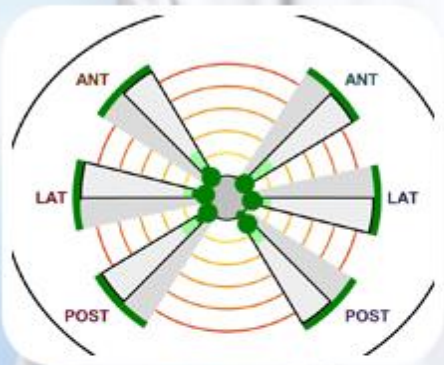
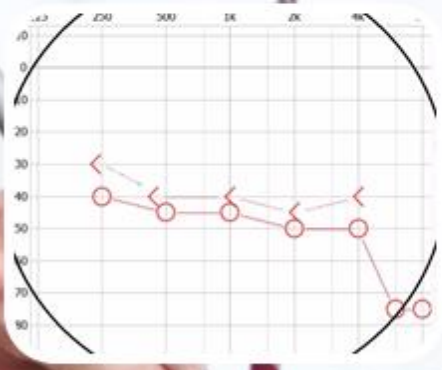
VESTIBULOMETRY *- its relevance in clinical practice*







Dr Anirban Biswas

Neurotologist

Kolkata, India

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What do we test??

Structural integrity of the balance system

- 5 parts of the vestibular labyrinth
- Oculomotor system
- Neural pathways

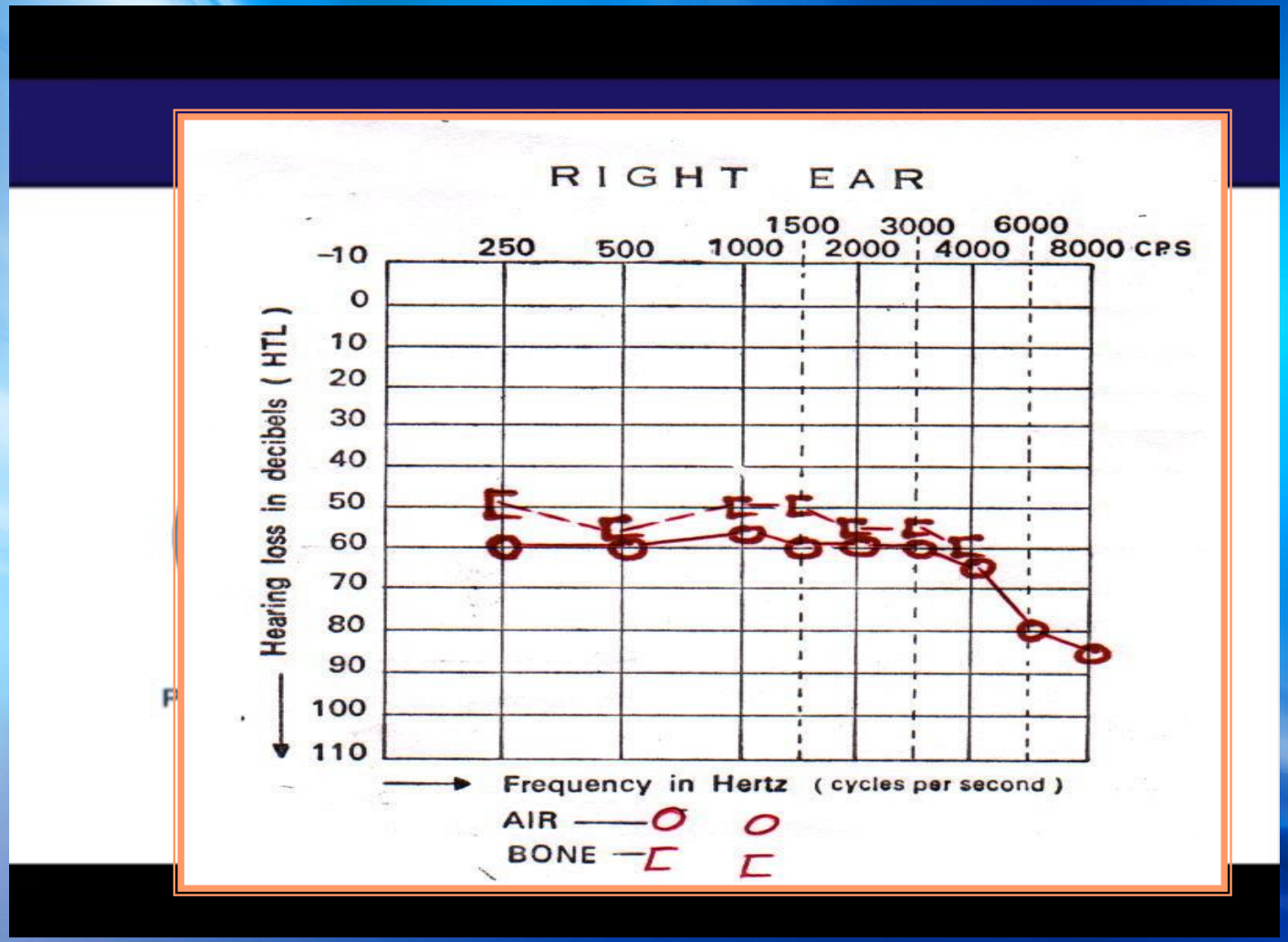
Functional integrity of the balance system

- Gaze stabilisation (VOR)
- Postural stabilisation (VSR)
- Sense /perception of verticality

What do we not test??

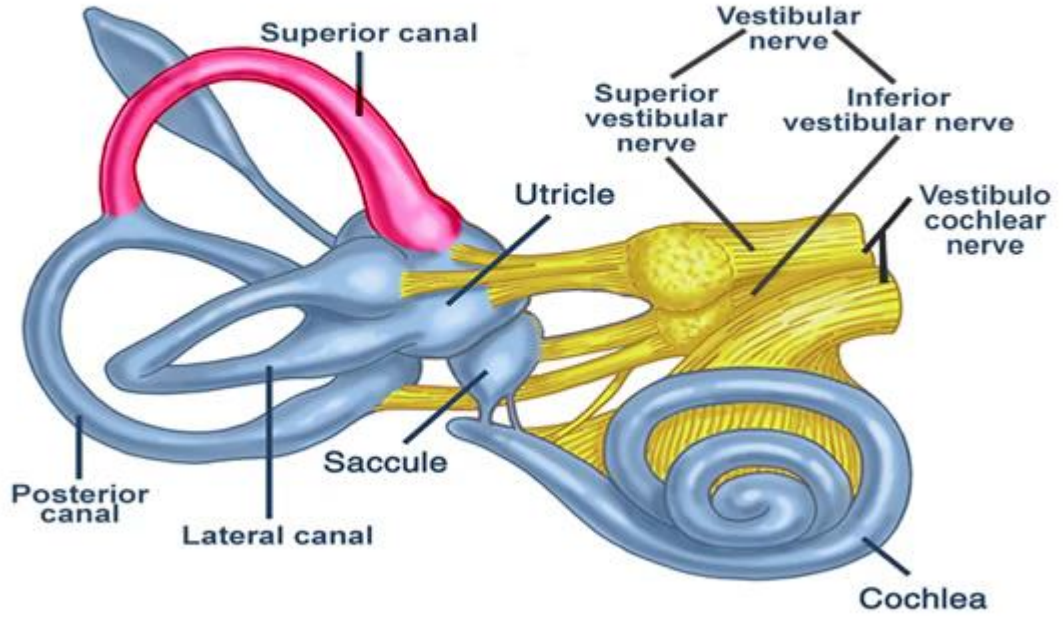
1) The cognitive system incl. memory
2) The psychic system
3) The CNS comprising of the visual & vestibular cortex which actually control the functioning of the balance system and subcortical centers that perceive the sensation of imbalance / vertigo

What is it that we can test & what info does contemporary vestibulometry give us ?



Each individual part and at different frequencies of vestibular stimulation

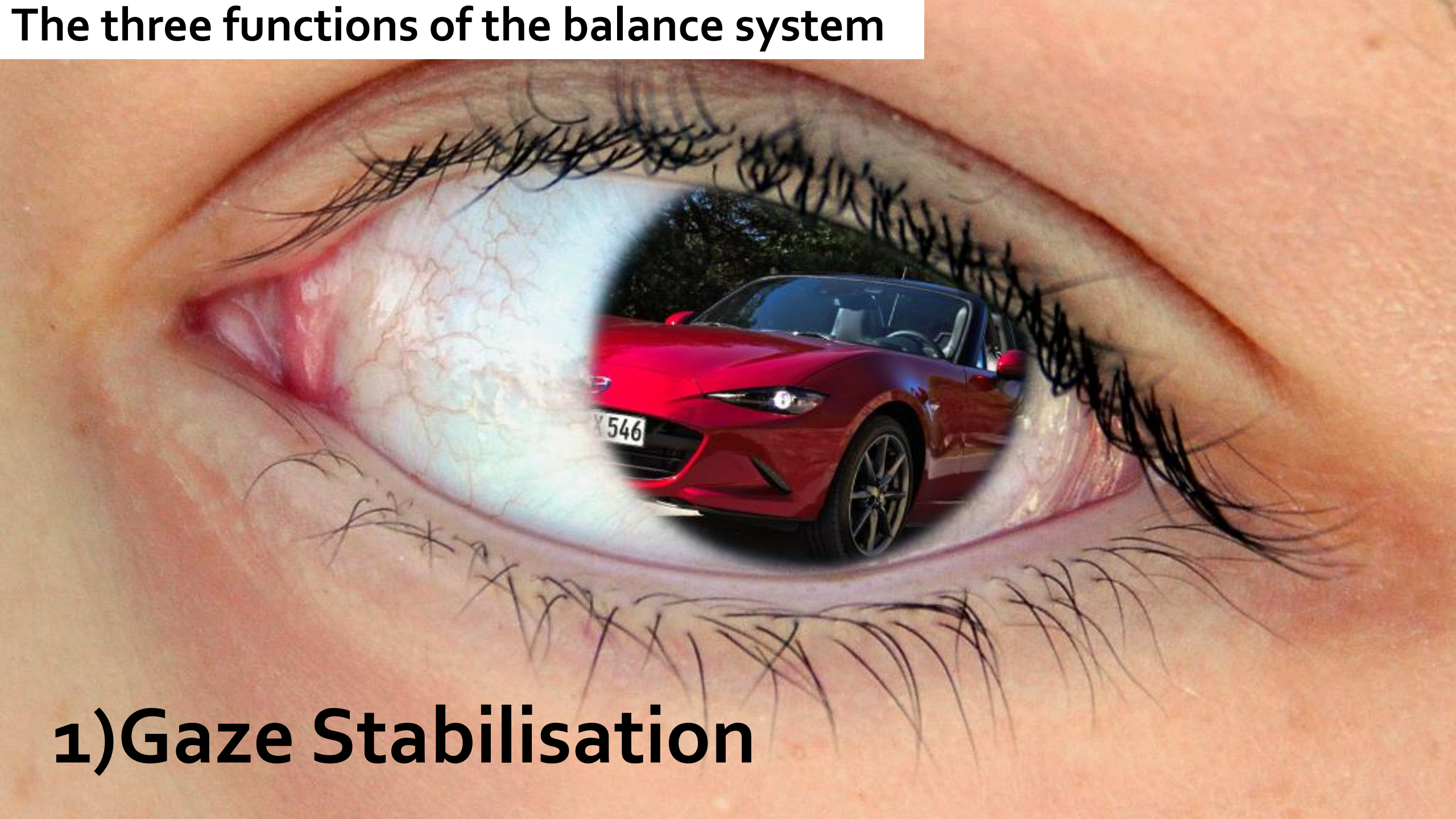
VESTIBULAR LABYRINTH



STIMULATING THE LATERAL SEMICIRCULAR CANALS AT DIFFERENT FREQUENCIES

STIMULATING THE SACCULE AT DIFFERENT FREQUENCIES

The three functions of the balance system



1)Gaze Stabilisation

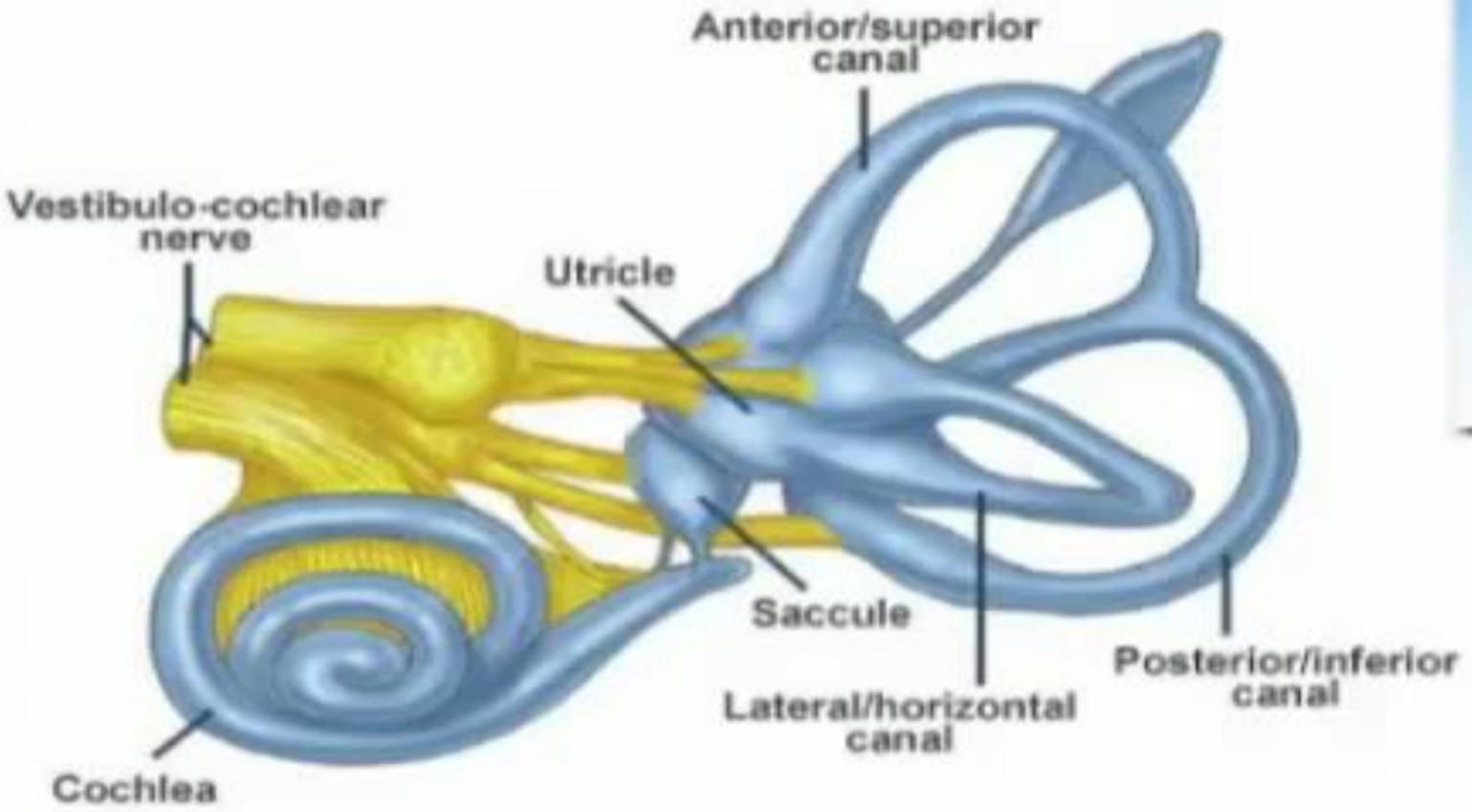
The three functions of the balance system

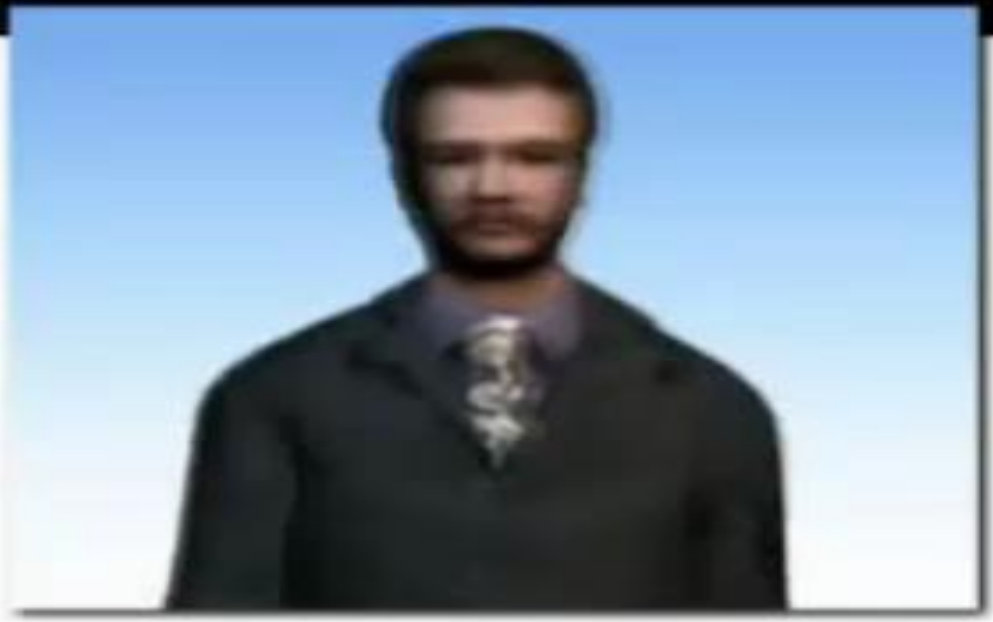
2)Postural Stabilisation

The three functions of the balance system

3)Perception of the verticality

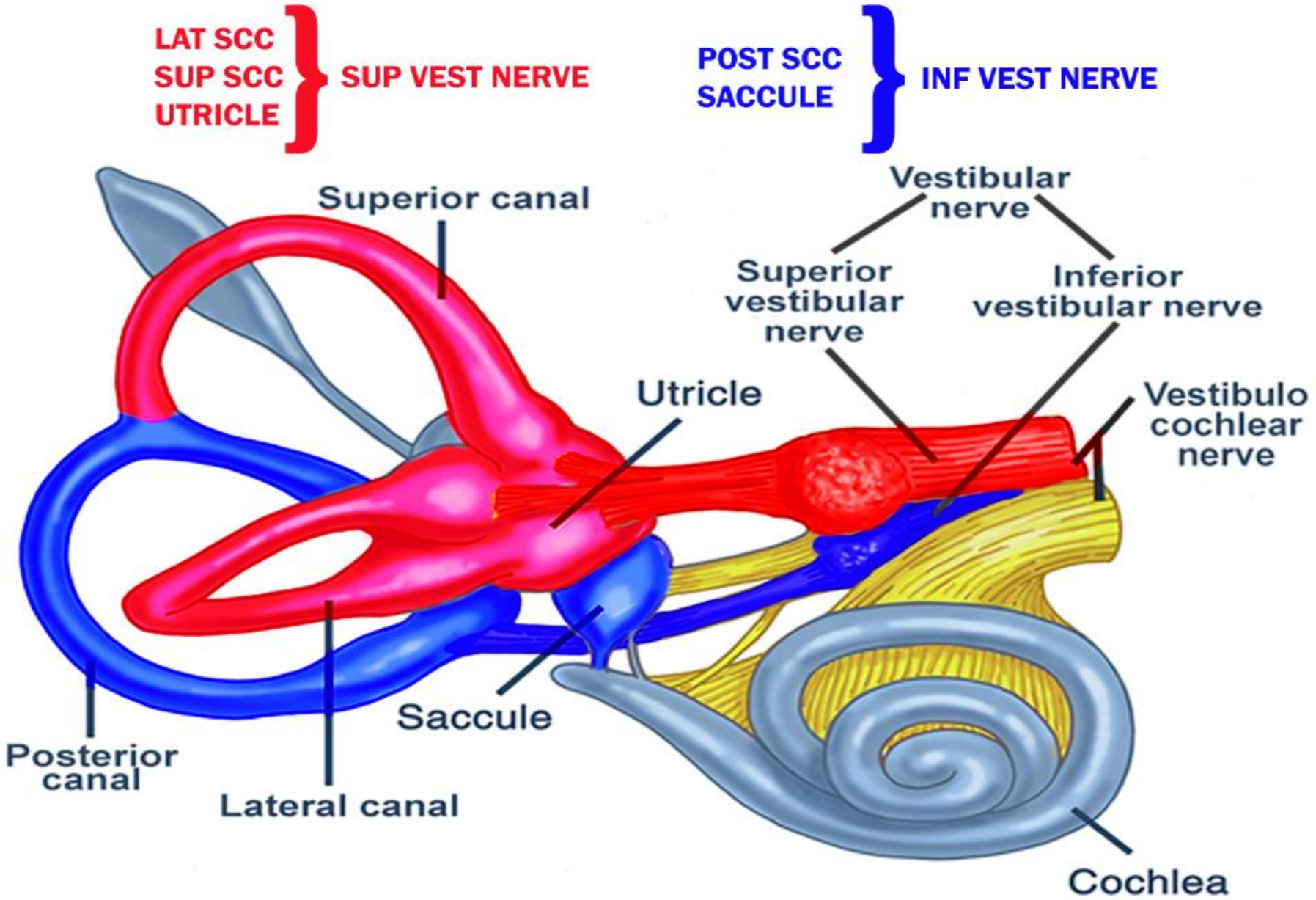
Each part senses one specific type of head movement, hence each part needs to be separately tested



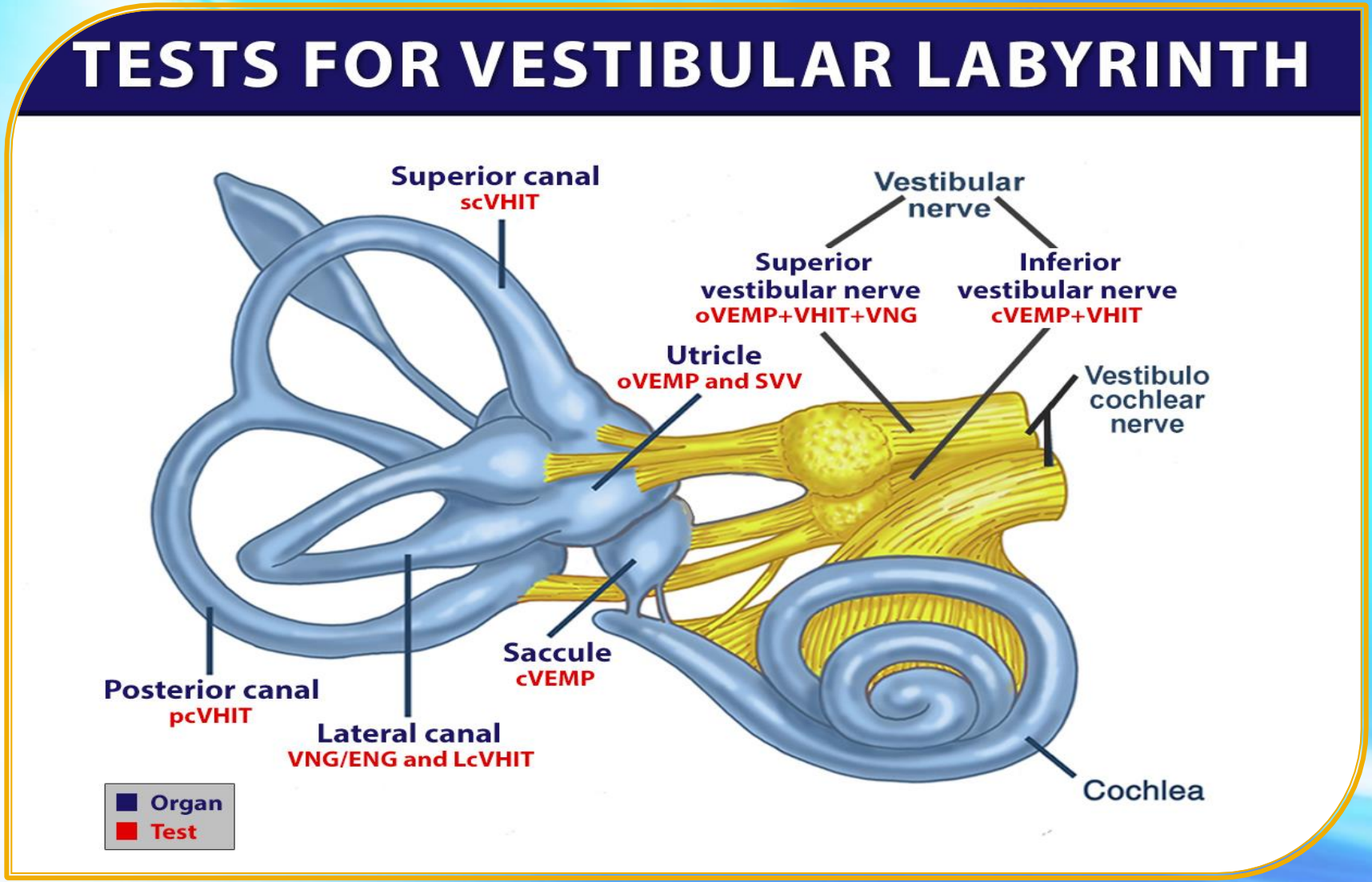


VESTIBULAR LABYRINTH

VESTIBULAR LABYRINTH



Functional status of each part of the vest. labyrinth can be evaluated with utmost precision today



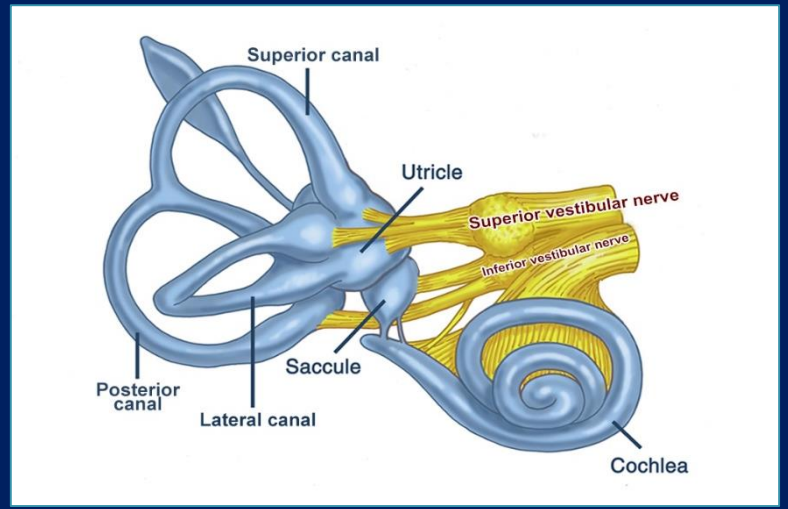
1)Each part of the vestibular labyrinth has a specific function

2) Functional integrity of each part of the vestibular labyrinth can be evaluated and at different frequencies of vestibular stimulation

The structure of the balance system

-each part needs to be tested

- **VESTIBULAR LABYRINTHS comprising of**
  - **3 semicircular canals, saccule, utricle**
- **VESTIBULAR NERVE with the sup. & inf. vestibular nerves**
- VESTIBULAR NUCLEUS
- BRAINSTEM
- CEREBELLUM
- VESTIBULAR CORTEX
- EYES
- SPINAL CORD
- PERIPHERAL NERVES
- SKELETAL & EXTRA-OCULAR MUSCLES



Diagnostic tools available today

Vestibular function tests:-

- ENG
- VNG
- oVEMP
- cVEMP
- SVV
- VHIT
- DVAT
- Posturography
- CCG

Allied tests:-

- P T Audiometry with localising tests
- BERA
- ECochG
- NCV and SSEP
- Imaging studies
- Transcranial Doppler

Specific tests for each anatomical part

ANATOMICAL PART	TE

1) Whatever be the test, there is NOTHING to beat a thorough history taking, a proper clinical examination and the clinician's clinical judgment

2) All vestibulometric tests are only as good as the man-behind-the-machine and the clinician interpreting the test

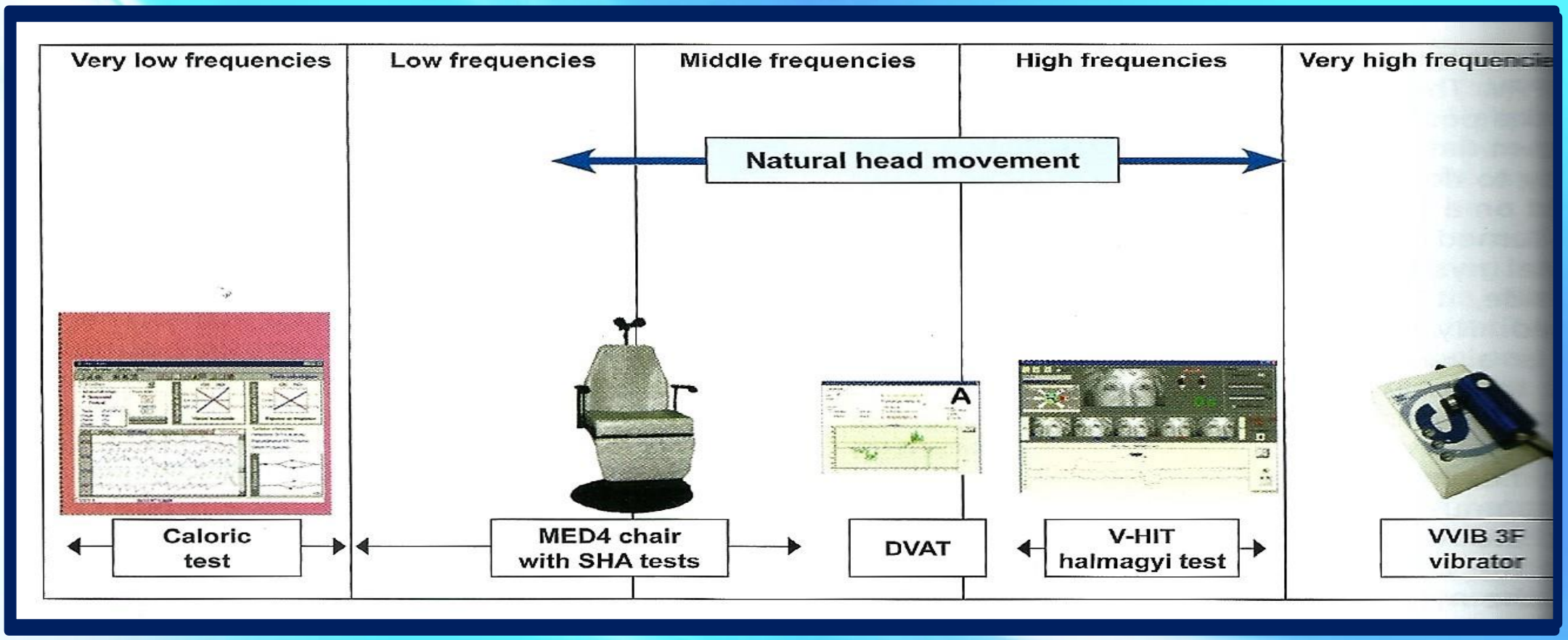
3) Just a test report without the detailed relevant history & thoroughly done clinical findings mean nothing

4) Test battery approach is essential; vest system cannot be assessed by any single test

tical (SVV)

NCV, SSEP

Different tests evaluate vestibular response at different frequencies of stimulation



Standard VNG/ENG test battery

VNG Test evaluates:-

1) **Oculomotor system (higher precision in VNG than ENG)**
2) **Sensitivity of lateral semicircular canal only**
3) **Structures tested are LSCC, Sup Vest nv,**
4) **Helps to document eye movements during positional tests & monitor corrective maneuvers**

Does not evaluate:-

1) Utricle , Saccule , anterior & posterior semicircular canals, Inf. Vest nv
2) Lateral canal at speeds in which natural head movements take place; tests LSCC at very low freq of vestibular stimulation

Fallacies & limitations of the VNG test

- Time –consuming test, unpleasant for the patient.
- Caloric VNG is an un-physiological test that stimulates lateral canal with a un-physiological/ unnatural stimulus and evaluates sensitivity of the lateral canals at frequencies below 0.005 Hz (*Frequency of normal head movements : 0.5 – 3.5Hz*)
- Due to anatomical variations in head size & structure of the ear, temperature at which endolymph of each individual will be stimulated is variable; structural differences between two ears of the same person are common
- Test is usually very erroneously done

SNEHA HEARING CENTRE

104/107, Saeed Plaza. Lakdi-ka-pul, Hyderabad
Tel: 040-23237772, 23212121

Patient Report - VNG

Patient ID:	A0211
Patient:	D.Suresh kumar
Birthdate:	7/9/1956
Gender:	Male
Address:	Nirmal
Phone:	9440060301
Physician:	Dr.Srinivas kishore ENT
Referral Facility:	Star hospital
Referral reason:	Giddiness
Operator:	SNEHA HEARING CENTRE
Report date:	11/2/2019

Results:

Total response from the right = **93 deg/sec**
Total response from the left = **22 deg/sec**
Baseline Shift = **0 deg/sec**
Unilateral Weakness = **62 % in the rightear.**
Gain Asymmetry = **53 % to the right ear.**

Left unilateral caloric weakness. Caloric responses of the left ear are **62 %** weaker than those of the right ear.
Right abnormal gain asymmetry. There is an abnormal gain asymmetry with right beating caloric responses **53 %** stronger than left beating caloric responses

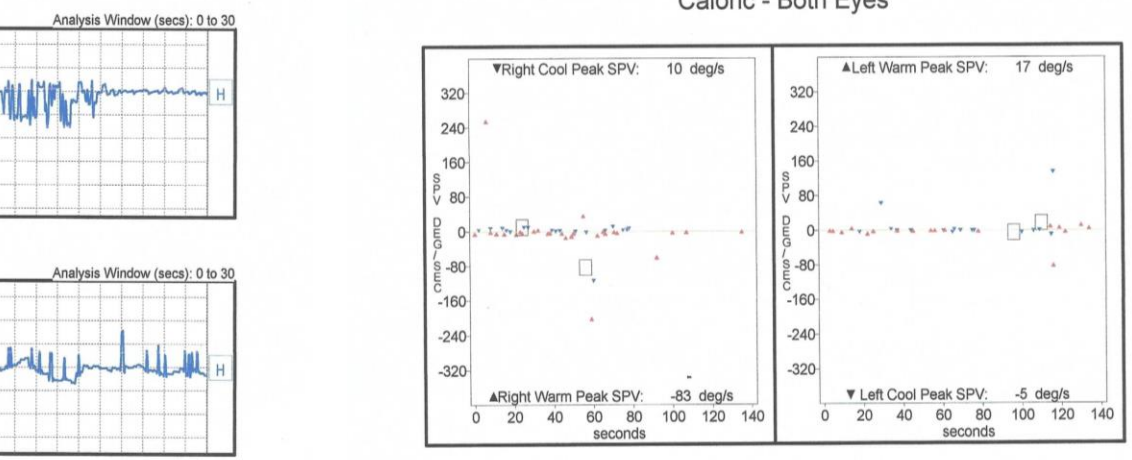
The Dix-Hallpike test for Bening Paroxysmal Positional Vertigo **(BPPV)** is **Negative.** Saccadic eye velocity and accuracy were normal. Visual Pursuit and optokinetic tests were normal and symmetrical.

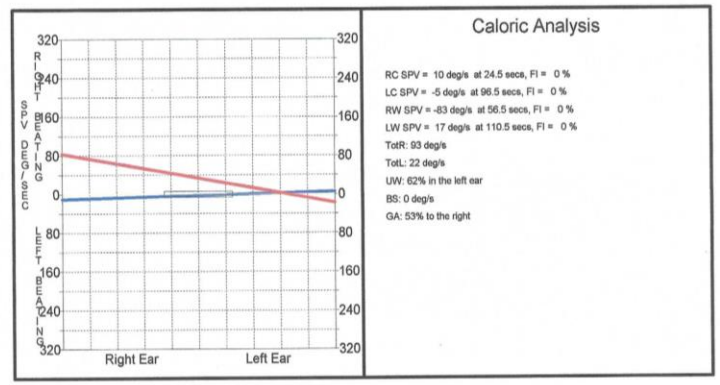
lickoo 02/11/2019
(Audiologist)

otometrics

Patient ID:
Patient Name: D, Suresh kumar
Birthdate: 7/9/1956
Session Date: 11/2/2019

Caloric - Both Eyes

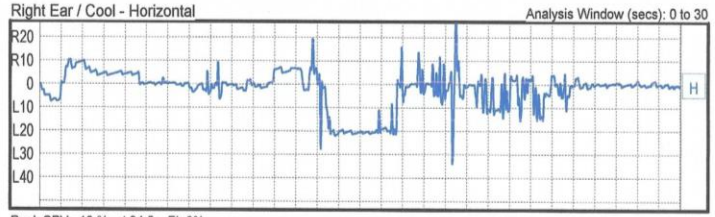




Patient ID:
Patient Name: D, Suresh kumar
Birthdate: 7/9/1956
Session Date: 11/2/2019

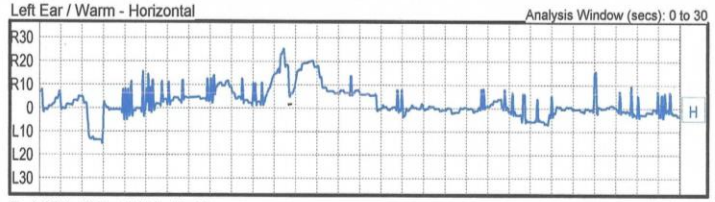
Caloric - Both Eyes

Right Ear / Cool - Horizontal — Analysis Window (secs): 0 to 30



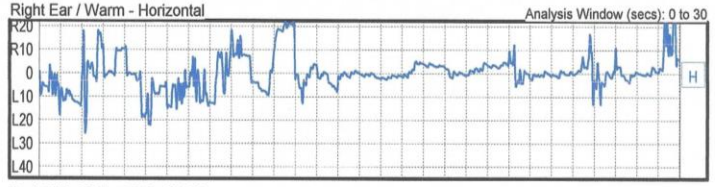
Peak SPV: 10 °/s at 24.5s, FI: 0%

Left Ear / Warm - Horizontal — Analysis Window (secs): 0 to 30



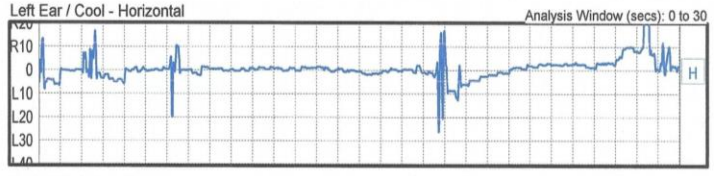
Peak SPV: 17 °/s at 110.5s, FI: 0%

Right Ear / Warm - Horizontal — Analysis Window (secs): 0 to 30



Peak SPV: -83 °/s at 56.5s, FI: 0%

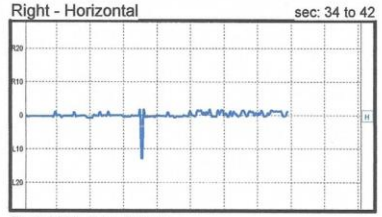
Left Ear / Cool - Horizontal — Analysis Window (secs): 0 to 30



Peak SPV: -5 °/s at 96.5s, FI: 0%

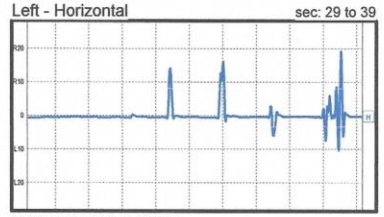
Gaze - Both Eyes

Right - Horizontal sec: 34 to 42



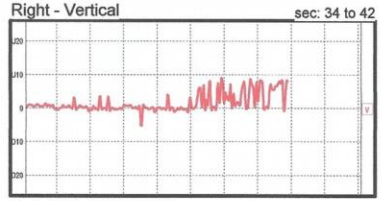
Peak SPV: -7 °/s at 29.5s

Left - Horizontal sec: 29 to 39



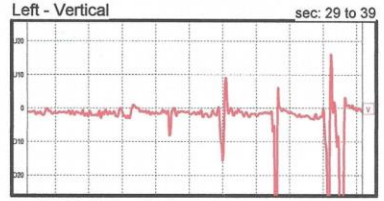
Peak SPV: -65 °/s at 10.5s

Right - Vertical sec: 34 to 42



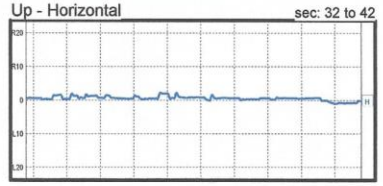
Peak SPV: -34 °/s at 21.5s

Left - Vertical sec: 29 to 39



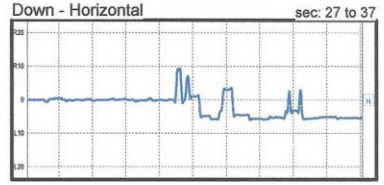
Peak SPV: -12 °/s at 29.5s

Up - Horizontal sec: 32 to 42



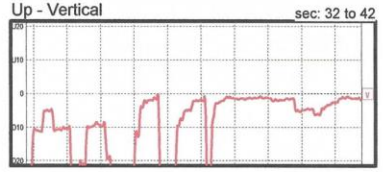
Peak SPV: -1 °/s at 32.5s

Down - Horizontal sec: 27 to 37



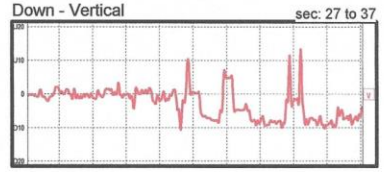
Peak SPV: 0 °/s at 0.5s

Up - Vertical sec: 32 to 42



Peak SPV: -4 °/s at 40.5s

Down - Vertical sec: 27 to 37

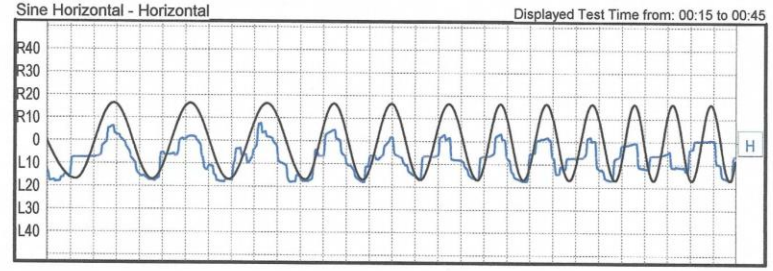


Peak SPV: -28 °/s at 17.5s

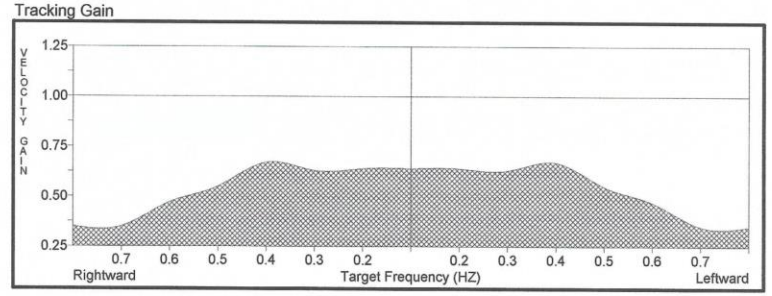
Patient ID:
Patient Name: D, Suresh kumar
Birthdate: 7/9/1956
Session Date: 11/2/2019

Tracking - Both Eyes

Sine Horizontal - Horizontal Displayed Test Time from: 00:15 to 00:45



Tracking Gain



Patient ID:
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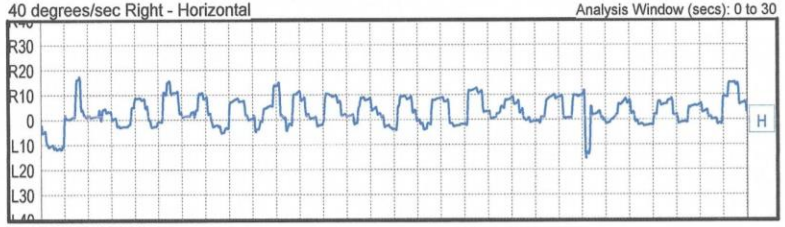
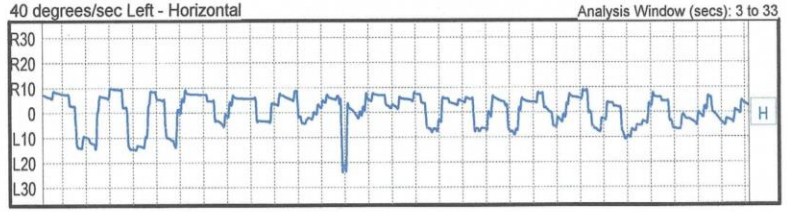
Optokinetic - Both Eyes

40 degrees/sec Right - Horizontal — Analysis Window (secs): 0 to 30



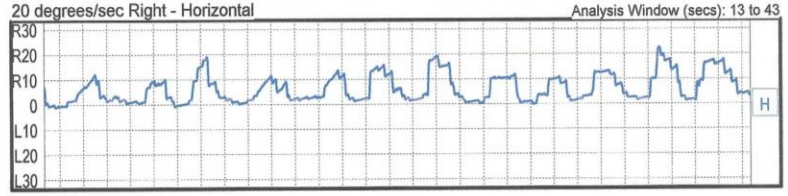
Peak SPV: 3 °/s at 27.5s

40 degrees/sec Left - Horizontal — Analysis Window (secs): 3 to 33



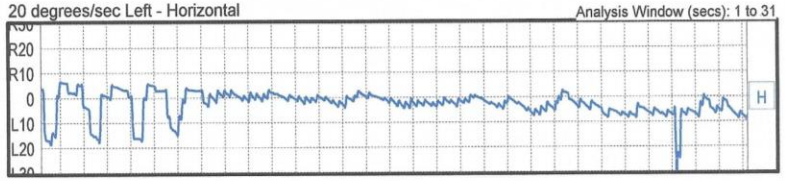
Peak SPV: -14 °/s at 1.6s

20 degrees/sec Right - Horizontal — Analysis Window (secs): 13 to 43



Peak SPV: 11 °/s at 19.5s

20 degrees/sec Left - Horizontal — Analysis Window (secs): 1 to 31



Peak SPV: -12 °/s at 13.1s

Patient ID:
Patient Name: D, Suresh kumar
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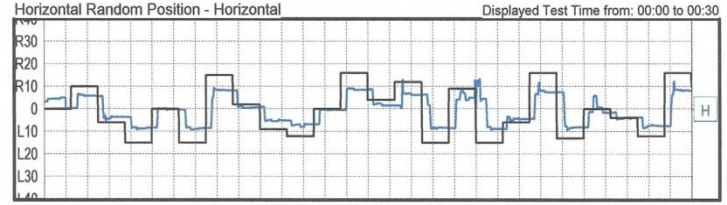
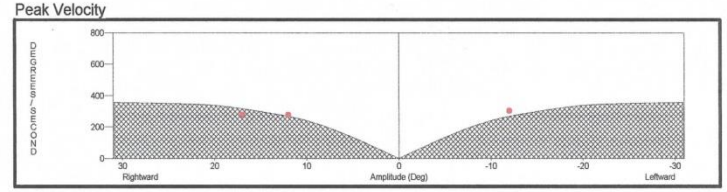
Saccade - Both Eyes

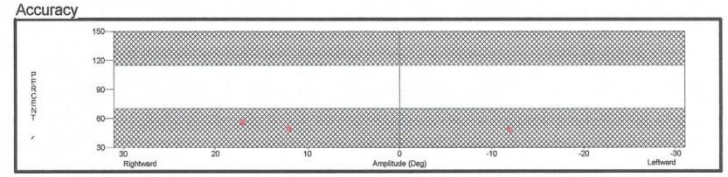
Horizontal Random Position - Horizontal — Displayed Test Time from: 00:00 to 00:30



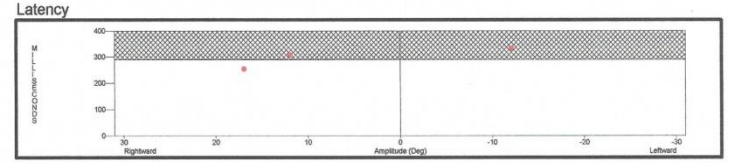
Peak Velocity



Accuracy



Latency



Patient ID:
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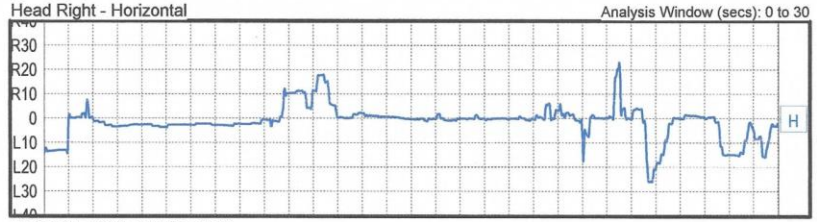
Birthdate: 7/9/1956

Session Date: 11/2/2019

Dix-Hallpike - Both Eyes

Head Right - Horizontal

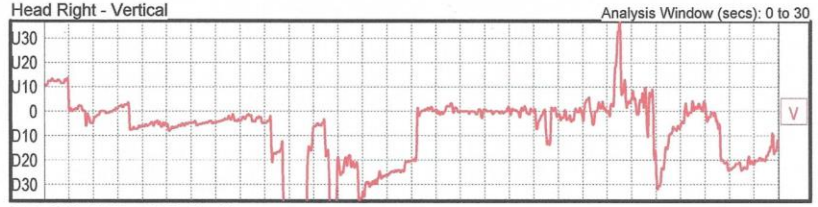
Analysis Window (secs): 0 to 30



Peak SPV: -40 °/s at 37.8s, FI: 0%

Head Right - Vertical

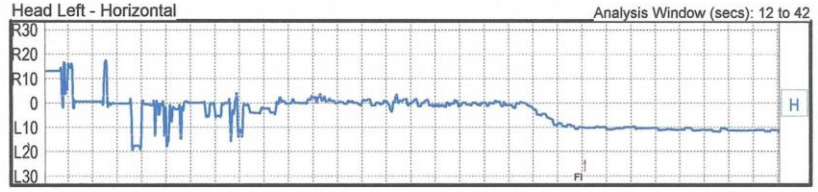
Analysis Window (secs): 0 to 30



Peak SPV: 40 °/s at 16.5s, FI: -4%

Head Left - Horizontal

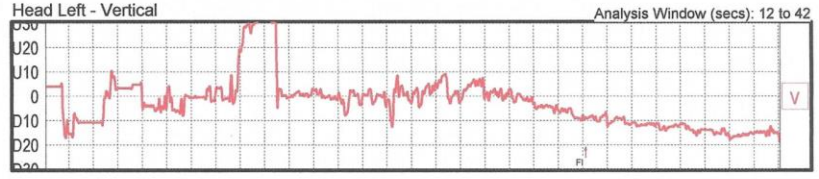
Analysis Window (secs): 12 to 42



Peak SPV: -6 °/s at 7.5s, FI: 0%

Head Left - Vertical

Analysis Window (secs): 12 to 42



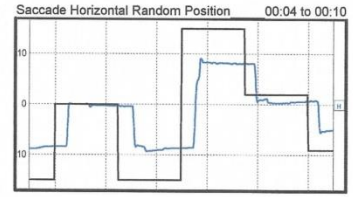
Peak SPV: 14 °/s at 6.3s, FI: -15%

Patient ID:
Patient Name: D, Suresh kumar
Birthdate: 7/9/1956

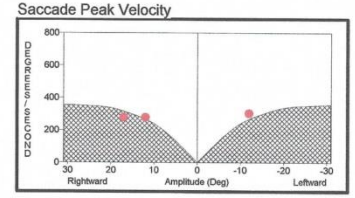
Session Date: 11/2/2019

Saccade-Both Eyes and Tracking-Both Eyes

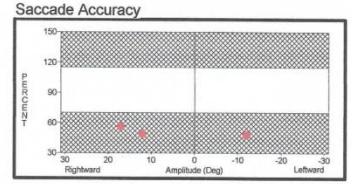
Saccade Horizontal Random Position 00:04 to 00:10



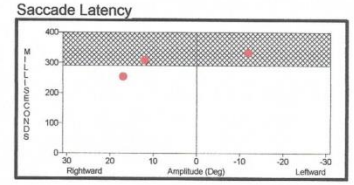
Saccade Peak Velocity



Saccade Accuracy

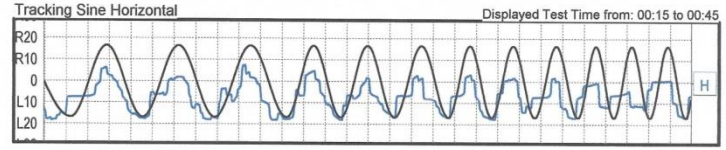


Saccade Latency

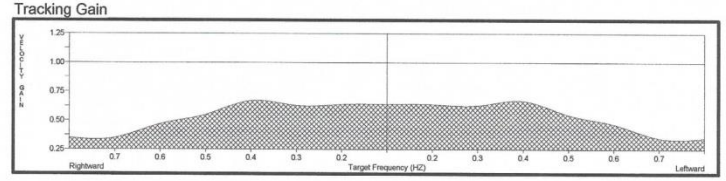


Tracking Sine Horizontal

Displayed Test Time from: 00:15 to 00:45



Tracking Gain



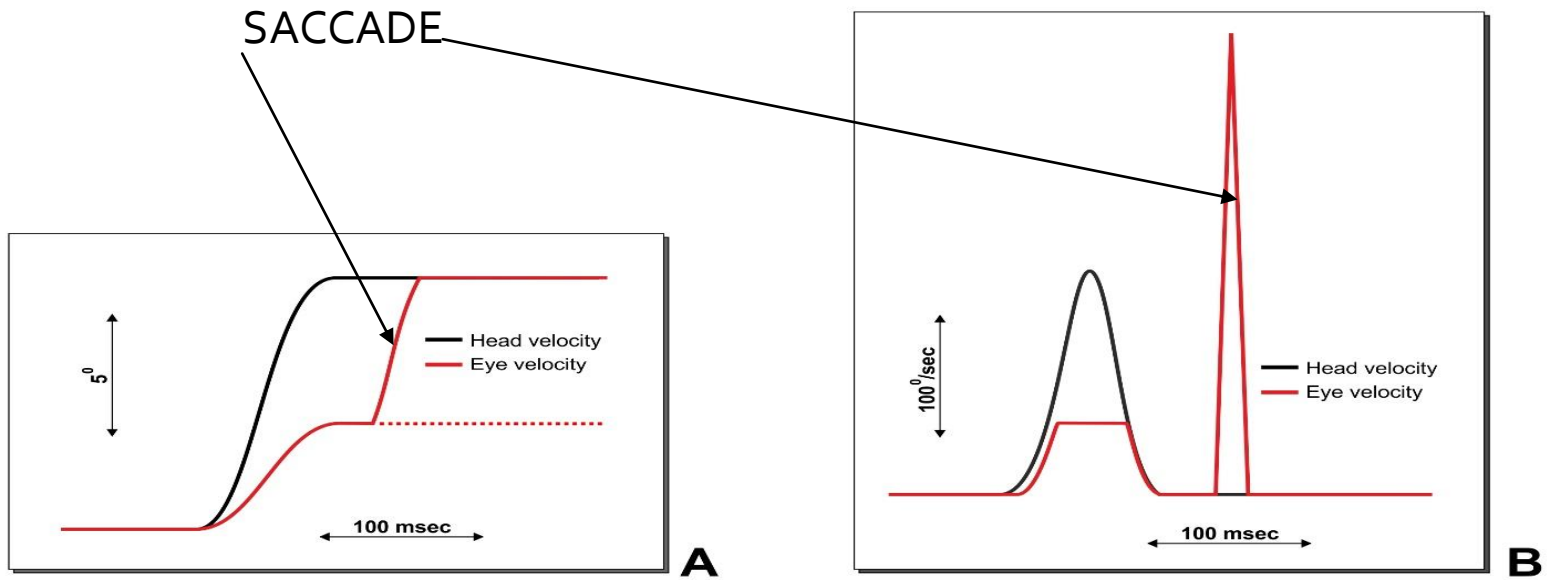
Video Head Impulse Test (VHIT)
– a test of the VOR

Normal & pathological VOR

NORMAL

PATHOLOGICAL

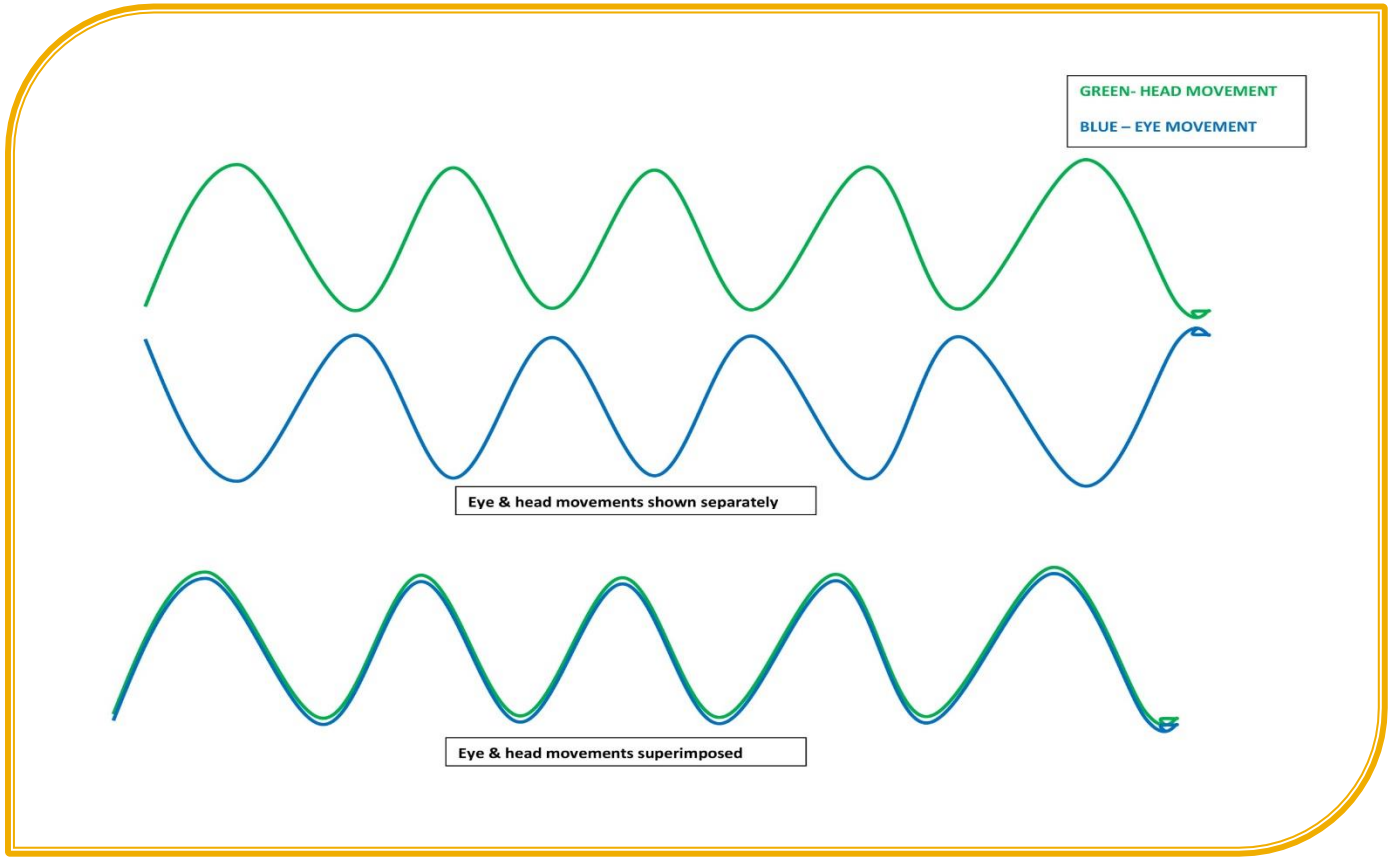
GRAPHICAL DEPICTION OF SACCADE



EYE & HEAD POSITION

EYE & HEAD VELOCITY

VHIT measures the gain of the VOR

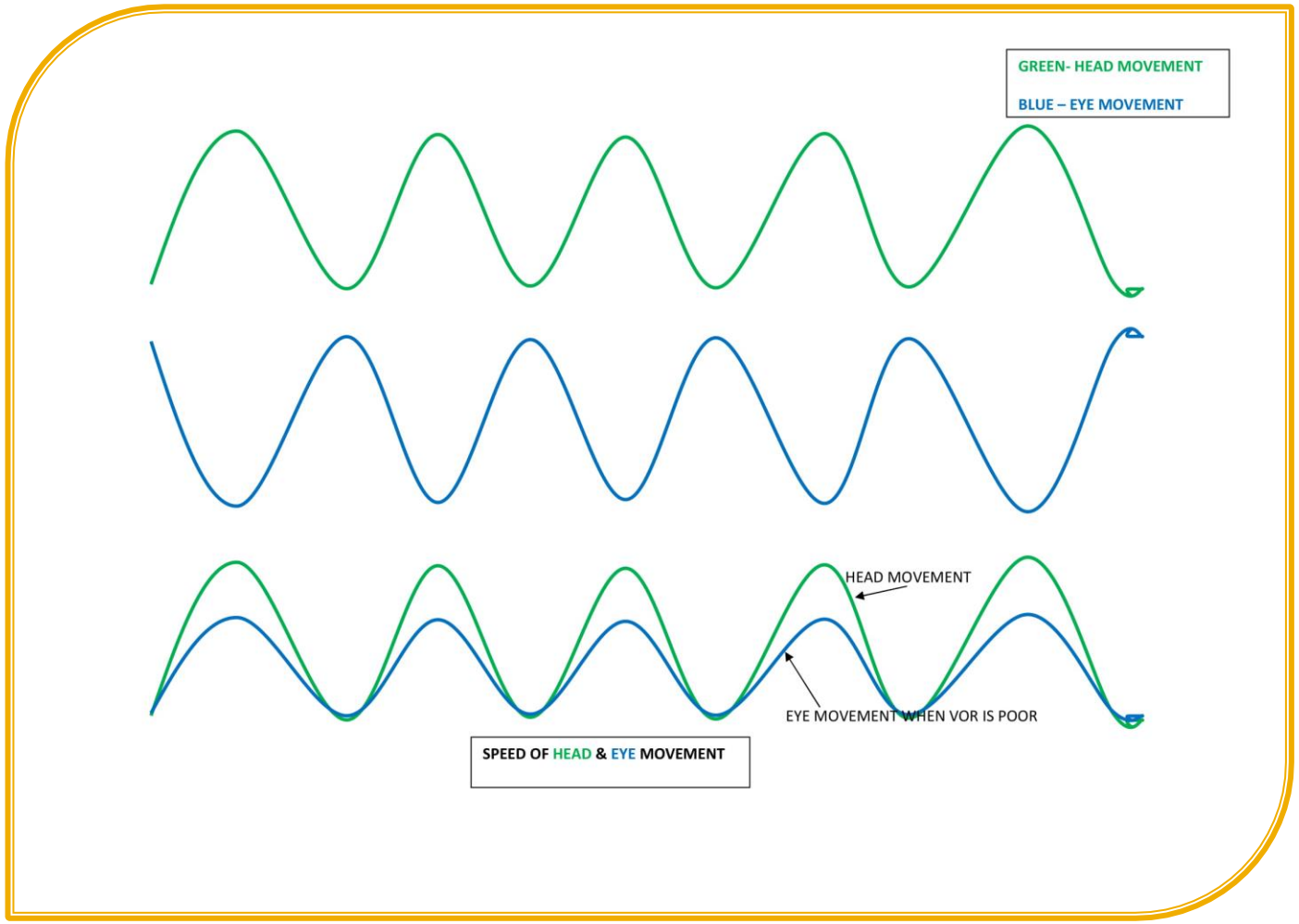


Gain of VOR is =

$$\frac{\text{Velocity of eye movement}}{\text{Velocity of head movement}} \times 100$$

Ideally gain should be 1 as the velocity of eye movement should be equal to the velocity of the head movement; in % it should be 100%

VHIT measures the gain of the VOR



Gain of VOR is =

$$\frac{\text{Velocity of eye movement}}{\text{Velocity of head movement}} \times 100$$

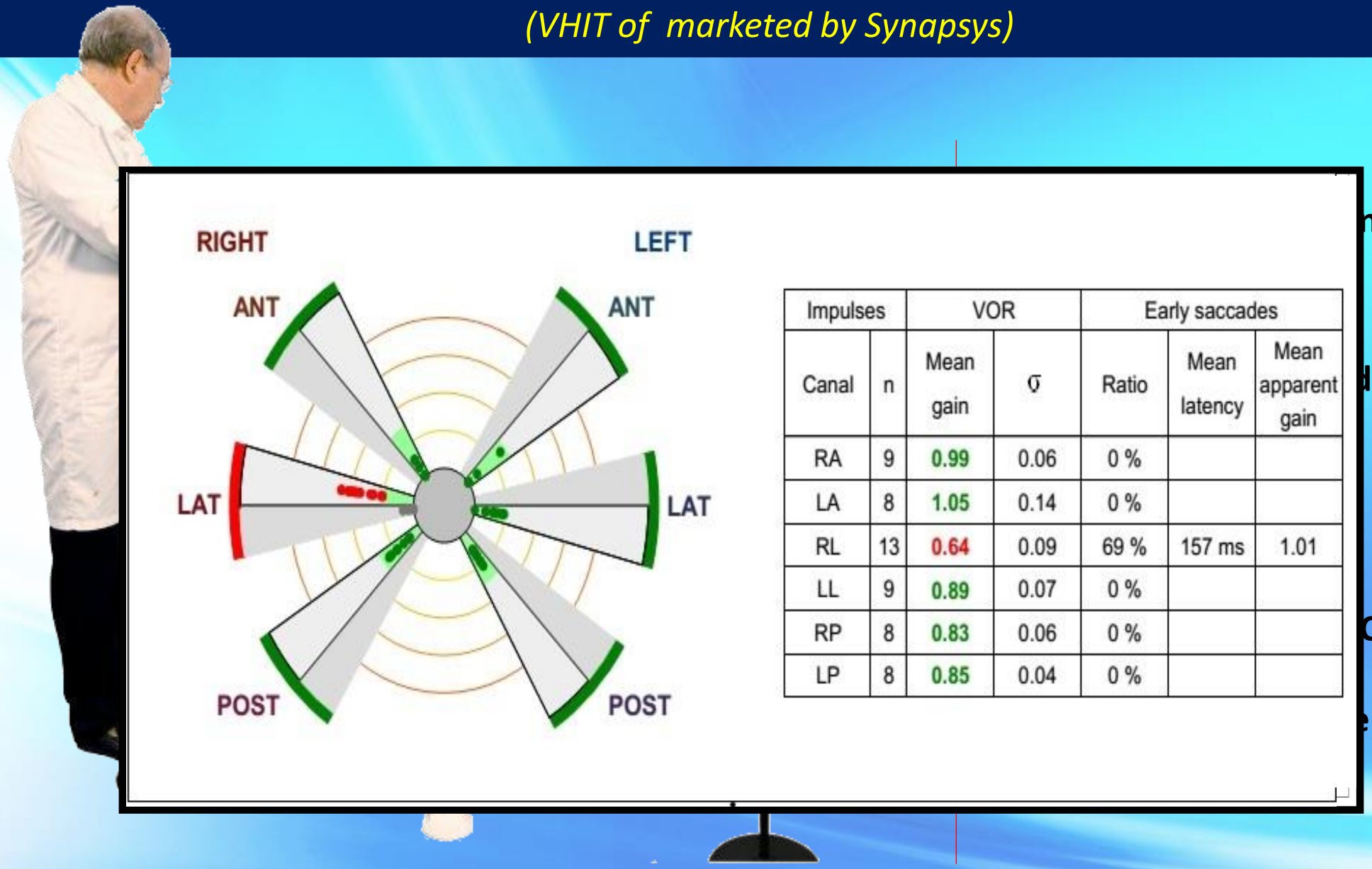
In hypofunction of the semicircular canal, the speed of eye movement is lesser than that of head movement and VOR gain is less than 1

Video Head Impulse Test (VHIT)

- Tests the function of the Vestibulo-Ocular Reflex (VOR) of **all 3 semicircular canals** of both sides; identifies which of the 6 canals has a lesion
- Not inconvenient for the patient; can be repeated many times at close intervals
- Very successful for testing young children
- Can be carried out in 10 minutes even by non –medical persons with a bit of training
- Unlike the caloric test, provides measures of the absolute level of canal function
- Best test to identify bilateral vestibular loss
- Helps in differentiating cerebellar stroke from Vest neuritis in acute vertigo
- Does not test utricle and saccule

Video Head Impulse Test (VHIT)

(VHIT of marketed by Synapsys)



Impulses		VOR		Early saccades		
Canal	n	Mean gain	σ	Ratio	Mean latency	Mean apparent gain
RA	9	0.99	0.06	0 %		
LA	8	1.05	0.14	0 %		
RL	13	0.64	0.09	69 %	157 ms	1.01
LL	9	0.89	0.07	0 %		
RP	8	0.83	0.06	0 %		
LP	8	0.85	0.04	0 %		

nt of the

detect

C USB port

e patient, no

Video Head Impulse Test (VHIT)

(VHIT of Otometrics)

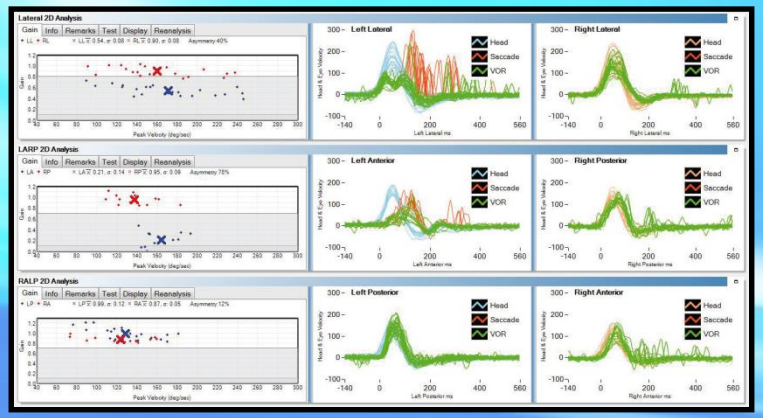
Camera over the patient's eyes unlike Ulmer VHIT

Dedicated software to detect Halmagyi sign

5 minutes protocol

Directly connected to PC USB / fireware port

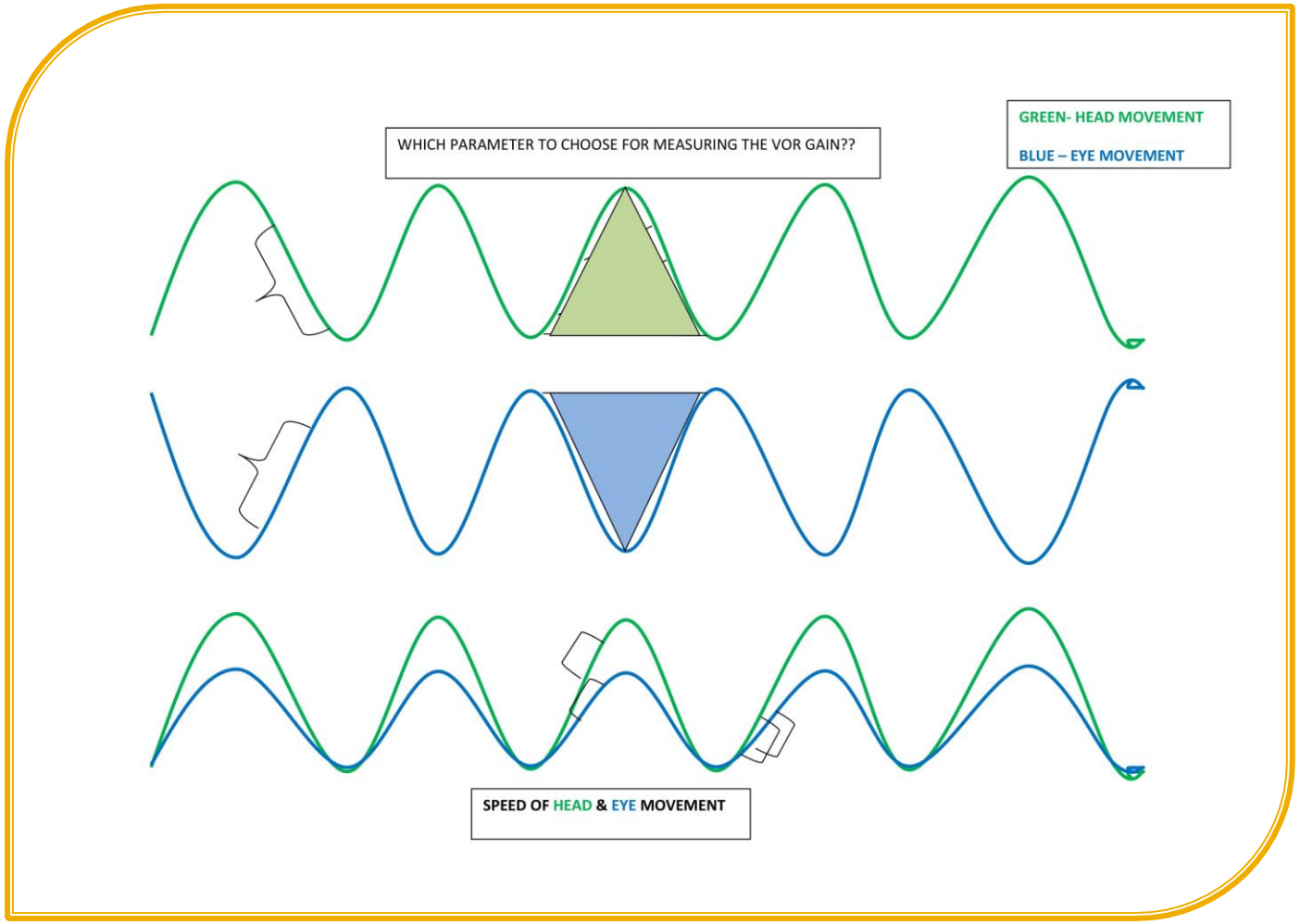
Very comfortable to the patient, no vertigo



Fallacies & limitations of the VHIT

- Slippage of the VHIT goggles (in case the googles type of VHIT is used) induces grossly erroneous results
- Tester must have proper training to perform a low amplitude & high velocity, high acceleration head movements
- Calculation of VOR gain is not standardized;

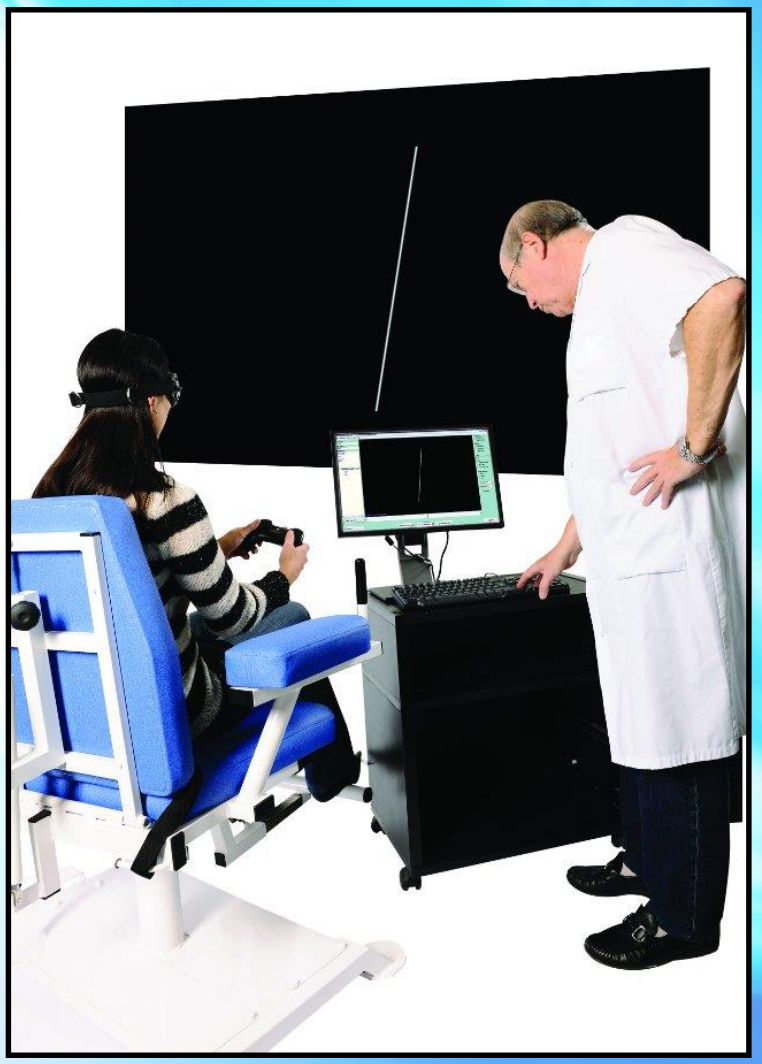
Fallacies in measurement of VOR gain



Anirban Biswas, *neurotologist*

Subjective Visual Vertical (SVV) test

-the set-up and the hardware



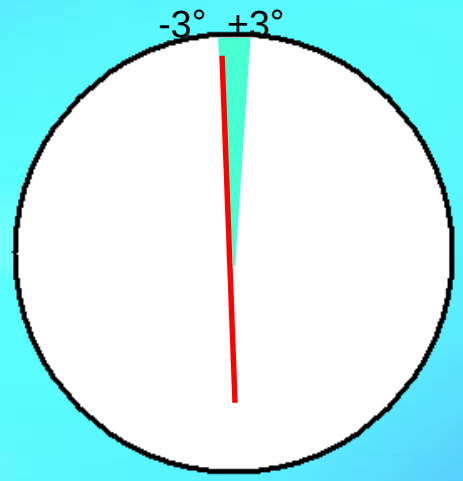
Any horizontal or vertical visual reference has to be completely suppressed

The Subjective Visual Vertical

- Very simple, easy to perform, very fast, very reliable test for evaluation of perception of verticality which is believed to be an otolithic (primarily utricular) function
- Non –invasive test entertaining for the patient and hassle free for the doctor
- Does not cause vertigo / nausea / vomiting
- Can assess acute /uncompensated vestibular lesions
- Dynamic subjective visual vertical test (a part of the SVV package) can identify *compensated* unilateral vestibular lesions

Protocol & Results of the SVV

- **Protocol:** alternate the directions, make at least 8 measurements, and calculate the average of the values at the end of the test



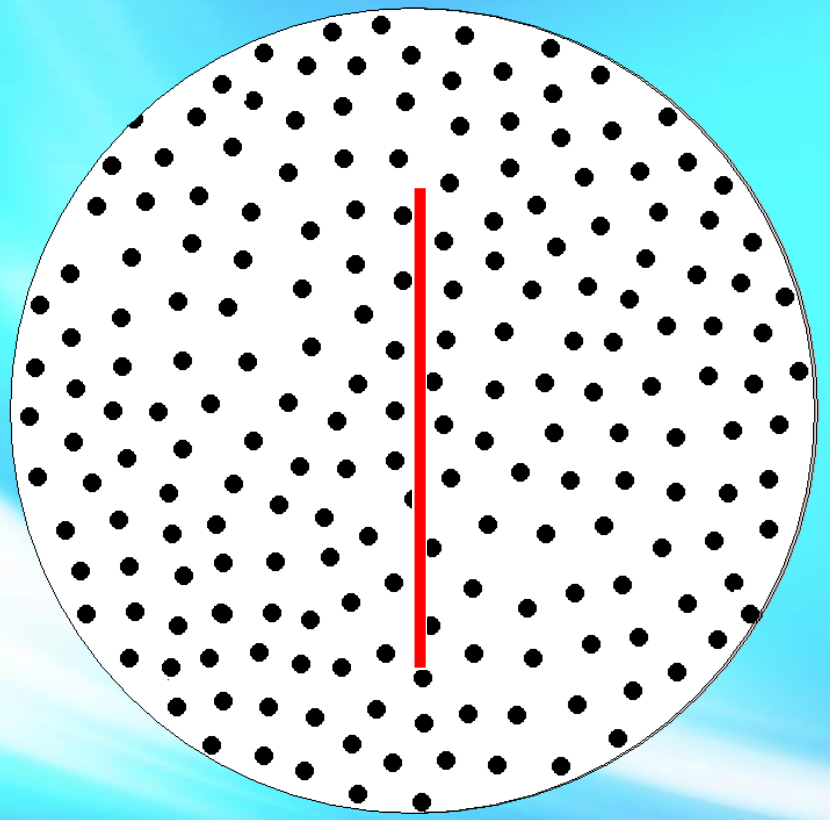
- **Results :**
  - Normal if<2.5°
  - Intense deviation if >10°

- **Interpretation :**
  - Deviates on pathological side in case of acute unilateral vestibular lesions

The SVV measurement is a very important part of vestibulometry , as it is the only test to assess the **perception of verticality** which is an otolithic function

Dynamic Subjective Visual Vertical

Optokinetic stimulation of 40°/sec. (CW and CCW) creates a symmetric deviation of the SVV



If the total deviation (R+L) is more than 10°, it is a sign of uncompensated unilateral vestibulopathy and a sign of visual dependance.

Fallacies of the SVV test

- It tests the PERCEPTION OF THE VISUAL VERTICAL which is believed to be dependent on MULTIPLE sites of the vestibular system not the utricle only
- Though a reliable test in acute unilateral vestibulopathy, findings are unreliable in chronic compensated vestibular lesions
- Test not adequately authenticated by reliable studies, no available practice guidelines
- Visual reference cues have to be completely eliminated and mechanisms to keep head straight are essential for the test to be reliable but rarely followed
- In real life, visual cues are always present, hence the test is ?unrealistic and does not assess balance function, rather the perception of verticality in real life situations

VEMP test

A myogenic response from muscles of the neck or eyes, in response to loud acoustic stimulation.

VEMP is primarily the result of stimulation of otolith organs (the saccule & utricle)

Otolithic sensitivity can be evaluated very simply by the VEMP test

AC- Ocular VEMP

- **Stim-** *AC sound in ear*
- **Response-** *in contralat inferior oblique ms*
- **Type of response-** *excitatory response*
- **Nature of response-** *contraction of inf. oblique muscle of contralateral side*
- **Evaluates-** *ipsilateral* **URTICLE**
- **Also tests -** *ipsi. superior vestibular. nv*

Loud sound stimulates utricle → vestibular labyrinth activated → vestibulo-ocular reflex stimulated → contraction of eye muscles

AC- Ocular VEMP

AC- Cervical VEMP

- **Stim -** *AC sound in ear*
- **Response -** *in ipsilat SCM muscle*
- **Nature of response-** *cessation of contraction of a tonically contracted ipsilateral SCM muscle of same side*
- **Evaluates -** *ipsilateral* **SACCULE**
- **Also tests -** *ipsi. inferior vestibular. nv*

Loud sound stimulates saccule ⟶ vestibular labyrinth activated ⟶ vestibulo-collic reflex stimulated ⟶ response in ipsi SCM muscles

AC- Cervical VEMP

Fallacies and limitations of VEMP tests

- cVEMP is only valid if it is a rectified VEMP i.e., the pre-stimulation contraction of the SCM are identical on both sides
- Asymmetrical placement of electrodes on SCM / IO muscle invalidates the test and presents erroneous results
- Asymmetric air-bone gap between the 2 ears or conductive deafness produces wrong results
- Opined by experts as a unreliable test of otolith function *('Class U evidence of otolith function'*)

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SPECIAL ARTICLE

Practice guideline: Cervical and ocular vestibular evoked myogenic potential testing

Report of the Guideline Development, Dissemination, and Implementation Subcommittee of the American Academy of Neurology

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ABSTRACT

Objective: To systematically review the evidence and make recommendations with regard to diagnostic utility of cervical and ocular vestibular evoked myogenic potentials (cVEMP and oVEMP, respectively). Four questions were asked: Does cVEMP accurately identify superior canal dehiscence syndrome (SCDS)? Does oVEMP accurately identify SCDS? For suspected vestibular symptoms, does cVEMP/oVEMP accurately identify vestibular dysfunction related to the saccule/utricle? For vestibular symptoms, does cVEMP/oVEMP accurately and substantively aid diagnosis of any specific vestibular disorder besides SCDS?

Methods: The guideline panel identified and classified relevant published studies (January 1980–December 2016) according to the 2004 American Academy of Neurology process.

Results and Recommendations: Level C positive: Clinicians may use cVEMP stimulus threshold values to distinguish SCDS from controls (2 Class III studies) (sensitivity 86%–91%, specificity 90%–96%). Corrected cVEMP amplitude may be used to distinguish SCDS from controls (2 Class III studies) (sensitivity 100%, specificity 93%). Clinicians may use oVEMP amplitude to distinguish SCDS from normal controls (3 Class III studies) (sensitivity 77%–100%, specificity [illegible] oVEMP threshold may be used to aid in distinguishing SCDS from controls (3 Class III studies) (sensitivity 70%–100%, specificity 77%–100%). Level U: Evidence is insufficient to determine whether cVEMP and oVEMP can accurately identify vestibular function specifically related to the saccule/utricle, or whether cVEMP or oVEMP is useful in diagnosing vestibular neuritis or Ménière disease. Level C negative: It has not been demonstrated that cVEMP substantively aids in diagnosing benign paroxysmal positional vertigo, or that cVEMP or oVEMP aids

Dynamic Visual Acuity (DVA) test

The clinical / bedside DVA test:-

- The Visual Acuity (V… head fi…
- …
- …of VA by more than 2 lines in Snellen's chart indicates **poor VOR**
  - *hence diagnostic of **peripheral vestibular lesion***

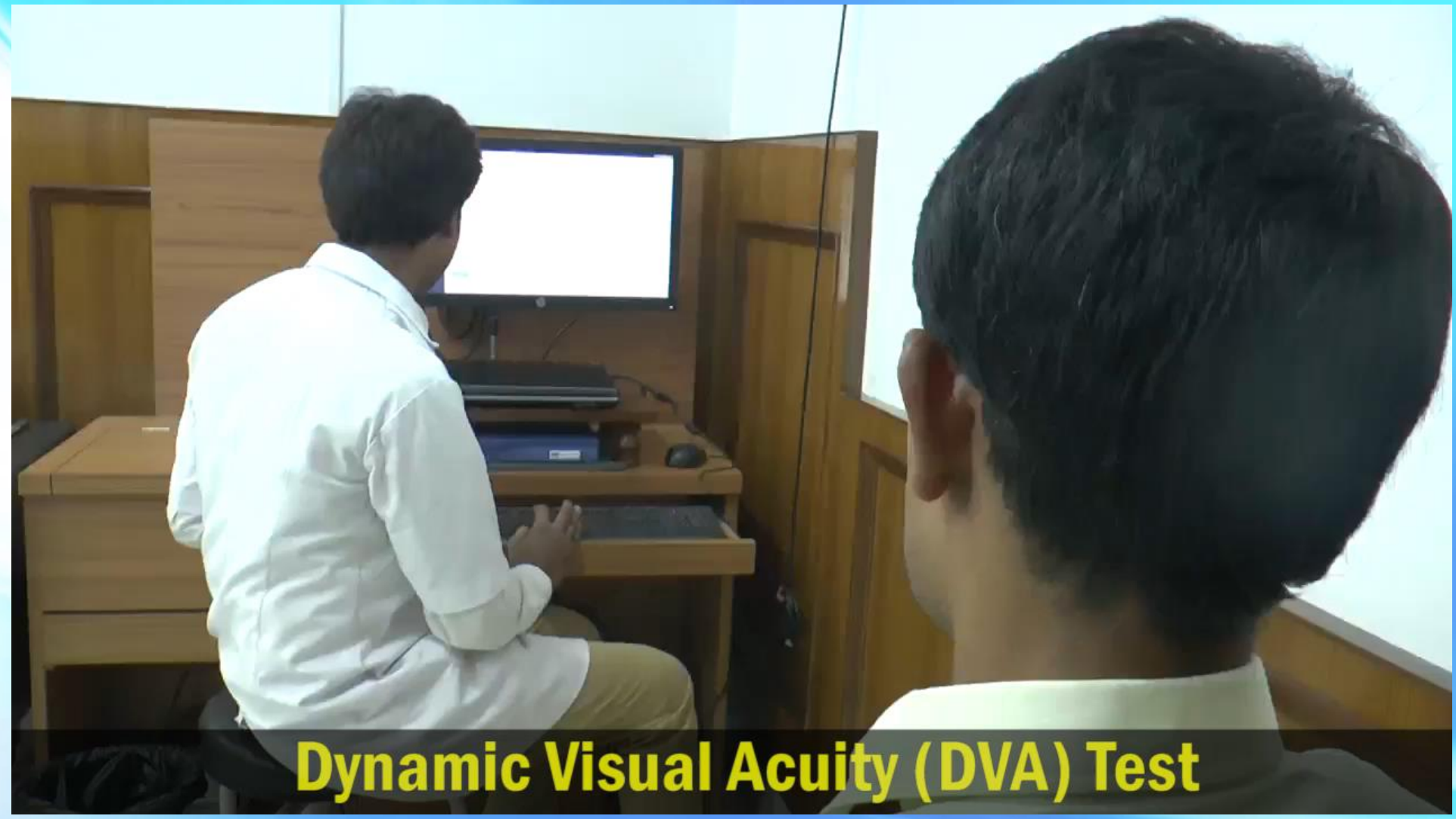
But this clinical test has many flaws as there was no monitoring of the plane of head movement and the velocity of the head movement which needs to be above 100⁰/sec for VOR to be evaluated; hence was replaced by mechanised computerised DVA

SNELLEN's CHART

Mechanised / Computerised DVA

- A **rate sensor (3 axis gyroscope)** that can monitor the speed as well as the plane of the head movement.
- This ensures 95% specificity and sensitivity for VOR deficits
- Very easy, quick and reliable non vertigenic test

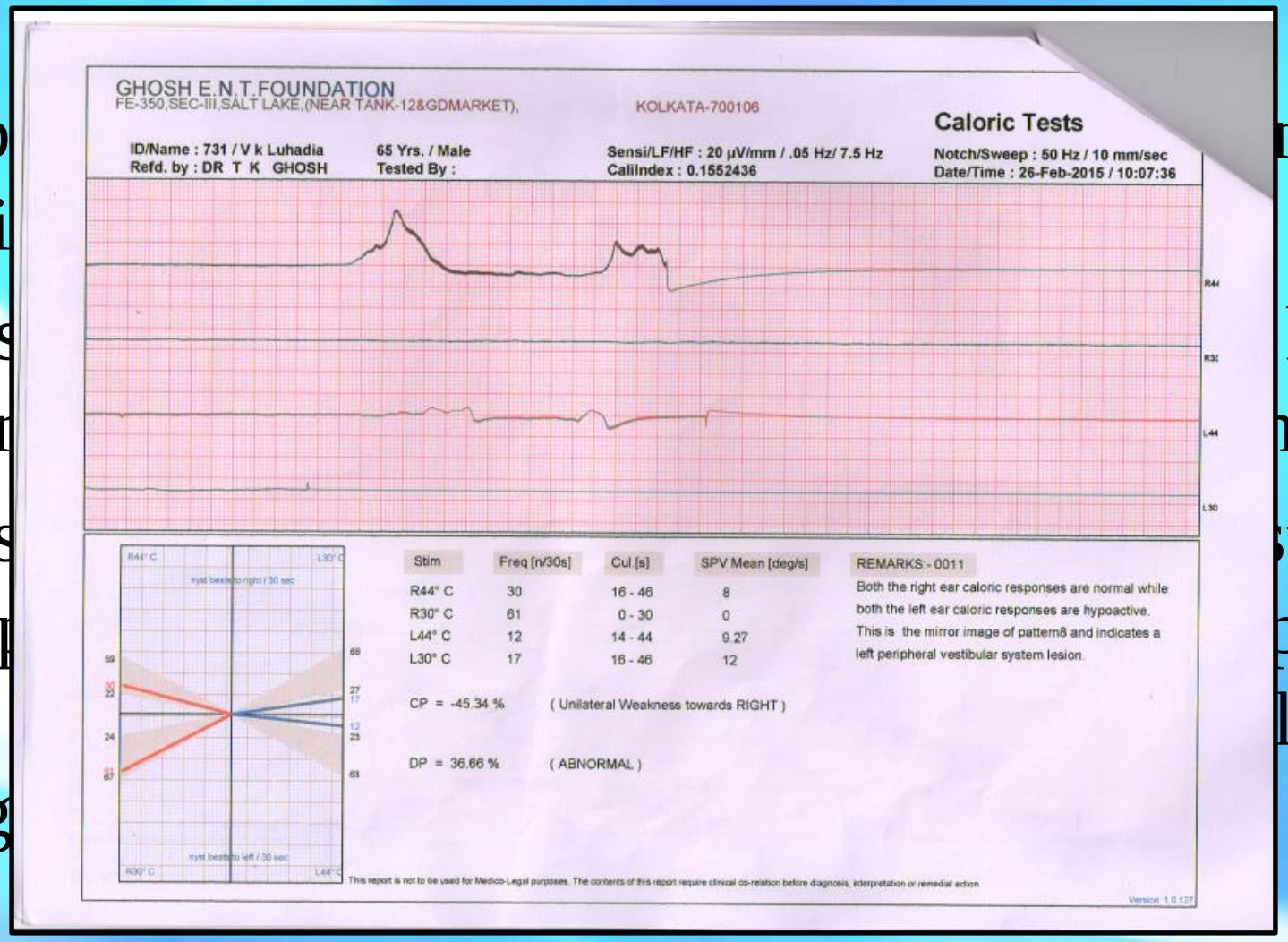
Mechanised / Computerised DVA



STABILOMETRY -test of static posturography

However

- All vestib … n behind the machi
- Most tests … has made vestibulor … ns today
- Clinicians … st until it has been p … person with sufficient … lar physiolog

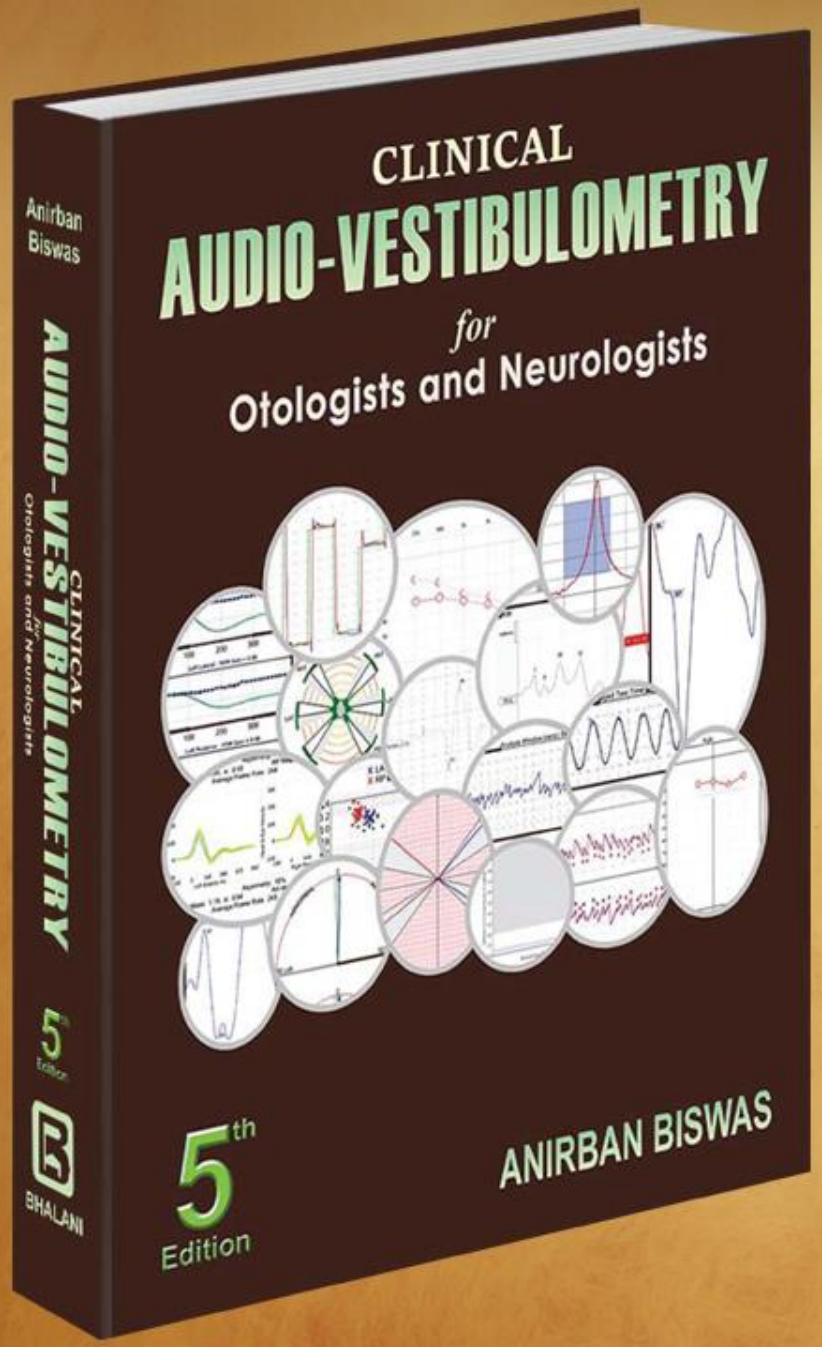


What is the use of these **VESTIBULAR FUNCTION TESTS??**

- The tests only help to partly confirm a clinical suspicion of the functional status of the different balance sensors; that too only if the tests are properly done
- The disease diagnosis is done primarily from the detailed history & clinical tests supplemented by information obtained from the vestibular investigations
- The organ that is defective can be identified by vestibulometry which helps in organ targeted vestibular physiotherapy, not so much in determining the nature of the pathology on which treatment will be based

Take home message

- In vestibulometry, a test battery approach is mandatory.
- Tests are not a replacement of the clinical history and clinical tests
- Only tests carried out or at least supervised by a trained clinician with sufficient knowledge on the functioning of the balance system in health & disease should be accepted.
- Vestibulometry of today can diagnose the site and nature of a lesion with utmost precision and accuracy *provided it is done by the right person*
- Interpretation of vestibulometric tests are to be done in accordance to the clinical history and findings & only by a clinician specialised in balance disorders not by a glorified switch presser.


CLINICAL
AUDIO-VESTIBULOMETRY
for
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Thank You