular reflex also which is like.

Like. It is a form of reflex which. In which the neck proprioception is the input. And it helps to stabilize the gates which is very prominent in chickens. But in human beings it is a like not that prominent.

Vestibule ocular reflex is predominantly. It helps to stabilize the gaze. And gaze stabilization is also done by somatosensory feedback which is coming from the body proprioception and the vision. Visual vestibular interactions are also helping to stabilize the gates. So.

So coming to the vestibule ocular reflex it helps to stabilize the vision. And it is one of the key diagnostic tool in neurotology. How it is a key diagnostic tool we are going to see. There are vestibule ocular reflex pathways that is through the vestibular nerve. The signal goes to the vestibular nuclei.

And then it is communicated with the three extraocular nuclei which helps to maintain this vestibular ocular reflex. And there are various pathways for vestibular ocular reflex. For example, just for the sake of time, I will just tell about the lateral canal, the horizontal canal semicircular canal pathway, which excitatory pathway, which starts from the lateral semicircular canal. It goes to the medial vestibular nucleus this and suppose this. Imagine that this lady moves her head towards the right side.

There is a stimulation of the right lateral canal and this pathway is stimulated and that leads to activation of the left lateral rectus and right medial rectus. So the eyes move opposite to the head movement. So left sided lateral rectus is stimulated and right sided medial rectus is stimulated in this particular lateral canal excitatory pathway. And if we look at the inhibitory pathway it is just like whenever the suppose imagine that she moves her head towards the left side then there is inhibition of the right lateral canal and there is activation of right lateral rectus and left medial rectus and the the eyes move towards the right side. So whenever she moves her head like towards the left, it will activate the right sided lateral rectus and left sided medial rectus.

So vestibular system function, it helps in coordination of eye movements through this reflex. And normally they are in balance because of. Because the both the vestibular inputs are equal and opposite it. So whenever the the vestibular system on the right side is trying to push the eyes, body and the limbs towards the right sided system is trying to push towards the left and left sided system is trying to push towards the right. So normally it is in balance because we have equal and opposite output coming from both the systems.

But in case of vestibulopathy there is imbalance and suppose there is left sided vestibulopathy, this right side overpowers and that's why there is a slow eye movement towards the left side and there is a fast component towards the right side. So right beating nystagmus is seen which is also seen in warm water irrigation of right side of or cold water irrigation of the left side. And unidirectional nystagmus is seen in bilateral vestibulopathy we don't see nystagmus but both the labyrinth are affected and there is no nystagmus. But patient is severely in a state of imbalance in these conditions. It's very important to check the vestibul ocular reflex which gives objective evidence of, you know, the vestibular deficit.

And I will tell you in this particular concept of this how to how the vestibular system works. Now again I request everyone to keep looking at this target. What happens is both the sided systems, left sided and right sided system have a basic firing rate. When we our head is even stable still we have some baseline firing that is pacemaker activity on both sides. But suppose now I ask all of you to turn your head towards the right side Slowly you turn your head to the right side.

What will happen is the right sided vestibular output like the right sided, the impulses which are going from the vestibular system towards the vestibular nuclear, they increase. And the left sided, there is inhibition on the left side. The left sided input which is coming from the vestibular end organ, it reduces. Okay? This happens in the slow movement.

Okay. When you are doing slow movement, there is in slow movement towards the right side. The right sided will get stimulated and left sided will get innovated. There is reduction in the impulses from the left side. But now let us see what happens when we do a quick movement, a rapid movement.

When you do a rapid movement towards the right side, what will happen is there is only stimulation of the right side and there is no stem. There is no like input coming from the left sided system. And here you are just checking the right sided system. So right sided semicircular canal. When you are doing a rapid movement.

So the most important thing when while testing the vestibule ocular reflex is rapidity of the movement. If the movement is rapid, then you are checking isolated the vestibule ocular reflex and not the other sided inhibition. So that's the importance of doing rapid head movements while doing the vestibular ocular reflex testing. That is radio head impulse test test. Now let us look at the bedside head impulse test which was what are the limitations of bedside head impulse test and what are the pros and what are the cons?

Head impulse test assesses the vestibular ocular reflex and which links the vestibular system to the ocular oculomotor muscles. And there are two versions of the test. One is bedside head impulse or clinical helmages test and or video helmagic test or video head impulse test. So there are two versions of this. And bedside head impulse test was first developed by Gabber, Professor Gaber Helmagi and professor ian Kurtos in 1988 to assess the function of semicircular canals during fast head rotations.

And the bedside head impulse test involves the patient fixating on a stationary target. When during the bedside head impulse test you ask the patient to look at your nose. Or during the COVID time we were telling the patient to look between the eyebrows and then you give quick head movements. You are doing quick head movements and trying to see whether the head velocity is generating equal and opposite eye movement. That means the eye will remain stationary.

You will feel that the eyes are stationary on the target. It. But if suppose it lags behind there will be a catch up sacade. So the head movement should be of high velocity. I I discussed the importance of that, why it should be high velocity.

Then it should be low amplitude and it should be unexpected to effectively stimulate the lateral semicircular canals. And in addition to horizontal canals, even anterior and posterior semicircular canals can can also be checked by doing the bedside head impulse test. In normal subjects, the vestibulo ocular reflex produces compensatory eye movements during head movements. And the eyes move in opposite direction of the head at approximately same velocity. And when the head moves to the right, the eyes move to the left.

When I move my head to the right and I want to reflexly, the eyes will remain on the target and they will move equal and opposite towards the left. So that is about this is, this is what happens in vestibular ocular reflex. So it appears that the eyes are remain stationary in the space but actually in the background they are moving. And like a gyroscope the eye is moving. It is detecting the speed and velocity acceleration of the head movement.

And immediately it is at adjusting the eye eyes on the target. The patient's eyes stay focused on the target and for example examiner's nose. And despite the head movement. So what happens in unilateral vestibulopathy is V function is reduced on the affected side. And the when the patient's head is moved towards the damaged side, the eyes fall short of the target.

For example, if I move my head towards the right and suppose I have have right vestibulopathy, the eyes will not be able to match the head velocity and it will fall short. And then there will be a catch up sacade. So that is called as catch up sacade. That is a refixation sacade like to, you know, to fixate on the target. It will make a sadic corrective eye movement.

So I will show you one head impulse in slow motion.

For example, when I move the head towards the left side, the the eyes are bang on the target. But when I moved towards the right side, there was a catch up circuit or corrective socket. So the catch up sacred helps to bring the eyes back to the target after the initial failed movement. And this abnormal eye response is a sign of vestibular dysfunction on the affected side. And ketchup sacades are of two types.

Okay, so there are, there is some overt sacade and a covert circuit. So what are the these two types of circuits like overt and covert. The over sacades occur after the head stops moving and are visible to the naked eye eye making them detectable on the bedside head impulse test. So during bedside head impulse test we are able to see this particular over sacade. But the COVID sacades occur during the head movement.

They are very fast and are not visible to the naked eye. During the head movement itself there is even if it lags behind it corrects itself with a catch up sacade. But it is it happens during the head movement. So it is not appreciable to the naked eyes. And that's where the you know it is an intermediate movement.

So for example it is one is fast moment that is normal. Then second is intermediate and there is a catch up which happens during the head velocity. And there is third is which we see during the bedside. That is it lags behind the head movement. And then there is a catch up second which is a over second it is over it is is see it it.

It can be seen. Covert means it co happens along with the head movement. So it is not appreciable to the naked eyes. So the limitations of bedside head impulse test are it cannot detect the COVID sacade limiting the diagnostic capacity and the bedside head impulse test. But it is most useful in acute setting in the bedside side to diagnose the vestibular hypofunction when the over sacades are more likely to be observed.

So bedside hair impulse test is nothing but a all or none test. Either it will show or it will not show. It will show means it is a over sacade that is abnormal. If it is normal then it will not it will not be able to detect the intermediate response which is present in partial vestibular deficits and which is very important to monitor the compensatory strategies which are happening with respect to rehabilitation in a patient with vestibulopathy. So this in this intermediate response is we are not able to see with the help of the bedside head impulse test.

And that's why that there is video head impulse test which helps to detect this particular intermediate response. The the absence of over sacket does not guarantee the normal function of the vestibul ocular reflex. If bedside head impulse test shows that it is normal, that doesn't rule out vestibular dysfunction because it could be old vestibulopathy or it could be a partial vestibular deficit. And it this particular then the vest the video head impulse test helps in monitoring the progression. As with the vestibular rehabilitation, how the V is improving over a period of time.

So the video head impulse test developed by Eric Ulmer to Measure functional deficits in a continuous range. And the video head impulse test is a quantitative method for assessing the vestibul ocular reflex text and it uses high speed cameras to record both over and over circuits. So the most important advantage of the video head impulse test it can assess the VOR gain. Vor gain is nothing. But I will simplify the VOR gain.

Suppose you invest money. Suppose you suppose invest Dh100 like for example hundred dollars and you gain like. Suppose invested amount become remains 100. So the gain is 1. Okay, but suppose the invested amount becomes like $80.

So the gain is 0.8 it has gone down. And suppose you the the gain like you the invested amount becomes $110. The gain is 1.1. So similarly we are testing the gain of the vestibular ocular reflex by we are divided by the head velocity, how much input we are giving and how much output we are getting. The eye velocity is an output and head velocity is a input we are giving.

And we are trying to check how much gain like we are gaining and that helps in checking the the gain of the six canals and it helps in like assessing their function. And it helps to identify the partial vestibular impairments. It is helpful in monitoring the compensation session methods and directing the rehabilitation efforts. The VHID provides feedback on the clinician's head impulses ensuring like improving testing accuracy because the system when it gives feedb back it helps the clinician to like you know to maintain the proper head velocity for getting the head impulses. VHIT has been validated against clear search coil.

My like I'm just going to take another five minutes and then we I will open it for question answer. Uh so we hit has been validated against CL search coil the gold standard for measuring eye movement. But VHIT is non invasive and more practical for clinical use. And we know that there are variety of eye movement analytical techniques like the ENG then the scleral search coil and the vng they are mainly to detect the eye movements ocular recordings and of course ENG technique is the older one. It measures the electrical potentials.

The VNGS tracks the eye movement and scleral search coil tracks the eye movement with a magnetic field. And more practical solution is VNG in case of checking the eye movement. But if it when it comes to the like bedside or you know clinical use for assessing the vestibule ocular reflex, uh the video head impulse test is more you know uh, useful as compared to the like uh scleral search coil. Uh the purpose of video head impulse test is to measure the vestibul ocular reflex which is the ratio of eye velocity to the head velocity during a head impulse. And a normal functional V should produce a gain close to one that is eye moment velocity is equal to head moment velocity.

So how much you are investing is nothing but the head velocity and how much you are gaining is the eye velocity. So that is the like. So we have to divide the I velocity by the head velocity to calculate the gain. And there are various methods in different systems to calculate this gain. So the minimum requirements for the V heat systems is accurate head velocity measurement and accurate eye velocity measurement.

So there are two components of video head impulse test. There should be a measure of head velocity and there should be a measure of eye velocity. So if we get these two parameters, that is eye velocity and the head velocity, the ratio calculation by different methods will help us to get get the V V gain. And that will help us to see the vestibul ocular function is normal or not. And there are two systems, a remote camera based system which uses a F camera to capture the patient's head and eye movements.

And the software analyzes the video using eye tracking and head pose estimation algorithms to calculate velocity and position. So this is one system where there is a remote camera which will calculate both both the things that is head velocity and the eye velocity. And there are head mount based systems which consist of head mounted device with an integrated accelerometer which helps in to calculate the head velocity. And infrared cameras are there. The accelerometer measures the head velocity while the camera measures the eye velocity from reflections on a silver mirror.

Software combines both inputs to calculate the VOR gain. So these are the two systems which are available. So what I will do here is I will stop here because we have two more sessions of two hours and I hope I have covered the basics of you know, dealing with like basics of vor. Then we went into the bedside head impulse. Then we just started the entering into the video head impulse systems.

And there are two systems. One is video remote camera based and second is head mount base. So we will dive deeper into this in our subsequent webinars. We are going to have two more sessions where I I will go deeper and deeper into the mechanisms and deeper into clinical applications and cases I am going to present. So here I will stop and I will open up the forum for, you know, question answers, whichever you know, are posted.

I request the audience to post their questions and I'll be happy to answer the questions.

Dr. Pawar thank you so much for today's excellent presentation. I think we have all gained valuable insight into the fundamentals of vhit and its relevancing in clinical practice. Thank you so much. Dr.

Pawar. I can see three questions from the audience, so may you be so kind to click on a dedicated button, read the questions and provide an answer. Can you see the. The button yes Question answers? Yes, I got it.

Fantastic. Thank you so much. Yeah. Yes. So.

Okay. The.

Okay. There is one question we hit in Meniere's disease regarding the video head impulse. See, today's talk was mainly based on the basics of vestibul ocular reflex X and how it, you know, how we measure it and what are the anatomical pathways, physiological mechanisms happening when the head movements are happening. So we anyway we are going to de dive deeper into this. But to, to answer your question, in short, if we compare between vestibular neuritis and menus disease, if we look at the like type 1 hair cells and type 2 hair cells, the type 1 hair cells are are rapid, early responsive and which are important with respect to the vestibular ocular reflex.

And that's why we in commonly in vestibulopathy, that is we get this vor gain loss in patients with vestibular neuritis and in menial disease early stages it can. It can be normal. But as we as the patient keeps on getting the attacks, the patients can develop vestibulopathy and the patients can develop the V gain loss. Okay then, then the next question.

In migraine patients, how do you explain the pathophysiology of hyper reflexia? Again, it's a clinical question. I will reserve it for my second talk. I will be going deeper into this. But to cut short, migraine is a disorder of hypersensitivity.

Basically it is a disorder of sensory process thing because the. And there is hyper reflexia kind of hyper reflexia which happens in migraine patient and there can be increased V gain which can be seen. And I will dwell into the mechanisms in my next talk.

If we do only lateral video head impulse, what interpretation we could mic the question. So when we do only lateral canal video head impulse test, there are six canals. And suppose you are doing only lateral canal. It will just give you like you know, measure of lateral canal in high frequency stimulation. For example, if you do caloric testing, it is giving you to information of low frequency stimulation of lateral canal on that particular side.

So similarly the lateral video head impulse test only if you conduct the lateral canal. So it will give just information about high frequency Stimulation of the lateral canal. So suppose a patient has inferior vestibular neuritis. This. So in that particular patient, the posterior canal is involved.

So it will not help to, you know, detect that posterior canal loss. And even in superior vestibular neuritis, it will involve lateral canal and anterior canal. And there are of course cases of isolated anterior canal involvement. So there is. So if we do only lateral canal radio head impulse test, we can miss these conditions like the inferior vestibular neuritis or isolated involvement of anterior canal.

Or you will not be able to, you know, like, judge whether there is involvement of all the canals on one side. Then there are. So all these conditions can be missed if we are just checking the lateral canals in place of checking all the, you know, six canals. Okay, now, so do you use, do you use them when you already suspect vestibular migraine based on history? Very nice question.

Like, see clinically, if you are sure like it is, we are dealing with vestibular migraine. Ideally it is not going to provide any further information. But of course the increased gain can help in, you know, in some patients there is increased gain of vestibul ocular reflex and that will help us to specifically, you know, diagnose the condition. And many a times in vestibular migration screen the presentation is like atypical. There are no history, there is no history of headache or there is, the patient has forgotten the history of headache.

So in such cases you can always, you know, try to do it and try to differentiate it from vestibulopathy or Meniere's disease. And the gain, especially if it is little higher, it can help to cone down to vestibular mite migraine.

Then can a nurse manipulate the head in video head impulse test. This is very difficult question for me to answer because it depends on the country, specific guidelines, whether you know, they can do it or not. Next is okay, then next question is translational V. It's a very nice question. Translation V is nothing.

But when we are suppose now you are looking at the screen and you are making adjustments with your head moving forward, backward or side to side, then there is something called translational vor. And that comes into picture when we are doing these movements. And specifically this translational VOR is affected in patients with vestibular migraine. And that's why many, if you start asking this particular history whether they have difficulty or in focusing and concentrating, many of the patients will have, will give this history of, you know, difficulty in focusing and concentrating. And that is because of these, this particular defect in you know, they are not able to translate and maintain the clarity of vision.

And they will complain that there is a blurring of vision when they are looking at near object or screen or they are trying to fix it.

Yes. So the next question is it is not related to vhid, but. But it is about vestibuloic and vestibulo spinal reflex. All neck muscles are involved in these reflexes or is there a selective pathway for each? So for example, when we talk about the balance, always we say that the balance is controlled by three systems.

Vestibular system and the vision and the proprioception. But. But when it comes to how it happens then that there is a role of reflexes. For example, how the vestibular system helps in gauge stabilization is vestibul ocular reflex head stabilization. It achieves by the vestibulo colic reflex.

Now the question is about vestibulo colic reflex. The vestibular nuclei, once they receive the vestibular sensations, then they like through the medial vestibulospinal tract. They alter the tone of the muscles of the neck. That is through the vestibulocolic reflex. And that helps to stabilize the neck with respect to the vestibular stimulation.

So that is vestibulo colic reflex and vestibular spinal reflex is nothing. But the vestibular input input is helping us to stabilize the posture. So there are three stabilizations which happen with the help of vestibular input. One is vestibulo ocular stabilization, that is Gaze stabilization. The head stabilization happens with vestibulo colic reflex.

And the vestibulo spinal reflex helps in stabilizing the posture. So the vestibulo spinal reflex is through the lateral vestibulospinal tract. Fact. So the question was is there any selective pathway for each?

Yes.

The vestibul ocular reflex from each semicircular canal is different. There are different. There are excitatory pathways from each semicircular canal. There are inhibitory pathways from each. For V.

That is for about the V. The vestibulo colic reflex is through the medial vestibulospinal tract tract and the vestibulo spinal reflex is through the lateral vestibulo spinal tract. Means what? Like what exactly happens when this vestibulo spinal tract suppose reaches it will change. It will act on the anterior horn cells in that area.

For example, in the vestibulo colic reflex, the vestibular sensation comes to the vestibular nucleus from the vestibular nucleus. The vestibulo spinal medial vestibulospinal tract tract will send the impulses to the neck muscles and the anterior horn cells which control the neck muscles. The alpha motor neurons and gamma motor neurons which control the neck muscles will be accordingly stimulated based on the vestibular stimulus. So the. And that.

That is the reason why this vestibulo colic reflex activation happens in when various vestibular pathologies is and neck pain is a very common symptom of majority of the vestibular disorders. Neck pain is a very common symptom. For example, you check your next patient with suppose right vestibular neuritis. He will have spasm in the right sided neck more as compared to the left side. So vestibulo colic activation happens in this patient and that leads to, you know, spasm of the neck muscles.

Is there any role of visual attention of a patient on the VOR results? Yes. As I was discussing, suppose reflexively the head is stimulated and some patient is looking at some object. And the. There is a natural tendency when we are moving our head while walking, we try to fixate our gaze is that is reflexly it will happen.

Okay, but what happens? Suppose a patient decides to shift their attention to another object and not care about the head movement. Like for example, you are looking now at suppose my video and like there is some object in the peripher like you. You move your head. You can move your head keeping your attention to the screen.

Or. Or you can choose to, you know, look, move your eyes along with the head. So the attention definitely has a role because attention comes from the cortex and the reflex is happening at the brainstem level. So the visual attention can, you know, override the vestibul ocular reflex. So all the cortical like you know, the cortex is basically a consciousness.

Our state of consciousness ness and the brain stem is majority of the things which happen at the level of brain stem are nothing but they are reflexive things. So the cortex can override the visual attention can definitely override the this vestibul ocular reflex. That's a very important question by Dr. Alexandra.

Then. Okay, there are some compliments. Okay. And then one question I couldn't like understand. You said about the hedge head general head movements and angular head movements.

Whenever we do angular moment, there would always general moment also. So how to get pure angular momentum? Okay, I understood the question. Suppose like see, when we are naturally moving our head, there is a combination of linear and angular head moment. But when we are trying to check the vestibular ocular reflex view are we are isolating the movement and trying to do it.

For example, suppose this is right anterior canal. We are, that's why we are bringing the anterior canal and like we are specifically doing that particular head movement to stimulate that particular canal and we are doing angular head movement and we are trying to isolate it. That's why there should not be translational head movement during that time. It will like it will it. It can act as a noise or it can change the recordings.

So I hope I answered your question. It's how to get pure angular momentum is by doing the exact moment of that particular canal. Like for example for right lateral canal, doing right rightward head movement. And it should be unpredictable, low amplitude and it should be rapid. These three components should be satisfied.

Okay, what are the contraindications for video head impulse test? We are going to go into the details. But suppose somebody has neck pathology or unstable neck, it should be avoided. But. And even the lens dislocation like can happen.

So it's very important that you know to have to reserve this particular test and take you make it a routine that these things are checked before doing the testing. But of course the video head impulse test involves a quick jerky movement. In expert hands it is a very quick small amplitude movement. It's not, it should not be very, you know, large amplitude movement that can be really traumatic to the neck.

Okay, okay. So. Yeah, okay. Yes. In the.

My next talk I'm going to explain about possibility of video head impulse test in visually challenged individual. Today's Basically I want to restrict myself to. To mainly to the basics which are involved. That is anatomical pathways which are related to the vestibular ocular reflex and the physiology which is involved. So we are going to go deeper and deeper as we, you know, go into the next two sessions.

And there are certain, there are two compliments, one from Silvana. Congratulations. Thank you.

I would say loads of compliments. Loads of compliments.

Sorry. Okay. Okay, so the questions are finished. So I think that we are going to an end. And As I said, Dr.

Pawar, I saw and I'm still seeing a lot of compliments. You deserve everything. You deserve the best for this fantastic presentation. So we will meet again on April 22nd for the second session, Fundamentals of Video Head Impulse Test. Lesson two, Clinical Application and Interpretation.

Okay, so, so April 22nd, the second session with Dr. Vishal Pawar. Thank you so much once again, Dr. Pawaro. It was brilliant as usual.

Thank you. Thank you. In the meantime, for my lovely audience, don't miss our next webinar on April 10th with Professor Michael Kalberg. Professor Kalber is the president of the Barani Society. Okay.

Dr. Kalber will run a webinar dedicated to the Meniere disease, so please stay tuned on our channels. And as always, thank you so much for being part of Inventis Academia. See you soon. Bye.

Thank you. Bye.