Balance disorders

AR Currie

Tangmere Balance Disorders Clinic

and Waikato Hospital

Hamilton

New Zealand

Geospatial equilibrium = good balance

integration of multiple sensory systems

- **vestibular apparatus**
  - **central**
  - **peripheral**
- **vision**
- **somatosensory**
  - **joint proprioreception**
  - **touch/pressure sensation**
  - **muscle proprioreception esp cervical**

the three legs of a tripod

Geospatial equilibrium

depends on:

- motor function and joints

- cardiac rhythm and output

- cerebral perfusion

- intact neural circuitry

Dysequilibrium/balance disturbance

impaired central integratory function

faulty peripheral sensors

impaired motor function

Impaired balance function - assessment

understand the sensors

- **normal physiology**
- **neural connections**
- **nystagmus**
- **pathology**

listen to the history

a few basic tests

diagnostic grouping

The peripheral vestibular apparatus

accelerometers

- **linear** - **maculae of saccule and utricle**
  - **vertical (gravity included)**
  - **horizontal AP**
  - **horizontal lateral**
- **angular** - **semicircular canals**
  - **pitch**
  - **roll**
  - **yaw**

The hair cell - physical-neural transducer

- **cochlea**
- **semicircular canals**
- **maculae**

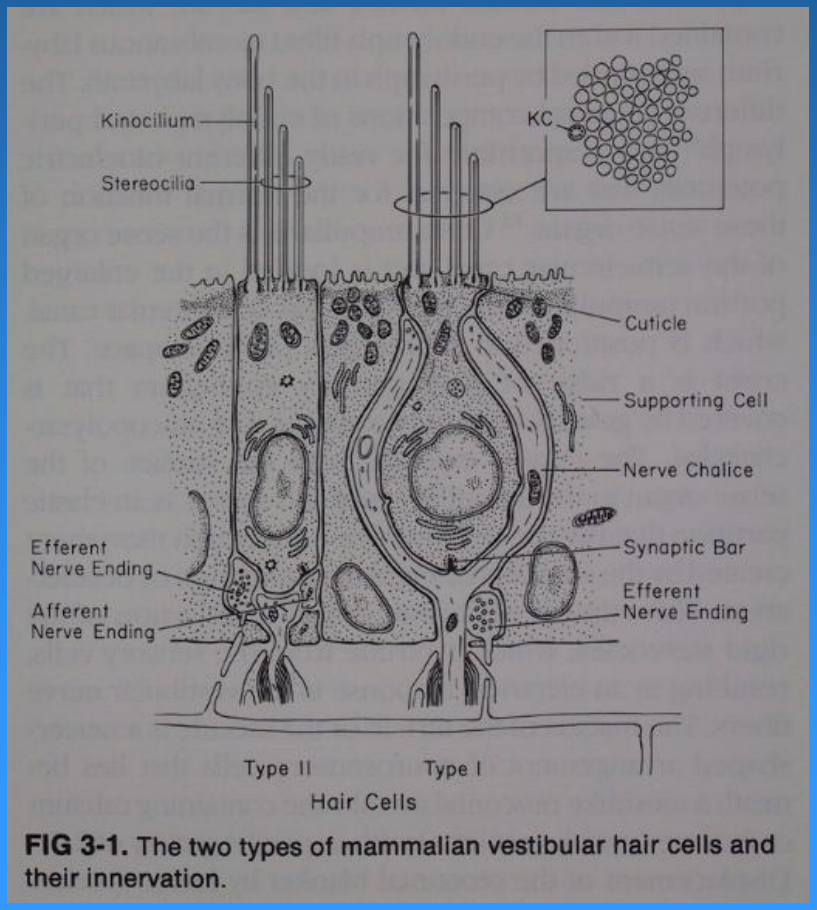
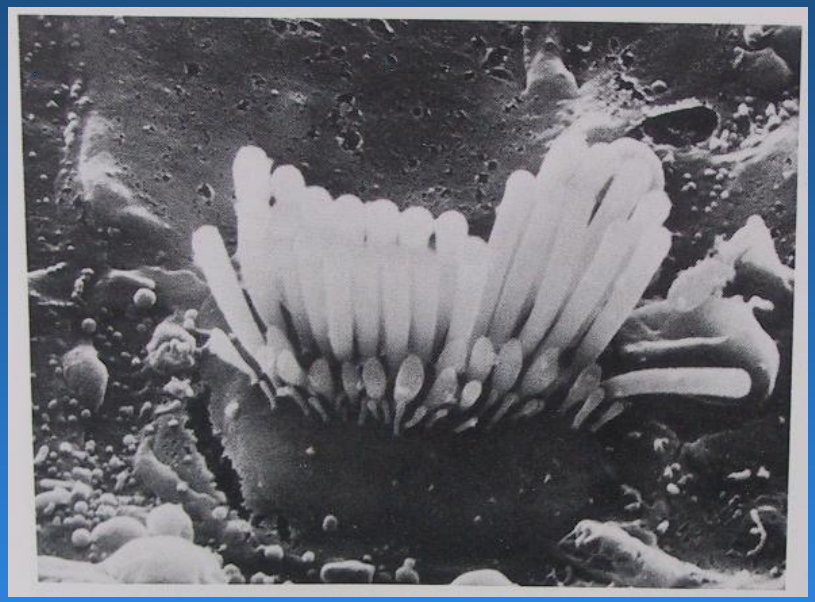
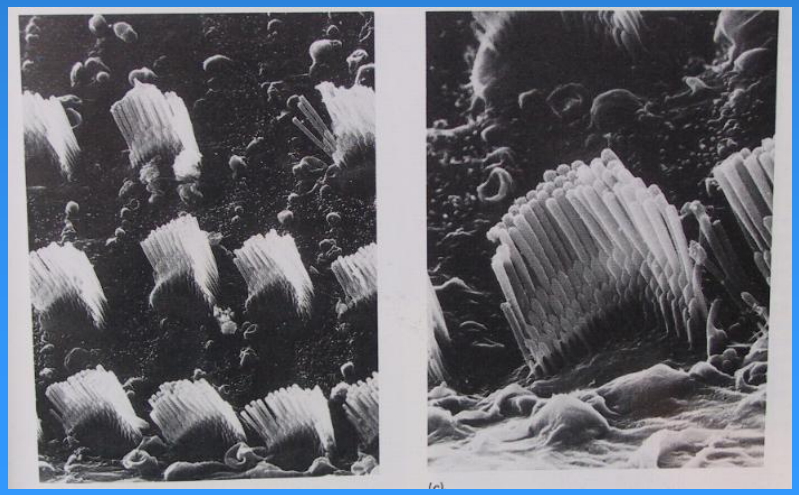
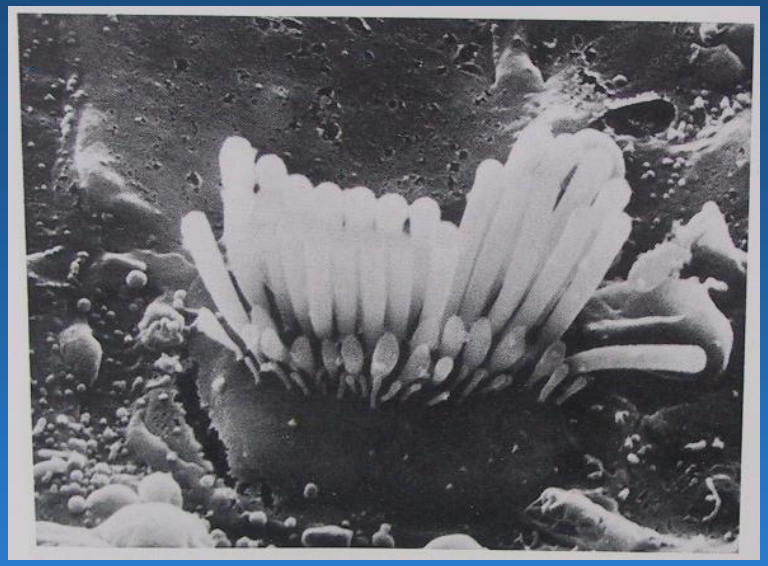


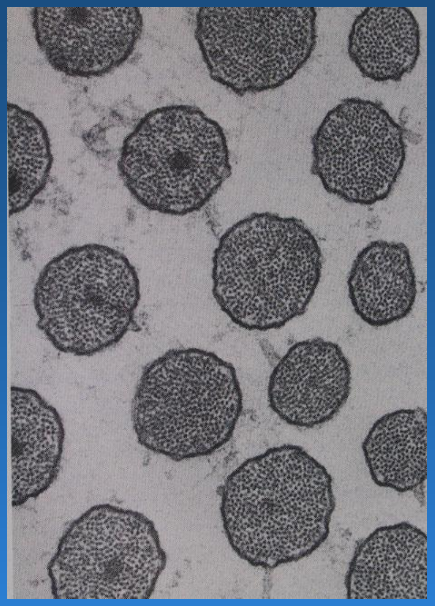
FIG 3-1. The two types of mammalian vestibular hair cells and their innervation.

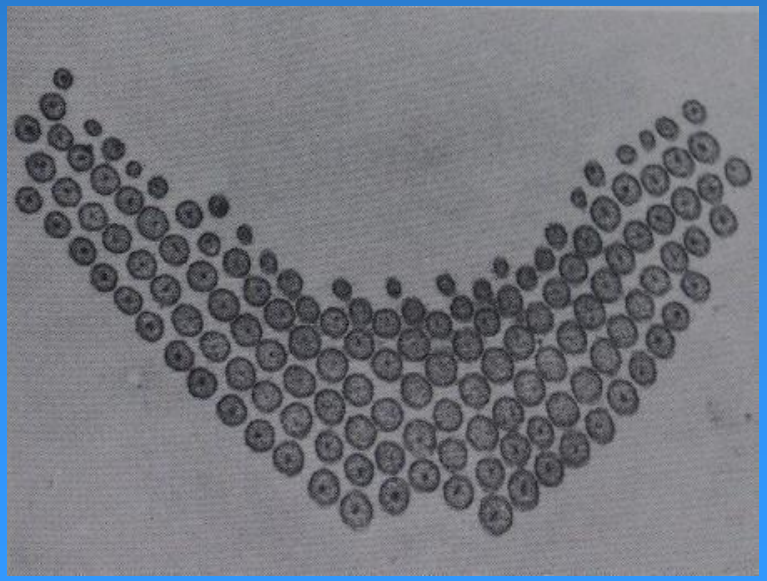


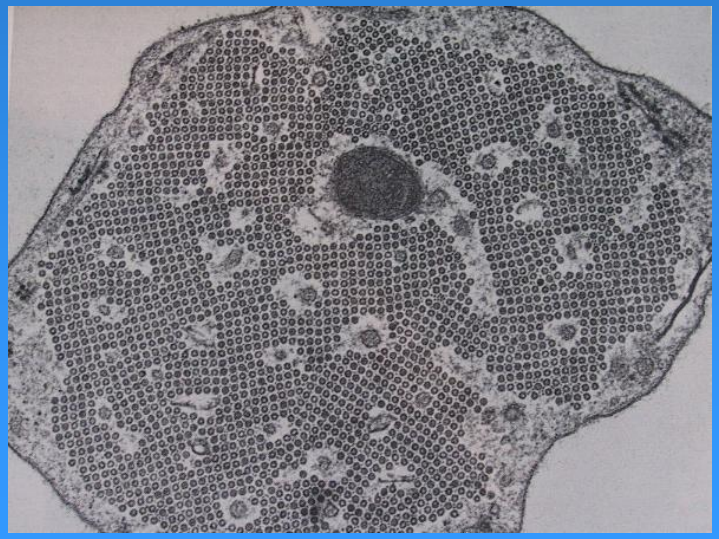


Hair cells

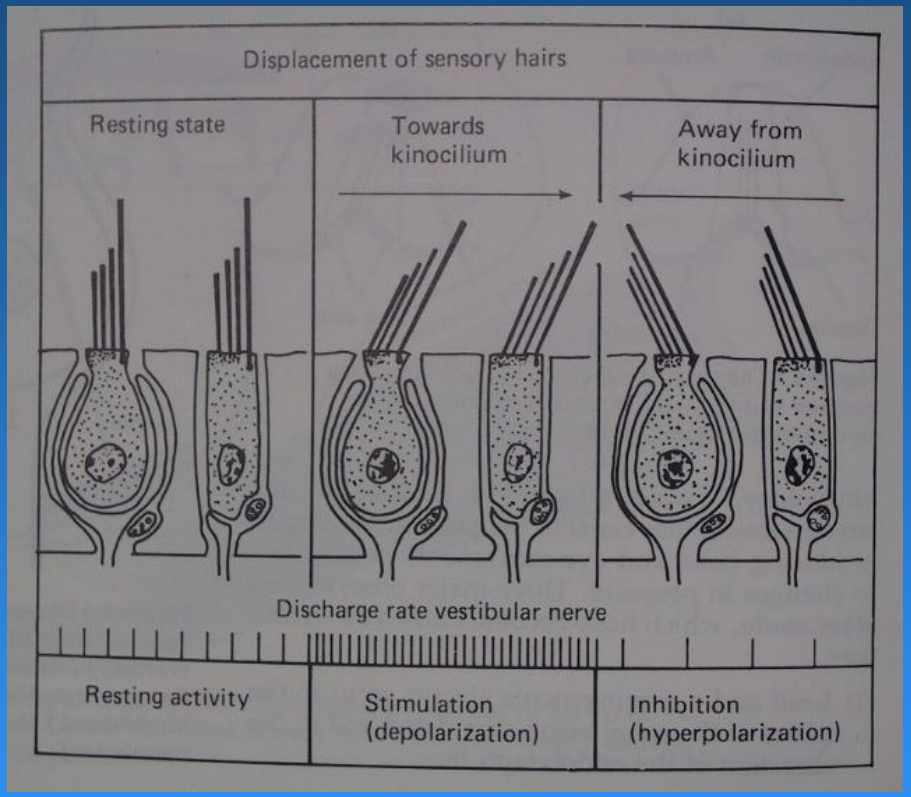


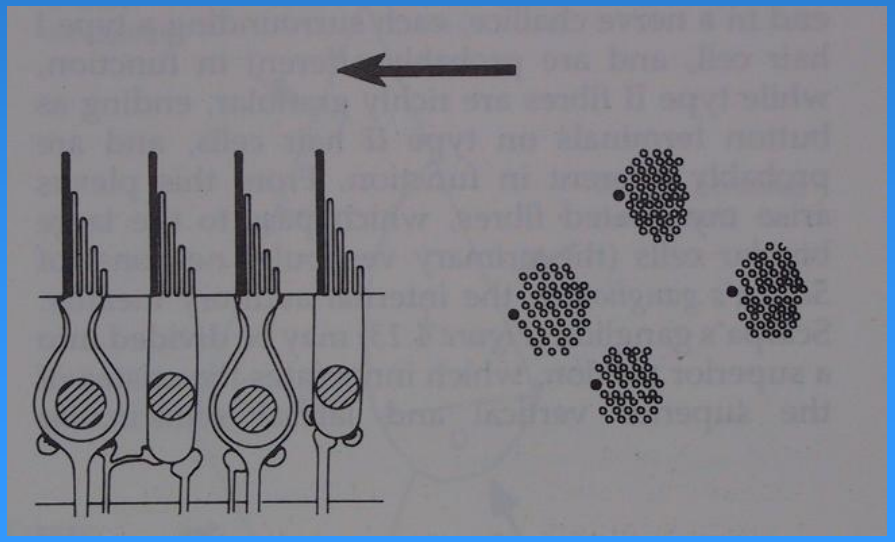




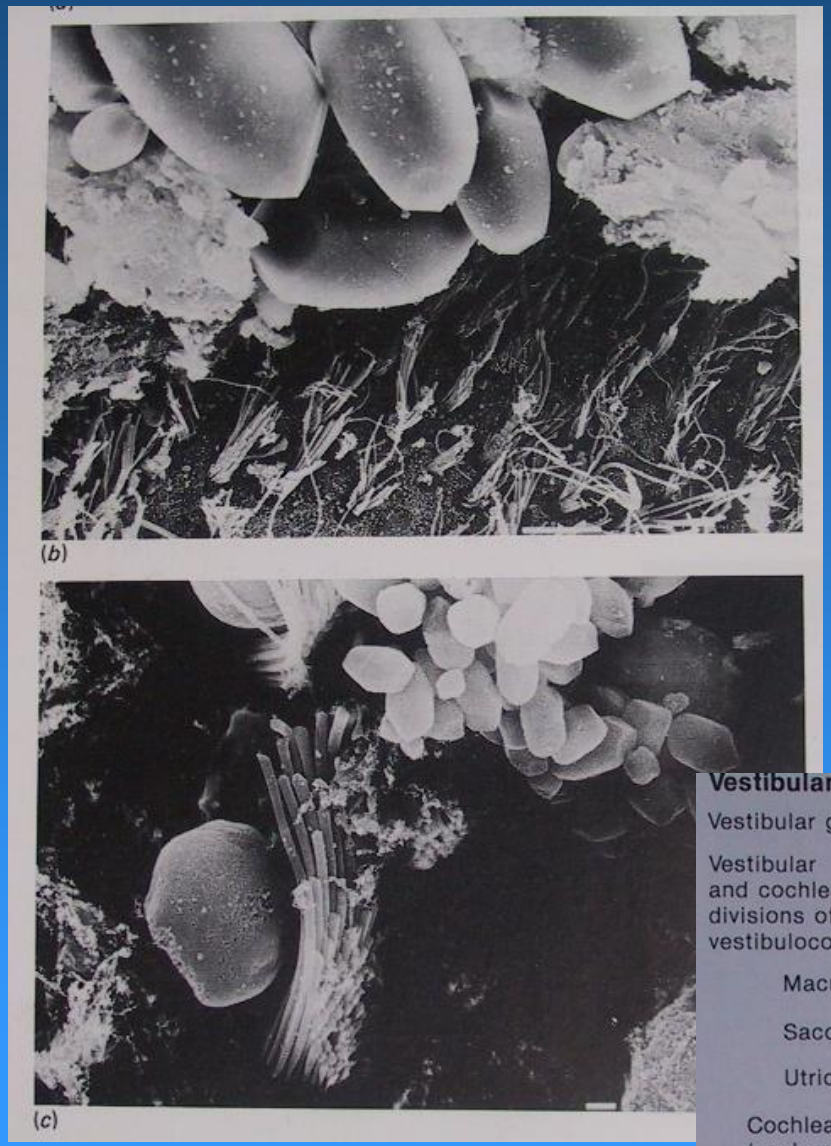


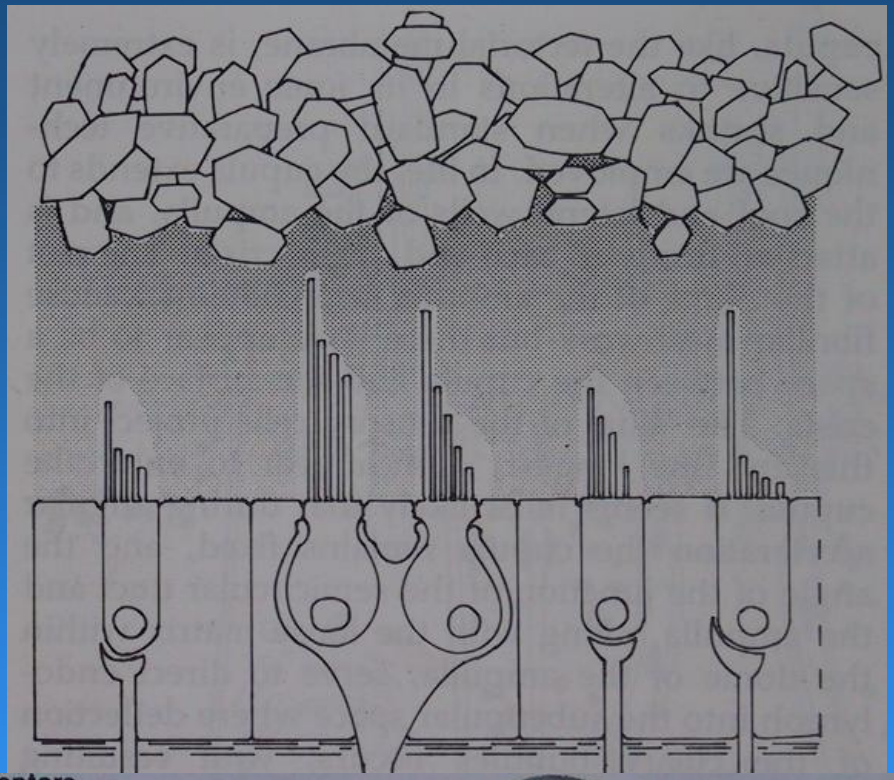
Hair cell polarisation

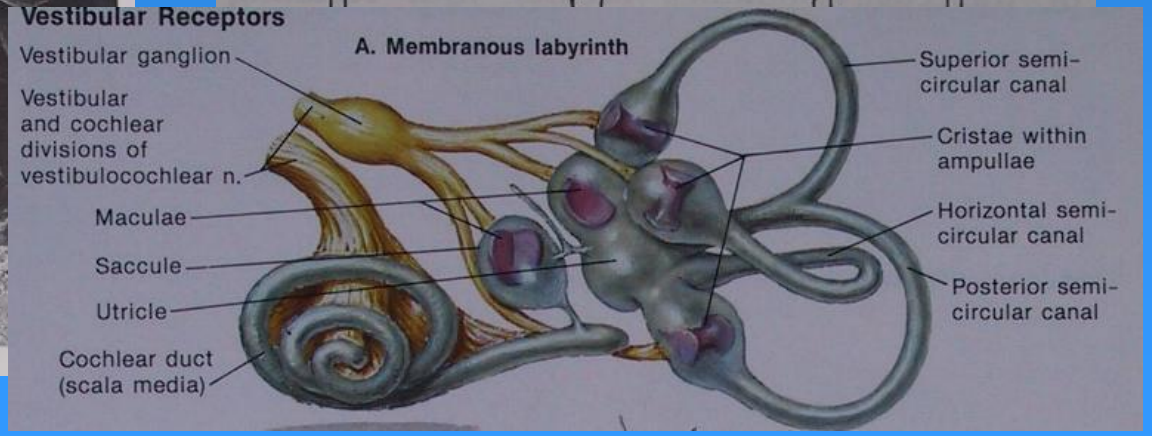




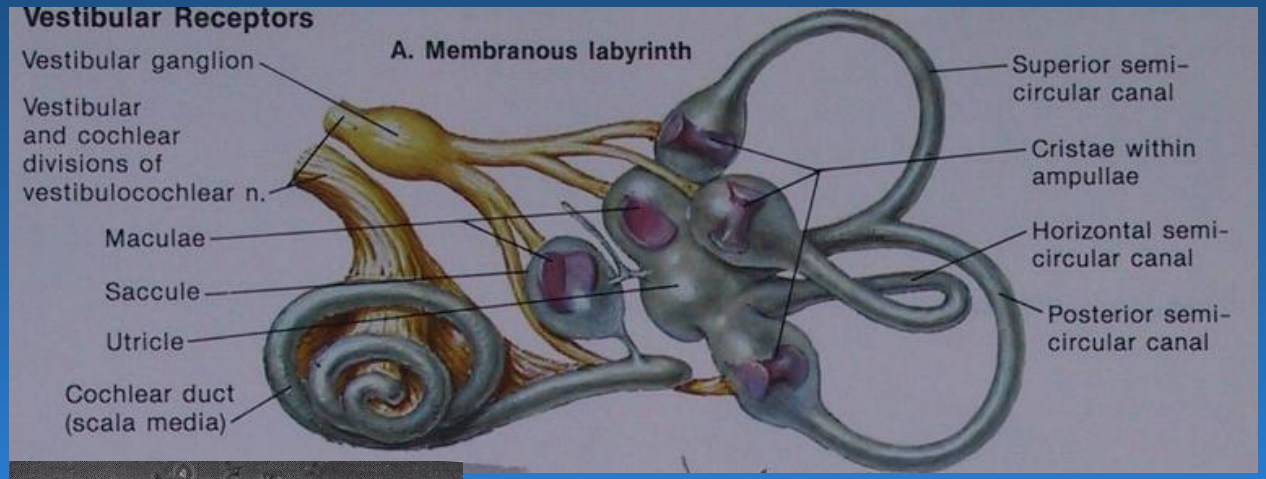
Maculae of saccule and utricle

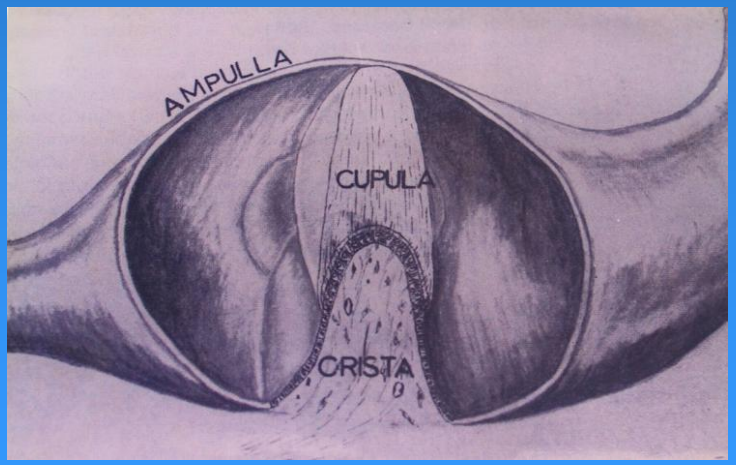


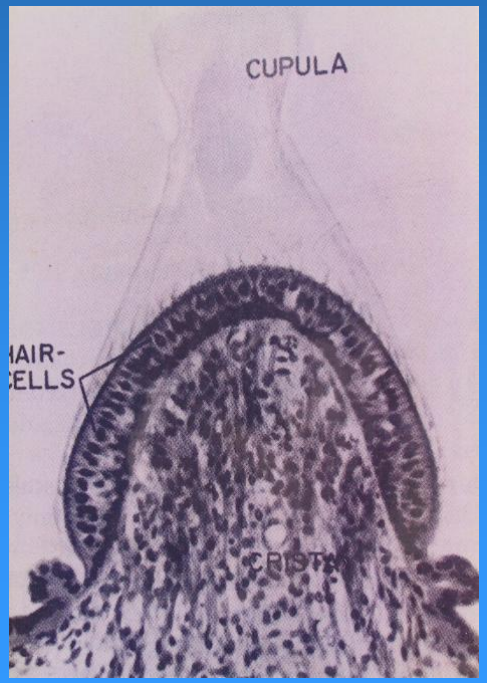




Semicircular canals







Ampulla and crista

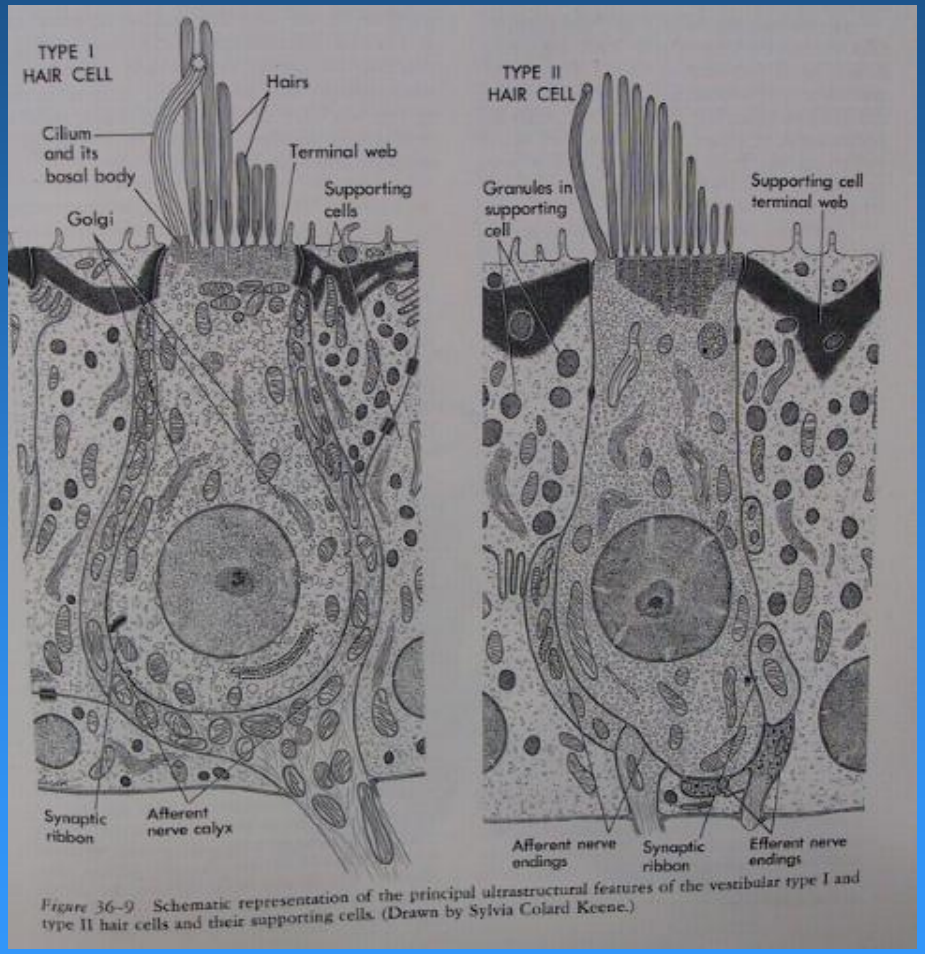
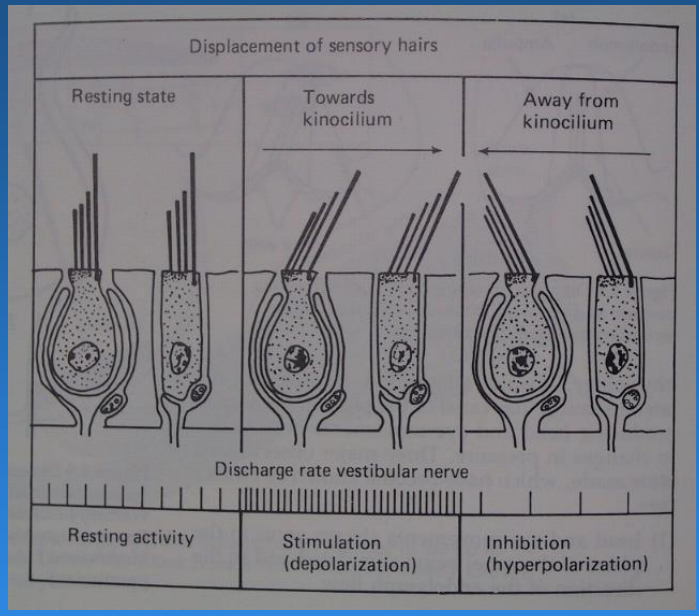
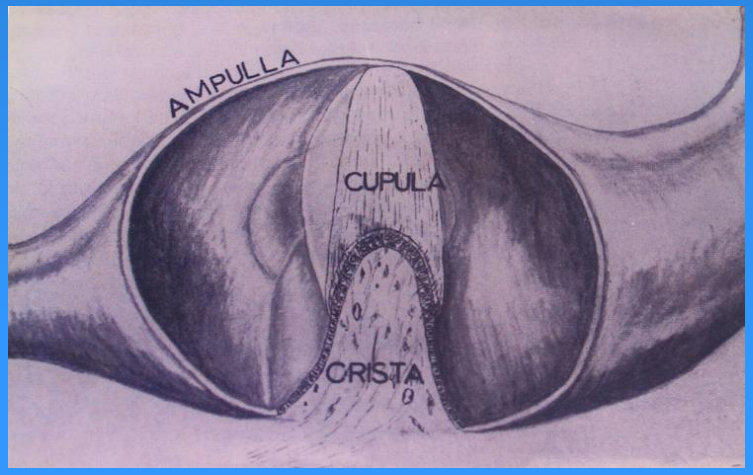
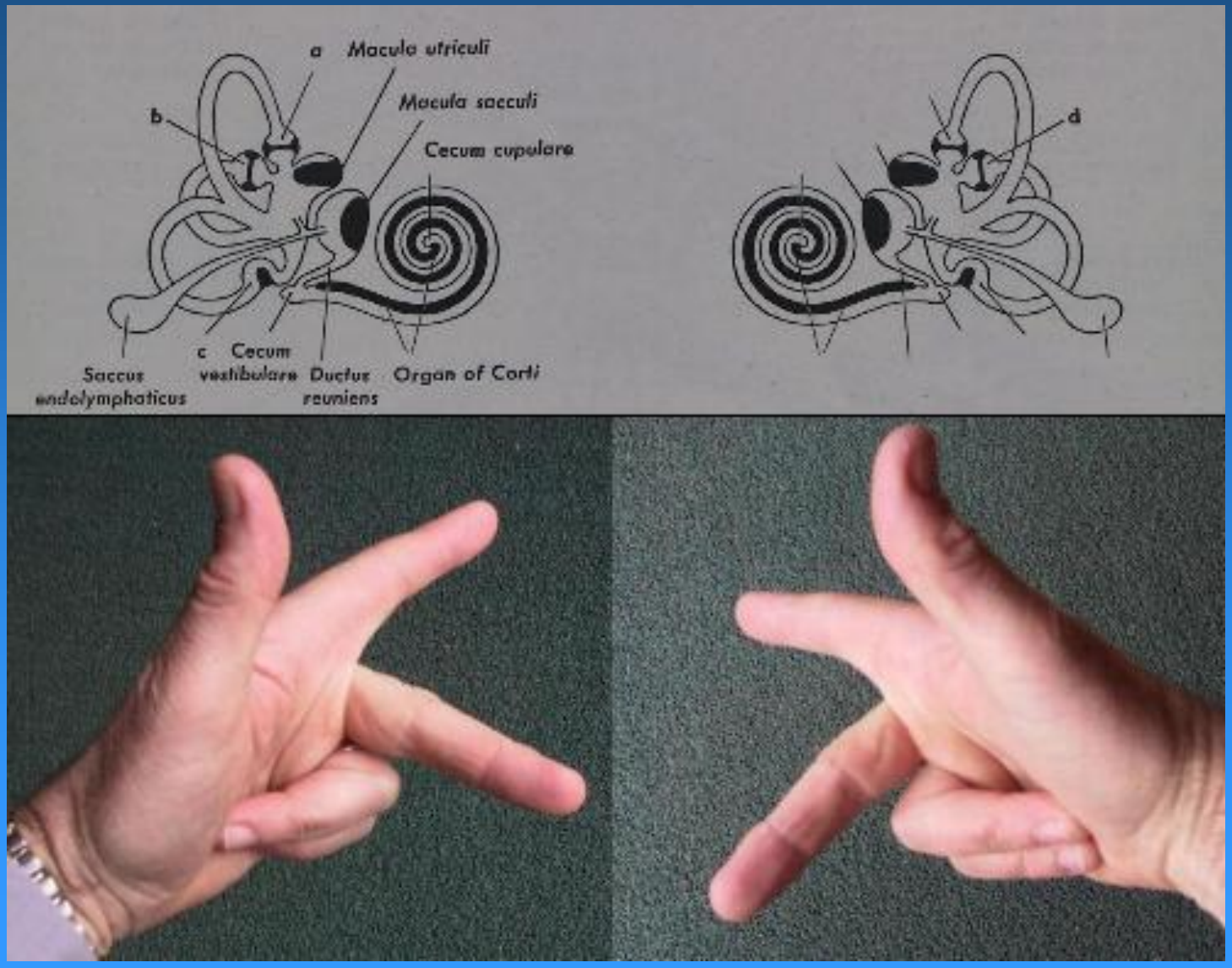


Figure 36–9 Schematic representation of the principal ultrastructural features of the vestibular type I and type II hair cells and their supporting cells. (Drawn by Sylvia Colard Keene.)





Angular accelerometers in three planes

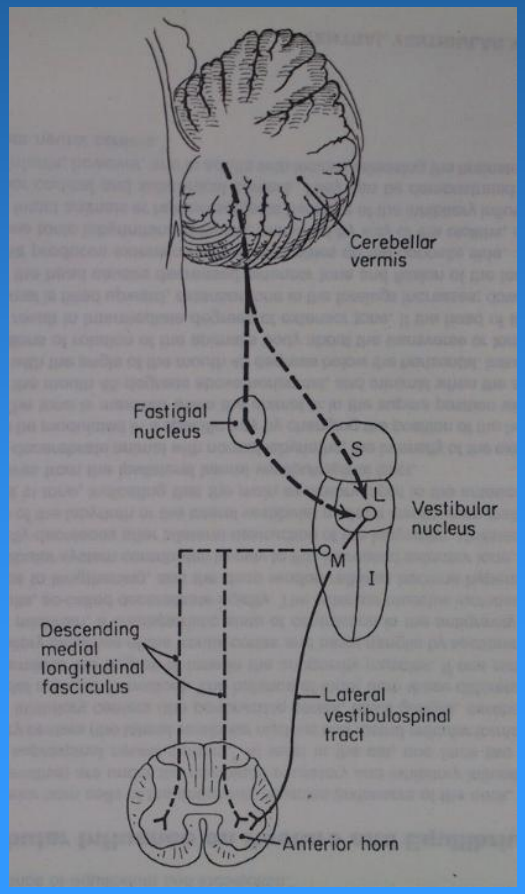


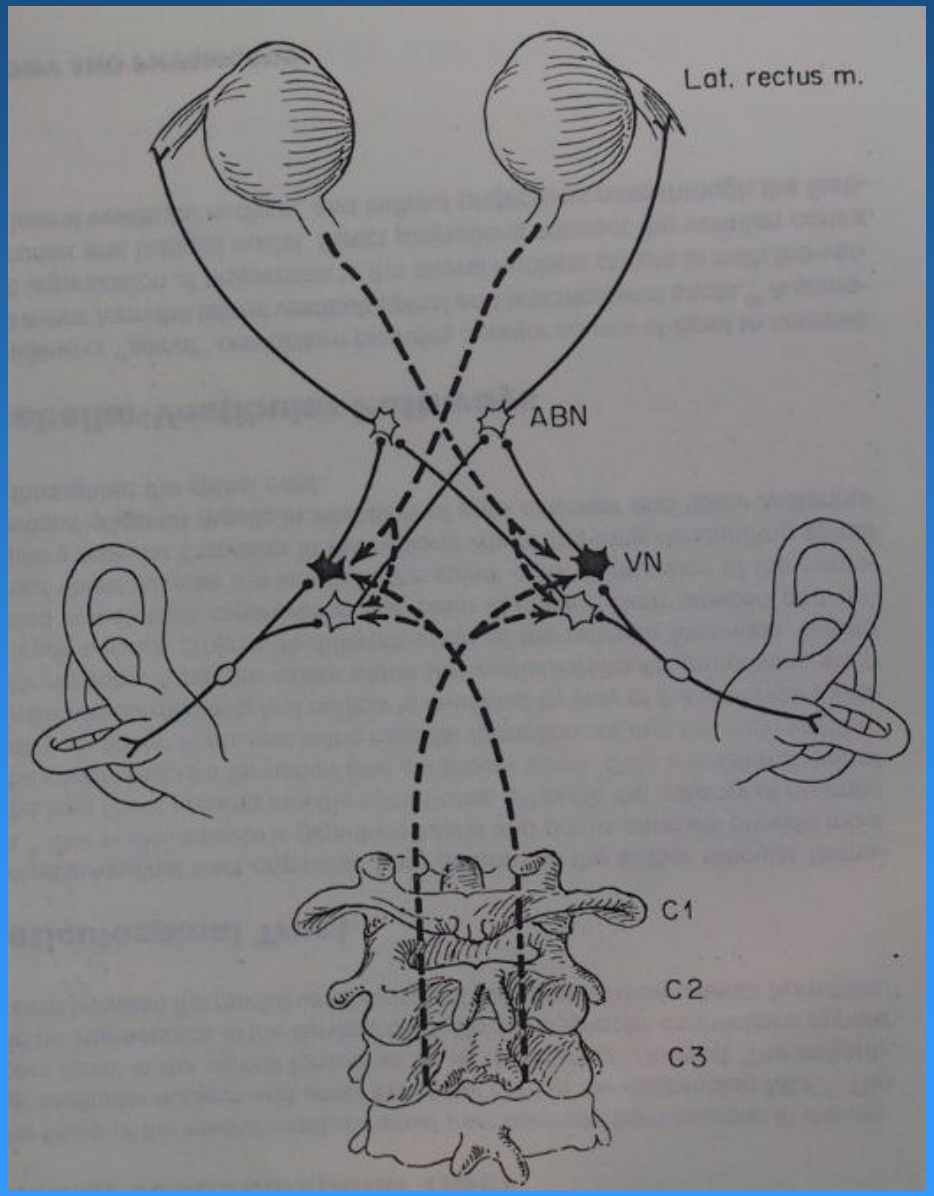
Vestibulo-spinal connections

postural muscles

especially cervical muscles

tight cerebellar modulation





Vestibulo-spinal connections

allows for vestibular control of posture and balance

tight inhibitory modulation by cerebellum

vestibular abnormality -> posture/gait abnormaility

postural abnormality -> vestibular symptoms
- especially in relation to the cervical spine

Vestibulo-cerebellar connections

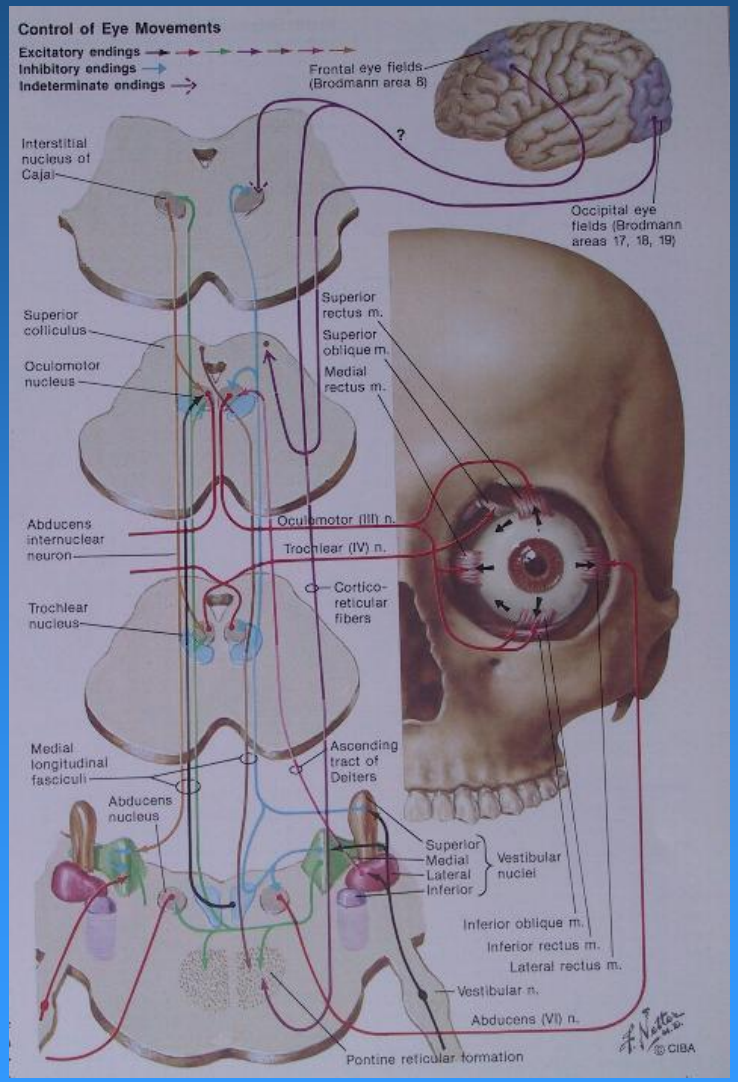
vestibular abnormality -> “cerebellar clamp phenomenon”

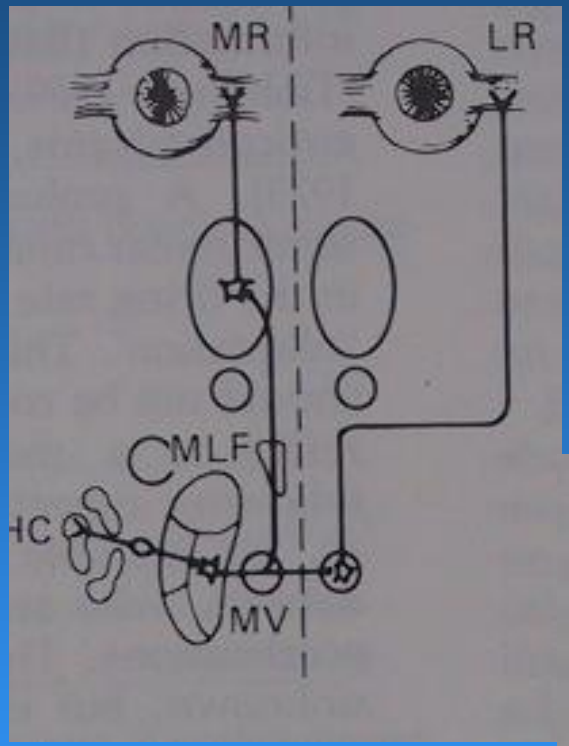
-> suppression of abnormal vestibular output

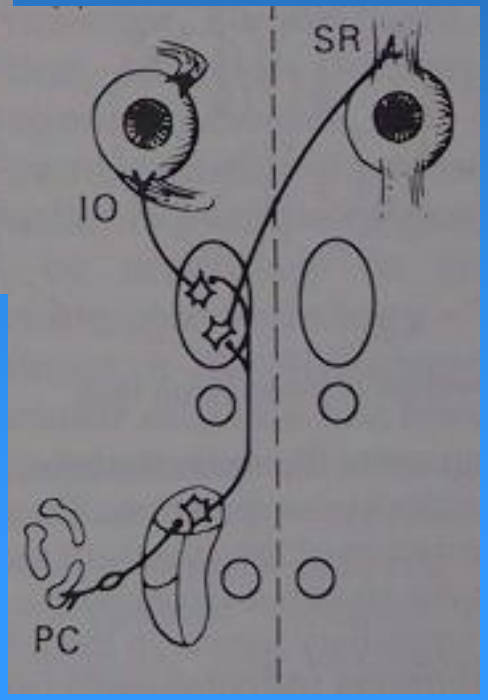
-> restoration of vestibular neuronal balance

-> symptomatic improvement within hours

Vestibulo-ocular connections







Nystagmus

a window in to the inner ear

detection (torsional nystagmus excepted!) requires

- the absence of visual fixation:

- Frenzel lenses - cheap

- videonystagmography - expensive

- electronystagmography - cumbersome

Nystagmus

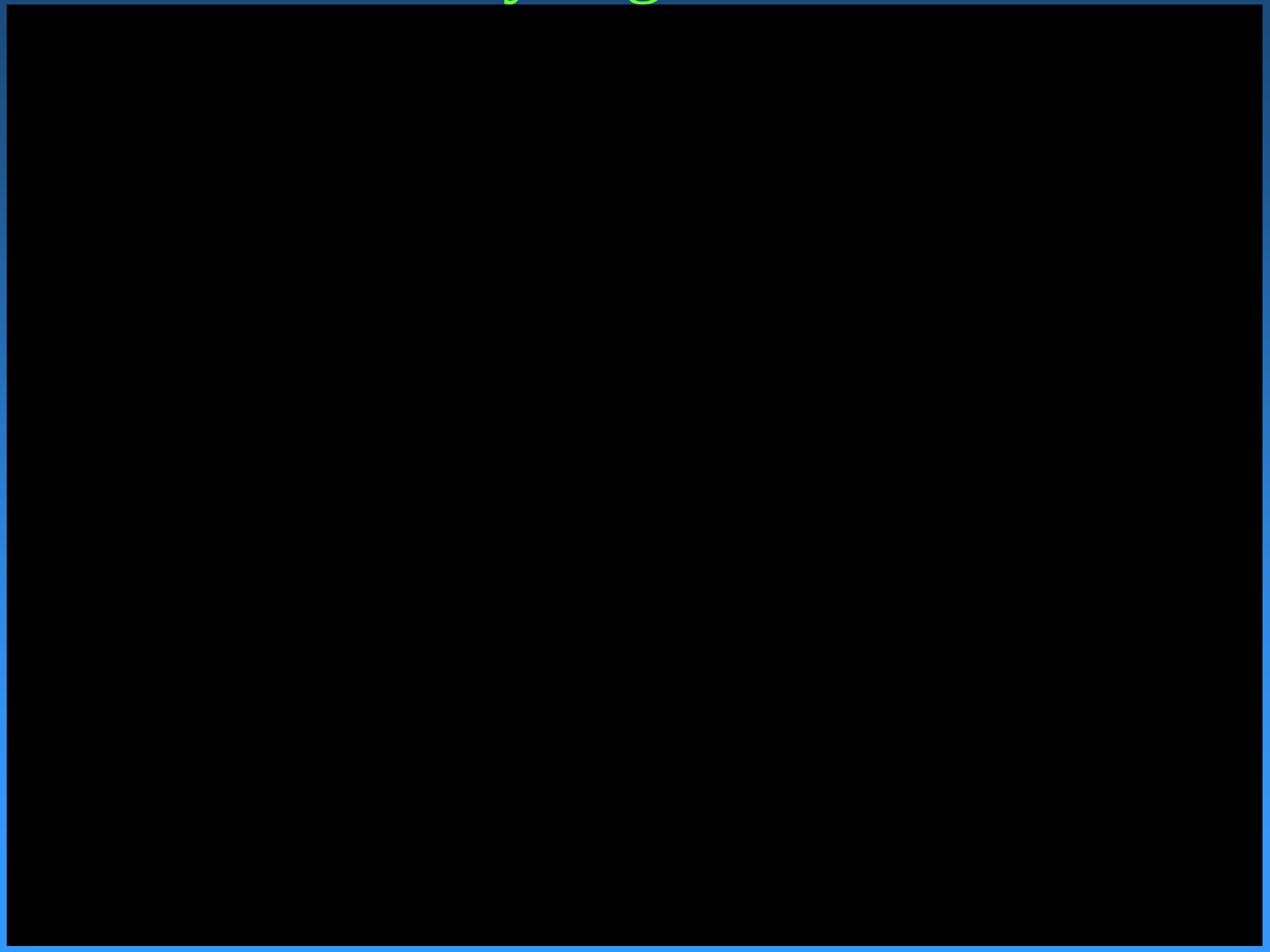
two components

- **slow phase - vestibular generated**
- **fast phase = saccade - CNS generated**
  - **retinal slip**
  - **ocular muscle proprioreceptor afferents**

description refers to fast phase

slow phase more helpful diagnostically

Nystagmus



Nystagmus

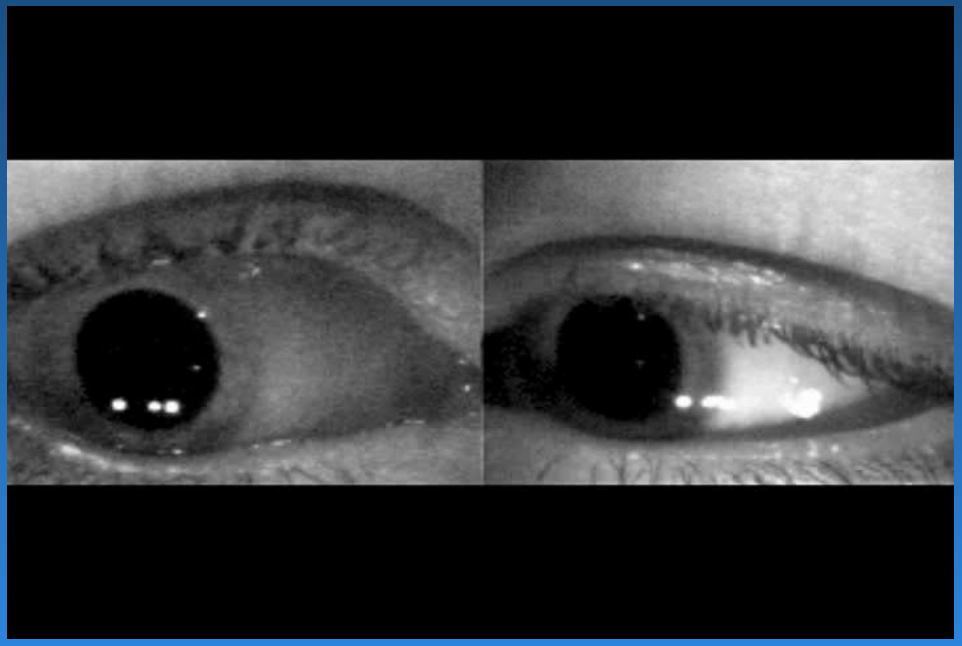
vestibulo-ocular reflexes:

- hair cell afferent

- oculomotor efferent to both eyes

- leads to conjugate eye movements

- both eyes “do the same thing”



Nystagmus

origin central/peripheral

peripheral origin

- **congugate**
- **systemic symptoms**
- **more symptomatic with eyes open**
- **associated nausea and vomiting**
- **suppressed by visual fixation**

central origin:

- **may be dysconjugate**
- **may be asymptomatic**
- **balance symptoms less with eyes open**
- **not suppressed by visual fixation**

Assessment of the patient with balance disturbance

History of the complaint

- **exact experience (avoid use of “dizzy/giddy”)**
- **duration**
- **timing**
- **relation to posture**
- **relation to movement**
- **movement hallucination?**
- **associated symptoms**
  - **nause/vomiting**
  - **cochlear**
  - **visual/neurological**
  - **cardiac (arrythmia\SOB)**

Medical history of the patient with balance disturbance

- general
- cardiovascular symptoms
- neurological symptoms

Especially
- hypertension and its treatment
- diabetes
- hypercholesterolaemia
- medications
- previous head injury
- toxic damage - aminoglycosides/chemotherapy

Examination of the patient with balance disturbance

- general medical
  - especially orthostatic hypotension
- ENT
- neurological
  - cranial nerves and cerebellum
  - eye movements
- vestibular
  - vestibulo-ocular and vestibulo-spinal reflexes
  - clinical posturography - eyes closed on foam

ENT Examination

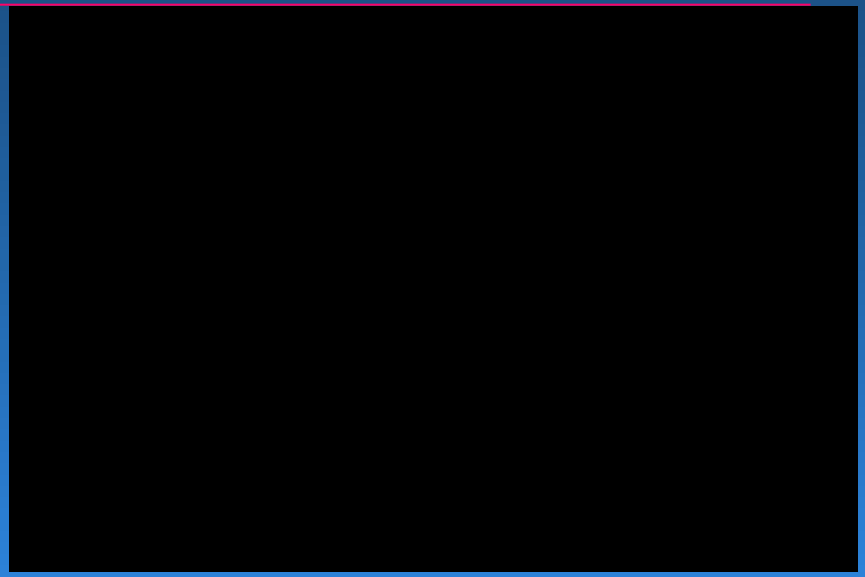
- **exclude local ear pathology**
  - **suppuration**
  - **cholesteatoma**
- **hearing, especially asymmetry**

Bedside vestibular examination

- **vestibulo-ocular reflexes**
- **vestibulo-spinal reflexes**
- **clinical posturography**

Vestibulo-spinal reflexes

Unterberger's/Fukuda stepping test



- past pointing

Doll's eye movement

Doll's Eye Movement Video

- slow
- dependent on visual fixation

> 30 degrees/s = Head thrust

- visual fixation fails -> saccade/s

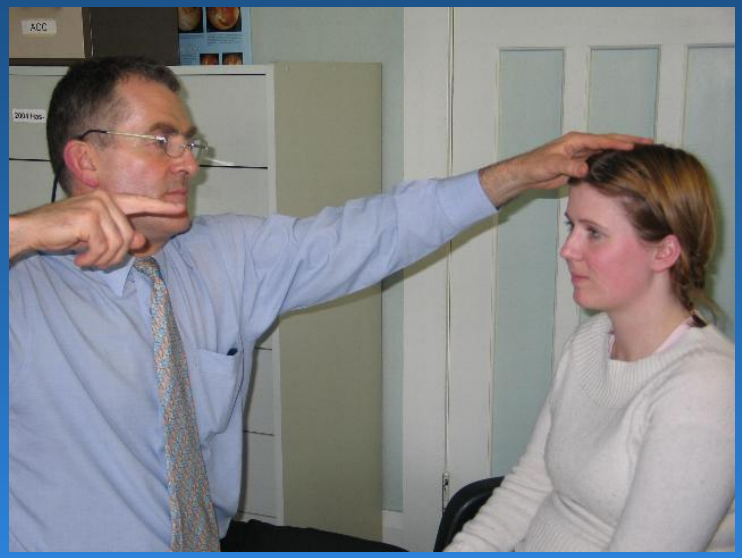
Halmagyi/head pulsion test - vestibulo-ocular reflex

Clinical eye movement examination

Smooth pusuit

and

Oculomotor



Optokinetic nystagmus

Smooth pursuit

Oculomotor
Cranial nerves 3, 4 and 6

Optokinetic nystagmus

Clinical posturography

- remove visual input

- remove somatosensory information

- rely solely on vestibular input

30 seconds without fall = normal

Clinical posturography

Diagnosis of the patient with balance disturbance

Acute loss of balance

- **Meniere's syndrome - first attack**
- **vestibular neuronitis**
- **cerebellar stroke**

Recurrent loss of balance

- **benign paroxysmal positional vertigo**
- **migraine**
- **Meniere's syndrome**

Chronic loss of balance - ataxia

Balance disturbance - prolonged history

Diagnostic dichotomy:

Recurrent/Episodic OR

Chronic/Non episodic

Balance disturbance - prolonged history

Episodic

- clearly defined bouts of imbalance
- limited duration - seconds to hours
- posture and movement related
- marked systemic symptoms
- prone to falling only during attack

Non episodic

- prone to it all the time
- unlimited duration
- minimal systemic symptoms
- prone to falling whenever up and about
  - ataxia

Non-episodic dysequilibrium

more likely to be of non-vestibular origin

diagnosis difficult

- **history**
- **careful physical exam esp neurologic**

may require physician/neurologist referral

Episodic dysequilibrium

more likely to be of peripheral vestibular origin

episodicity is due to the cerebellar clamp phenomenon

accurate diagnosis only if exam during attack

most common cause of recurrent vertigo is BPPV

- **easily diagnosed**
- **easily treated**

Acute dysequilibrium – 5 diagnostic categories

Benign paroxysmal positional vertigo
history, nystagmus on positioning

Migraine phenomenon
supportive hx – headache, MI, BF Fam hx

Meniere's – recurrent
related cochlear symptoms, HP

Vestibular neuronitis - single
HP, no cochlear symptoms

Neurological deficit – eye movements
CVA\CNS tumor\MS\??VBI

Benign Paroxysmal Positional Vertigo

common

easy to diagnose

easy to treat

Benign Paroxysmal Positional Vertigo

transient rotatory vertigo

distinctly positional

three cardinal positions

- **turning over in bed**
- **looking up steeply**
- **looking into a low cupboard**

no related auditory symptoms

tends to resolve spontaneously

Benign Paroxysmal Positional Vertigo

very intense symptoms, especially first attack
- **nausea and vomiting**
- **anxiety/panic**

may seem to last for days but vertigo transient

subsequent attacks better tolerated

anxiety/fear of future attacks often predominates
- **even when condition itself has resolved**

counterproductive in terms of compensation are:
- **position avoidance phenomena**
- **use of sedatives (e.g. Stemetil)**
- **limitation of physical activity**

BPPV - diagnosis

the Epley maneuver

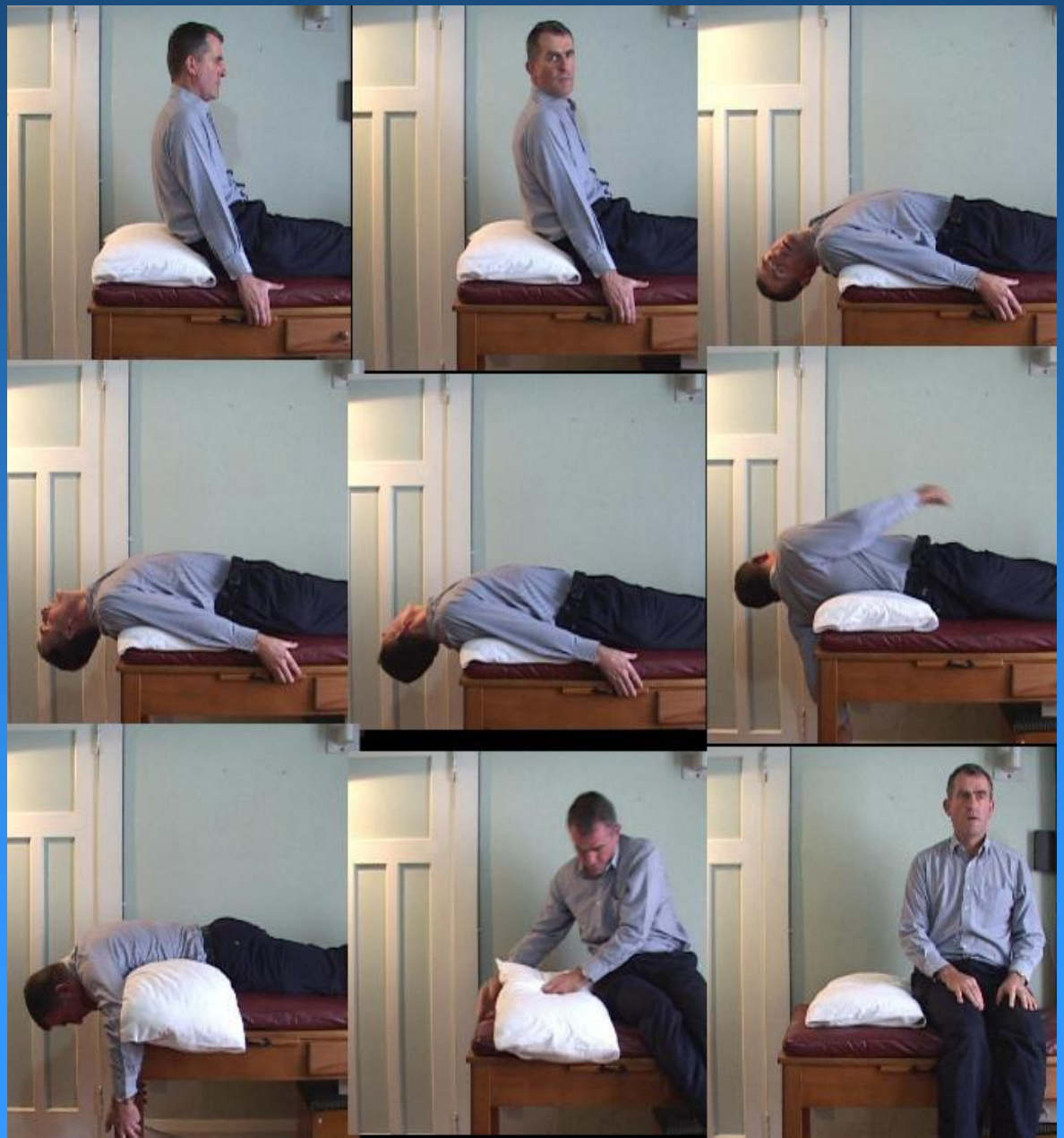
encourage patient to keep eyes open so you can see the eyes

- **elevate upper eyelid with finger to expose eye**
- **watch for rythmical eye movements - nystagmus**
- **typically rotatory movements (torsional nystagmus)**
- **few seconds delay before it starts**
- **lasts for up to half a minute then decays**
- **often associated with intense symptoms**

firmly encourage patient to continue

reassure and soothe throughout

BPPV - The Epley maneuver



BPPV - diagnosis and treatment

once diagnosis made move directly to treatment:

the Epley maneuver/Parnes modified

head must remain below level of body throughout

- **keep undermost arm above head of bed**
- **not to be turned under torso**

wait for intial nystagmus/symptoms to subside

quarter of a revolution at a time

wait thirty seconds before each turn

sit up with neck flexed until upright

beware of mass particle shift as attains upright positon

BPPV - treatment

treat one side at each consultation

immediately after treatment check for success

- **patient to lie on their side from sitting up**
- **with head turned to look up at the ceiling**
- **watch for nystagmus (usually intense)**
- **if nystgmus seen, repeat Epley maneuver**
- **take particular care of key points**

BPPV - post treatment

may feel “floaty” for two days

instruct to return promptly if:

- **still position intolerant after two days**
- **delayed recurrence**

refer to specialist if

- **not resolving as expected**
- **unusual features:**
  - **+ no delay before onset of nystagmus**
  - **+ no fatigue after some seconds**

The Ten Minute Exam for Dizzy Patients

Note gait (– part of cerebellar exam)

General ENT Exam (incl's some cranial nerves)

Exclude local ear pathology

Clinical VOR – head pulsion test of Halmagyi

Eye movements (– includes some cranial nerves)

- smooth pursuit/saccades/optokinetic nystagmus

Clinical posturography

Nystagmography

- spontaneous/head shake/positional

Asymmetric hearing loss

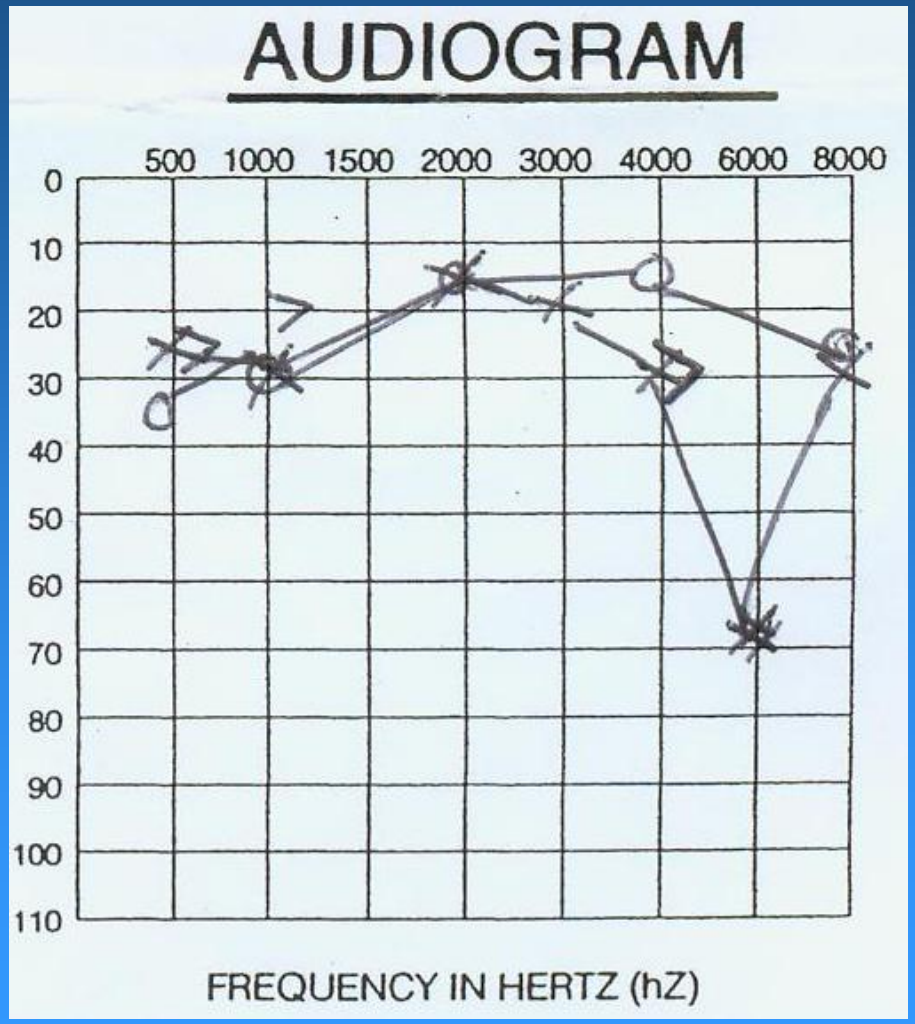
23 yrs female

Physically active

Six months progressive left hearing loss

No dysequilibrium/imbalance

Audio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500 1000 1500 2000 3000 4000 6000 8000
0
10
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30
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50
60
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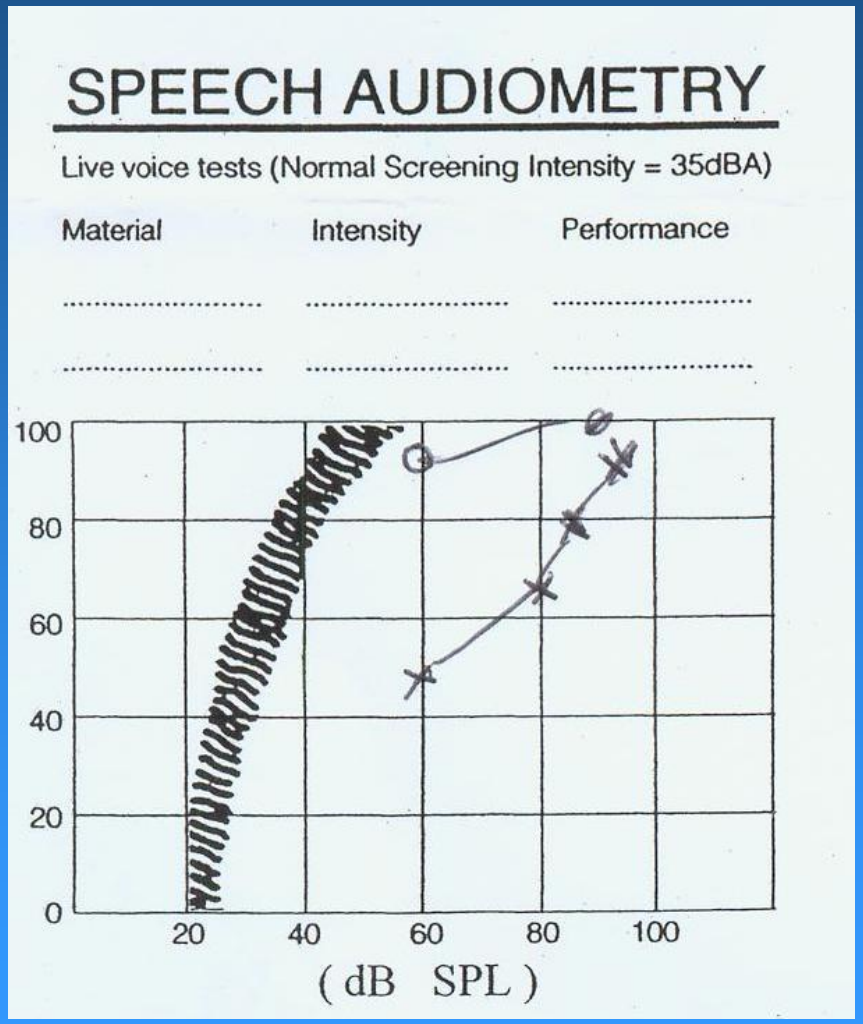
90
100
110
FREQUENCY IN HERTZ (hZ)


SPEECH AUDIOMETRY
Live voice tests (Normal Screening Intensity = 35dBA)
Material
Intensity
Performance
100
80
60
40
20
0
20
40
60
80
100
(dB SPL)

Examination

General ENT all normal

Cranial nerves intact

Cerebellar function within normal limits

Head pulsion test positive for left weakness

Doll's eye movement

- **slow**
- **dependent on visual fixation**

> 30 degrees/s = head thrust

visual fixation fails -> saccade

Head pulsion test

Ask patient to fix vision on target behind examiner

Head tilted down 30 degrees

Instruct not to blink

Move head to side opposite to test ear

Flick/pulse head back across midline

>30 degrees per second (rapid)

Watch for saccade as patient re-finds visual target

Examination

General ENT all normal

Cranial nerves intact

Cerebellar function within normal limits

Head pulsion test positive for left weakness

Video

Gaze paretic nystagmus

Gaze paretic nystgamus on looking left

None on looking right

Video looking right

Video looking left

Saccadic smooth pursuit to left

Clinical evaluation of smooth pursuit:

Saccadic on following to left

Smooth on following to right

Smooth pursuit

Saccadic smooth pursuit to left

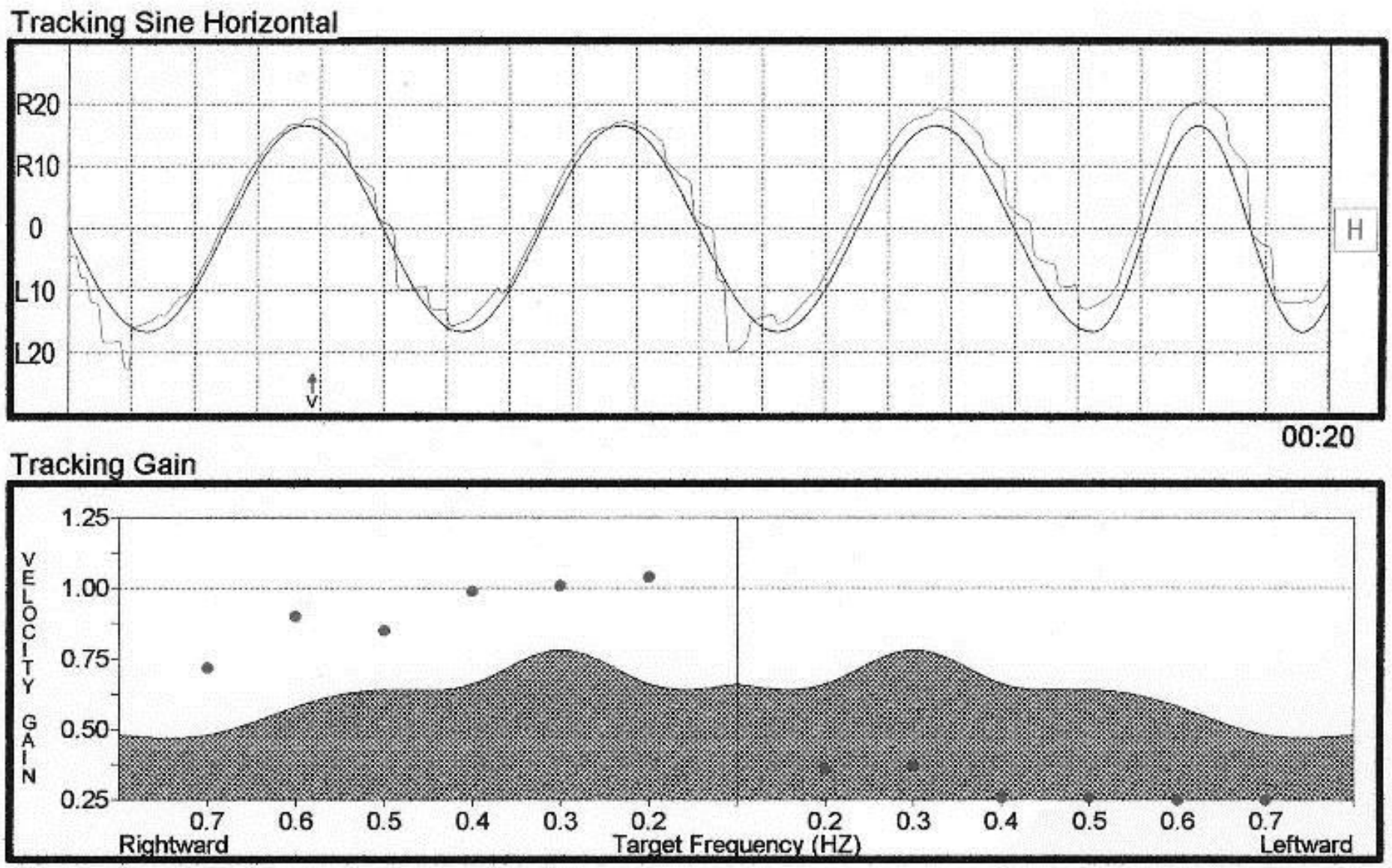
Clinical evaluation of smooth pursuit:

Saccadic on following to left

Smooth on following to right

Video

Saccadic smooth pursuit to left



Clinical evaluation of saccades

Head still

Look at tip of finger (held horizontal)

Look at other tip of finger

Vary finger position

Look for accuracy, smoothness, speed

Saccades




Innacurate saccades

Saccades innacurate

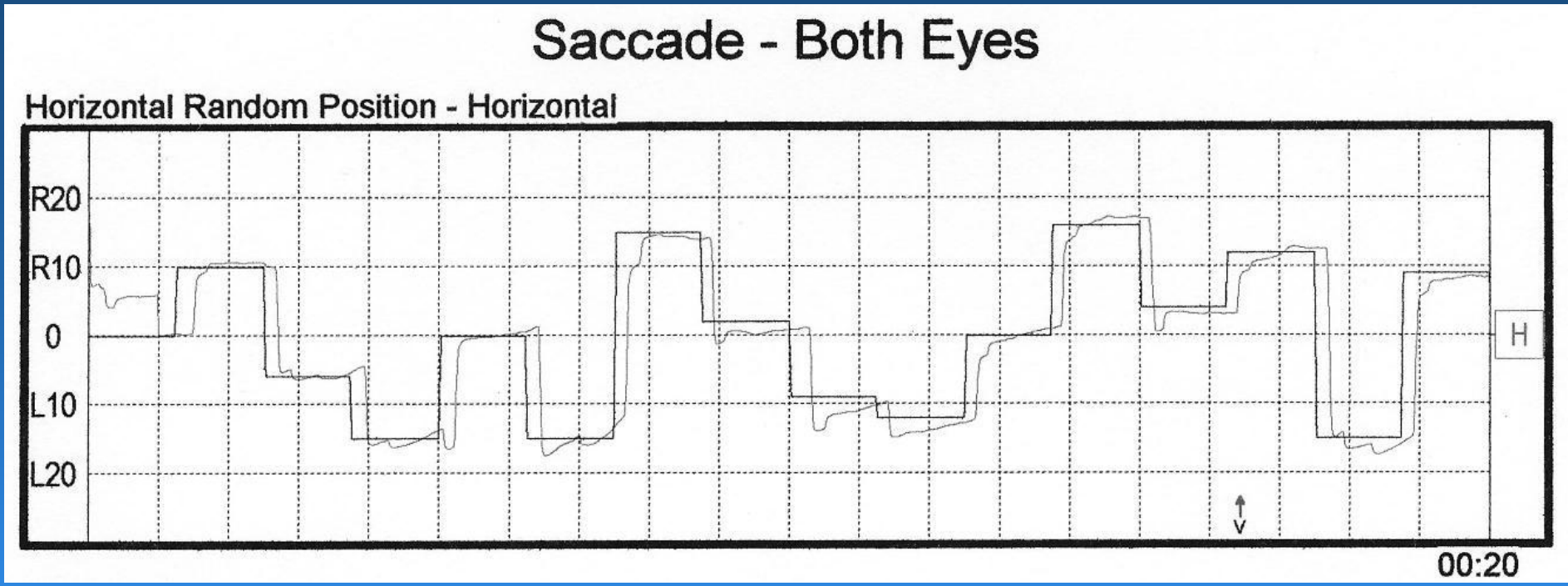
Especially on seeking target to left

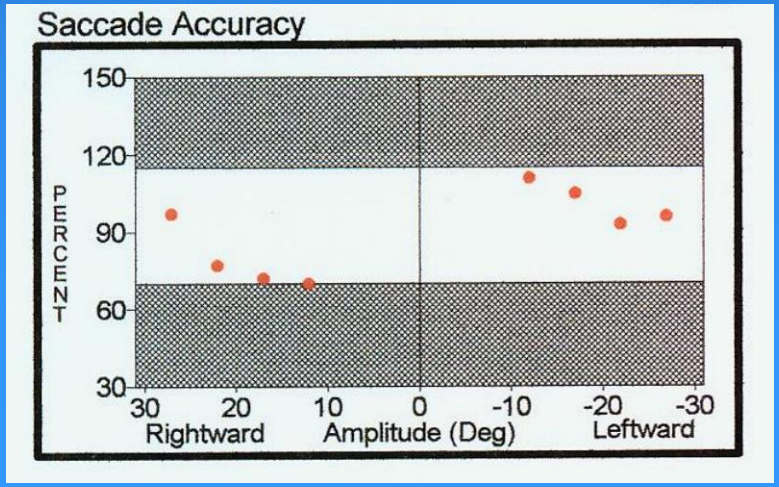
Overshoot on seeking target to left

Especially if abducting to left

Video

Asymmetric saccades





Clinical evaluation of optokinetic nystagmus (OKN)

Move a striped cloth in visual field

Instruct to keep watching straight ahead

Watch for generation

horizontal and vertical

Clinical evaluation of OKN

Optokinetic nystagmus

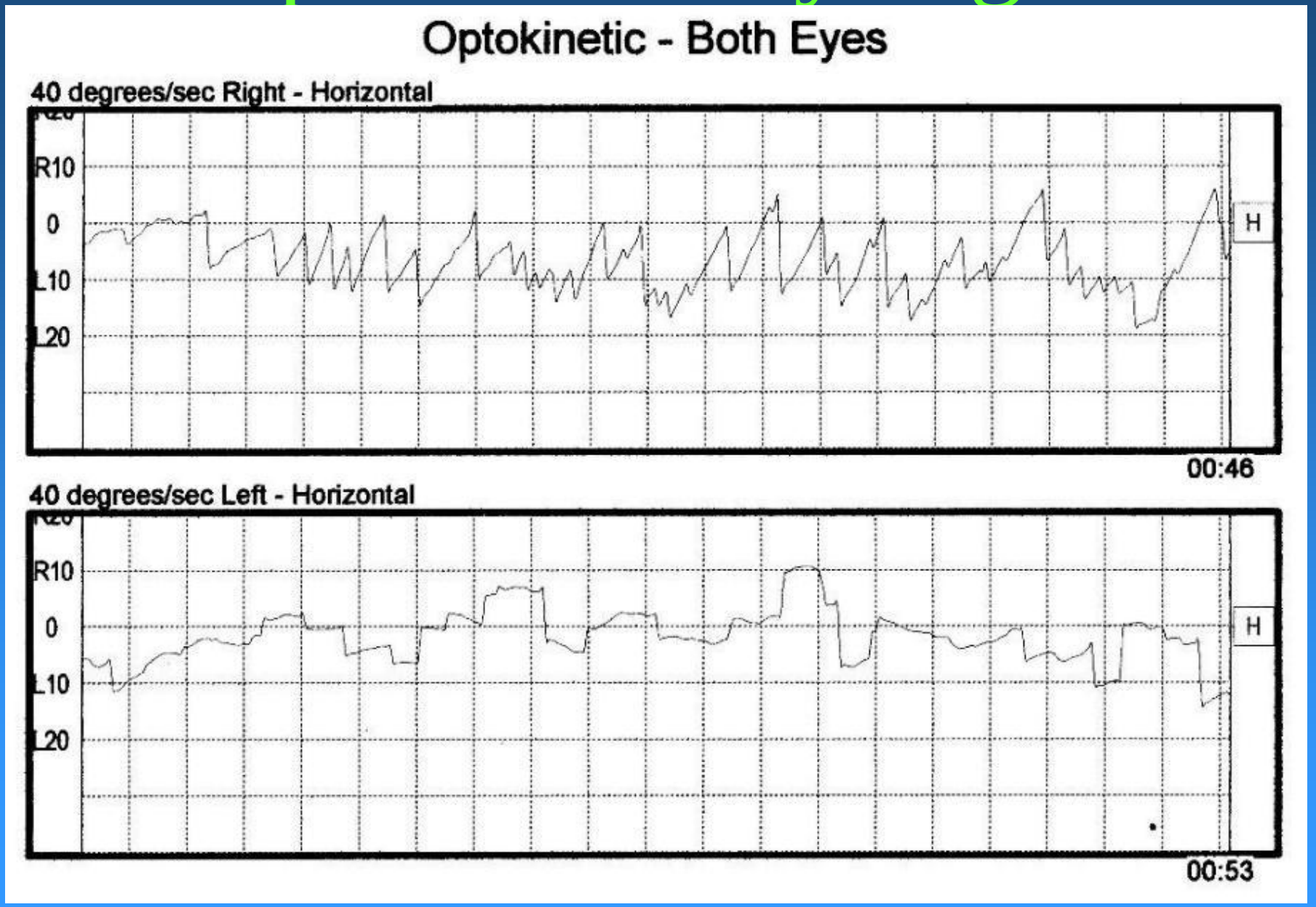
Present only with right moving target

None on left-moving target

Video right moving target

Video left moving target

Optokinetic nystagmus



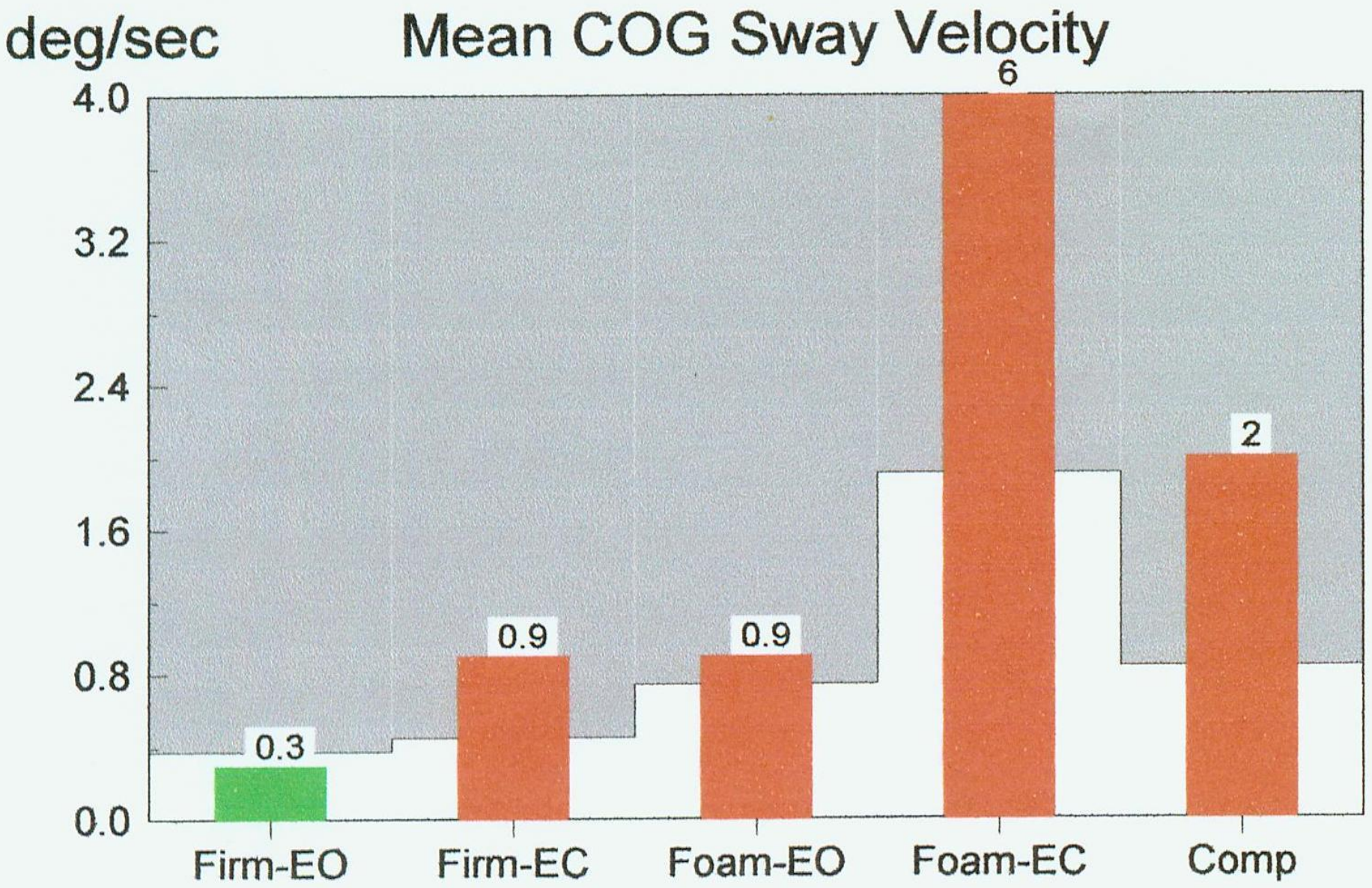
Clinical posturography

Clinical posturography

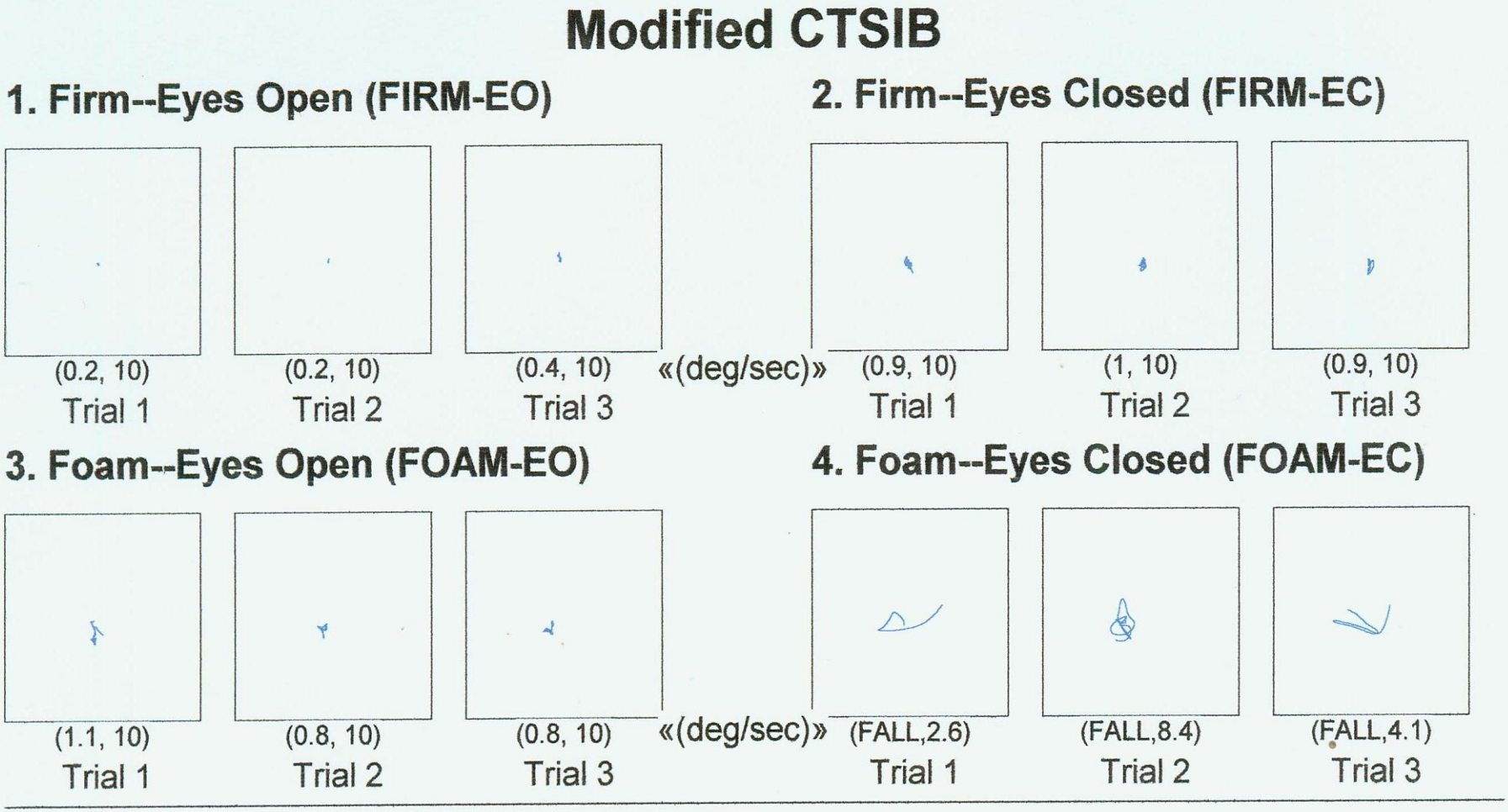
Duration of ability to stand

- **unsupported**
- **eyes closed**
- **on a compliant surface**
- **30 seconds requires**
- **at least one intact vestibule**
- **and static compensation of UVH**
- **this patient: less than 5s without fall**

Computerised static posturography

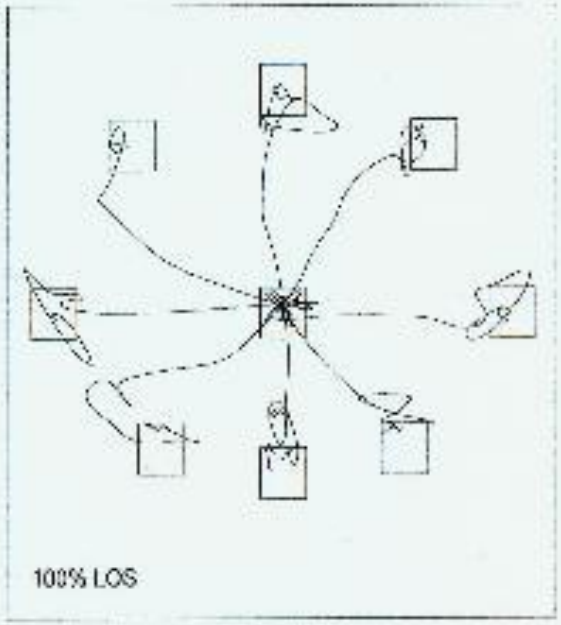


Computerised static posturography

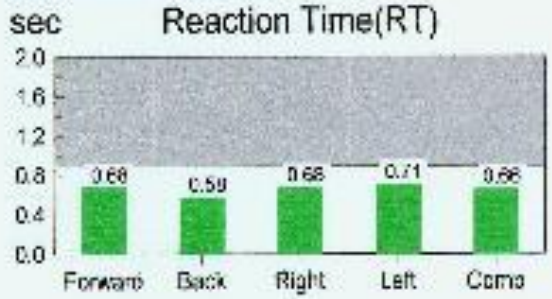


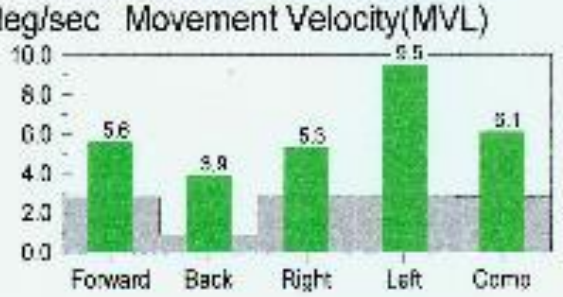
Comp-uterised static postur-ography

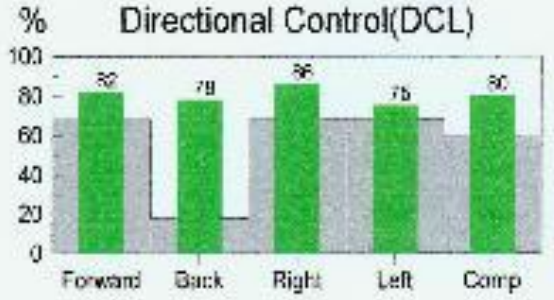
Limits Of Stability



Transition	RT (sec)	MVL (deg/sec)	EPE (%)	MXE (%)	DCL (%)
1 (F)	0.73	5.5	95	102	80
2 (RF)	0.60	5.5	84	103	89
3 (R)	0.72	5.2	89	108	88
4 (RB)	0.67	5.0	105	105	79
5 (B)	0.42	3.9	96	99	88
6 (LB)	0.80	5.8	96	113	58
7 (L)	0.69	11.1	96	113	82
8 (LF)	0.65	7.7	95	109	79







Assessment

Asymmetric sensorineural hearing loss

No spontaneous nystagmus

Gaze paretic nystagmus esp to left

Head pulsion test positive for R UVH

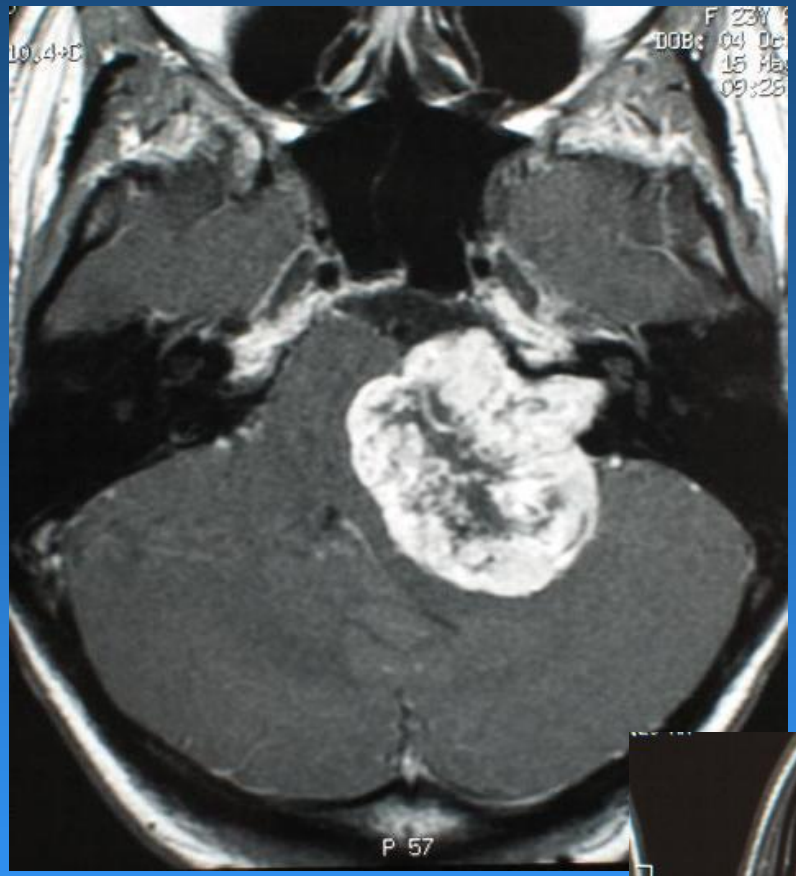
CNS signs on eye movement assessment

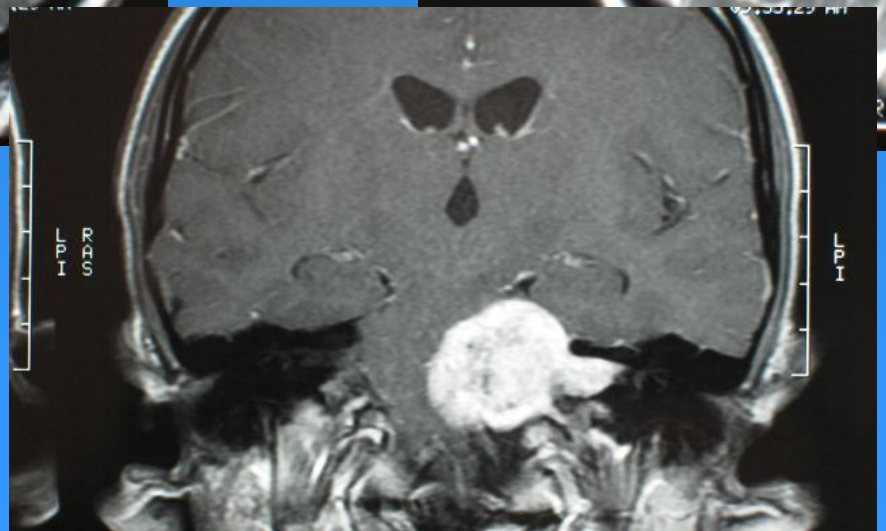
Diagnosis: ?

Diagnosis

Brainstem/root entry zone lesion

MRI scan





Diagnosis

Acoustic neuroma

Ataxia and vertigo

55 yrs male

Active horsehandler

Severe debilitating ataxia and vertigo

Began 3 weeks ago

Has had to stop work

Aggravated by movement

Associated nausea esp with movement

No cochlear symptoms

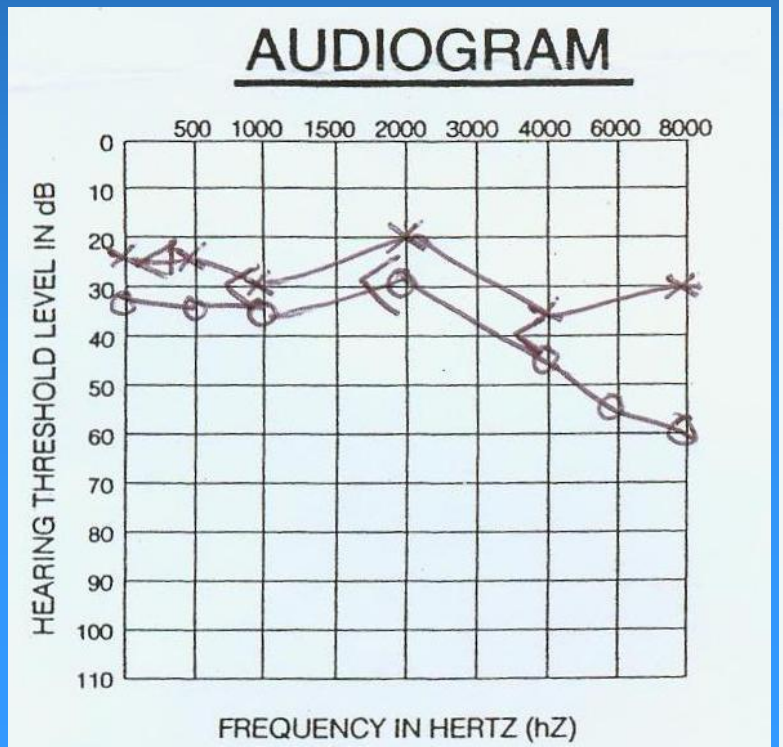
Examination

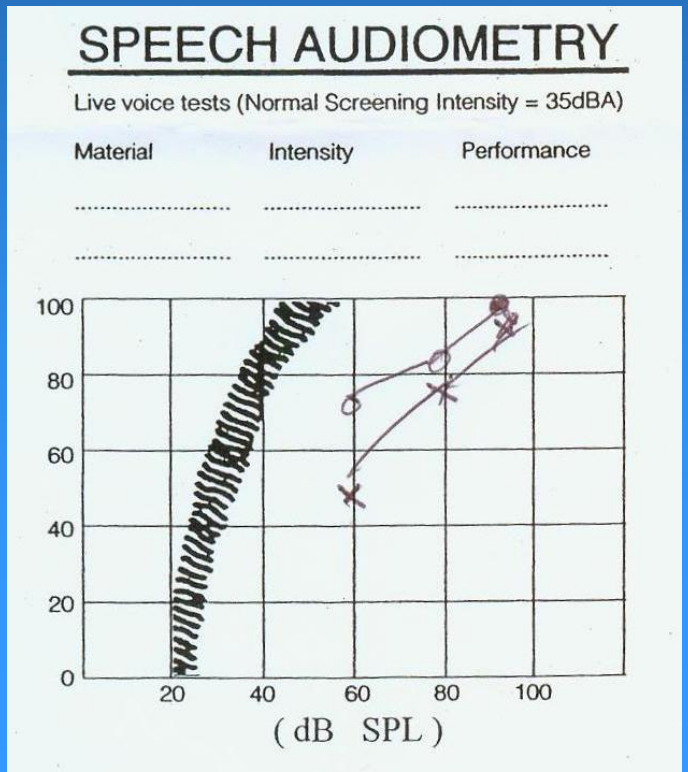
General ENT all normal

Cranial nerves intact

Cerebellar function within normal limits

Audio mild right asymmetric SNHL





Examination

General ENT all normal

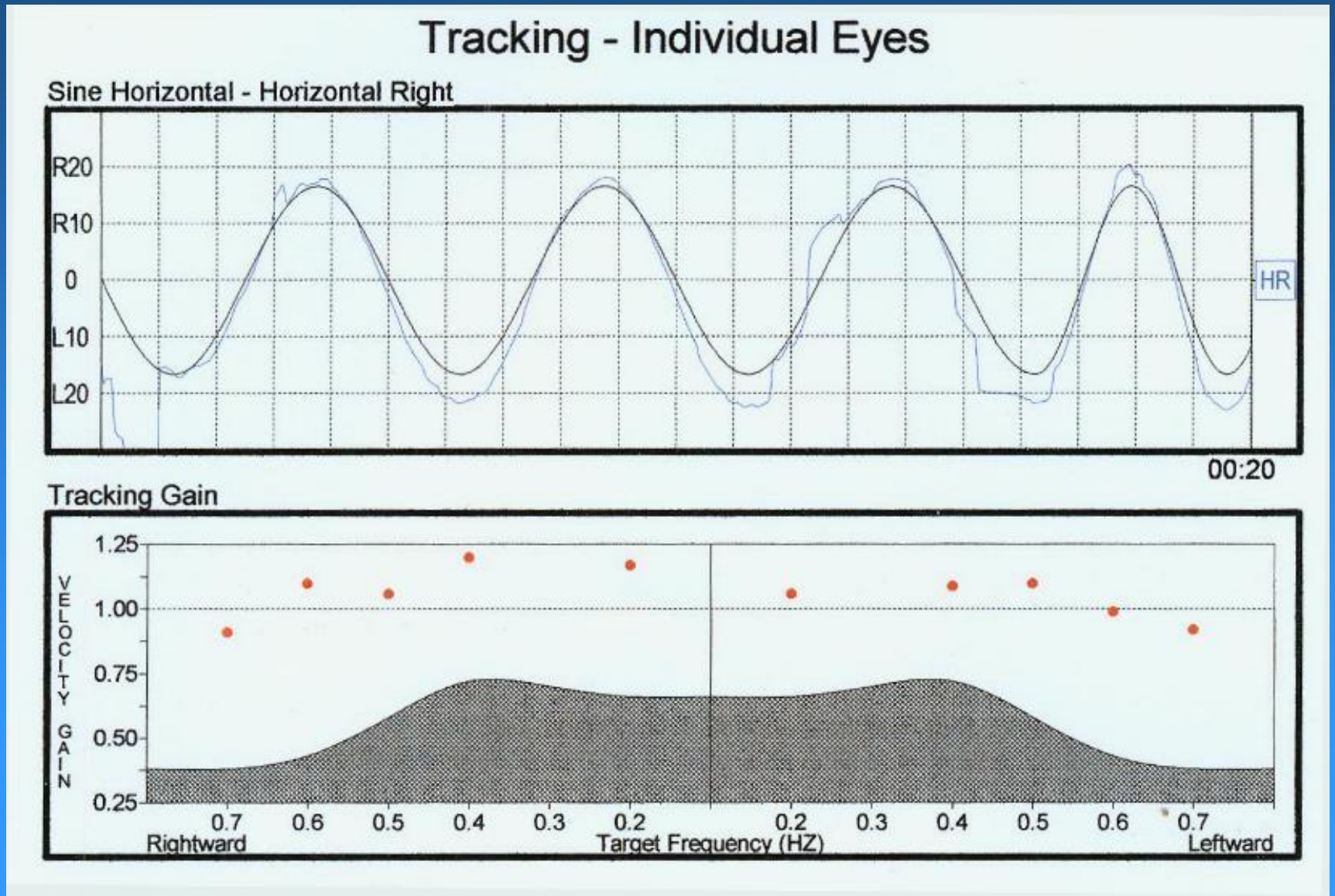
Cranial nerves intact

Cerebellar function within normal limits

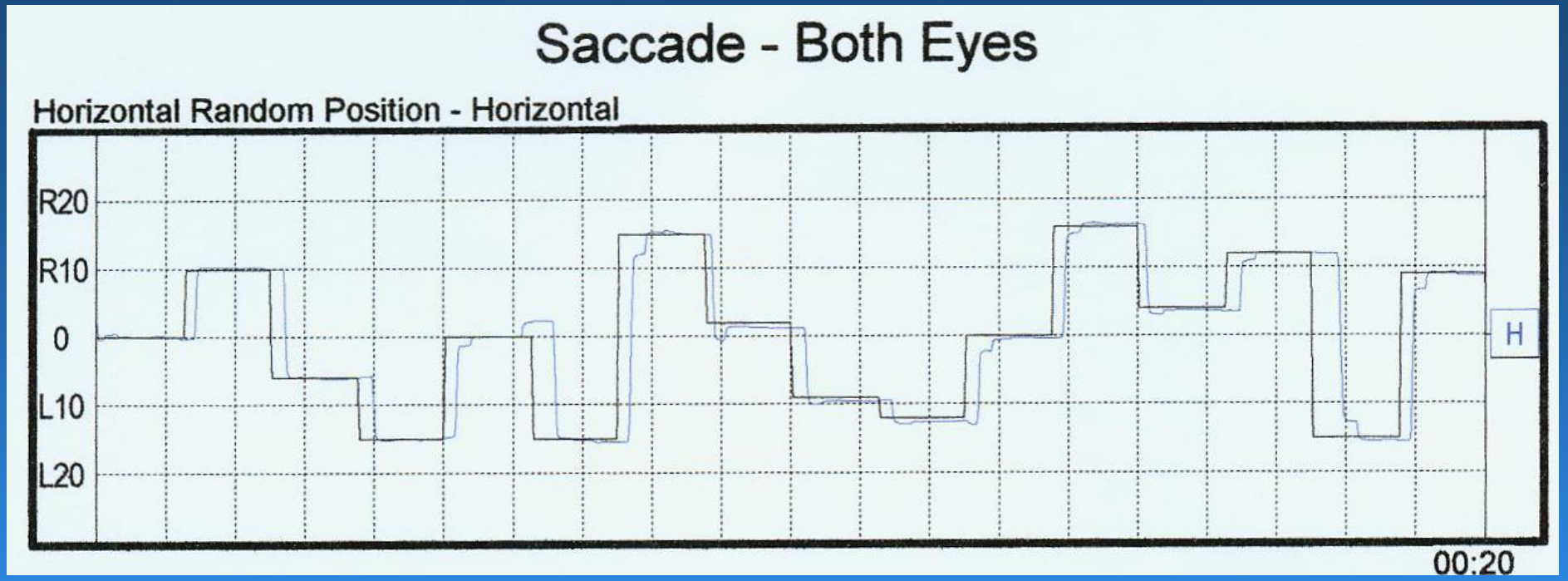
Audio mild right asymmetric SNHL

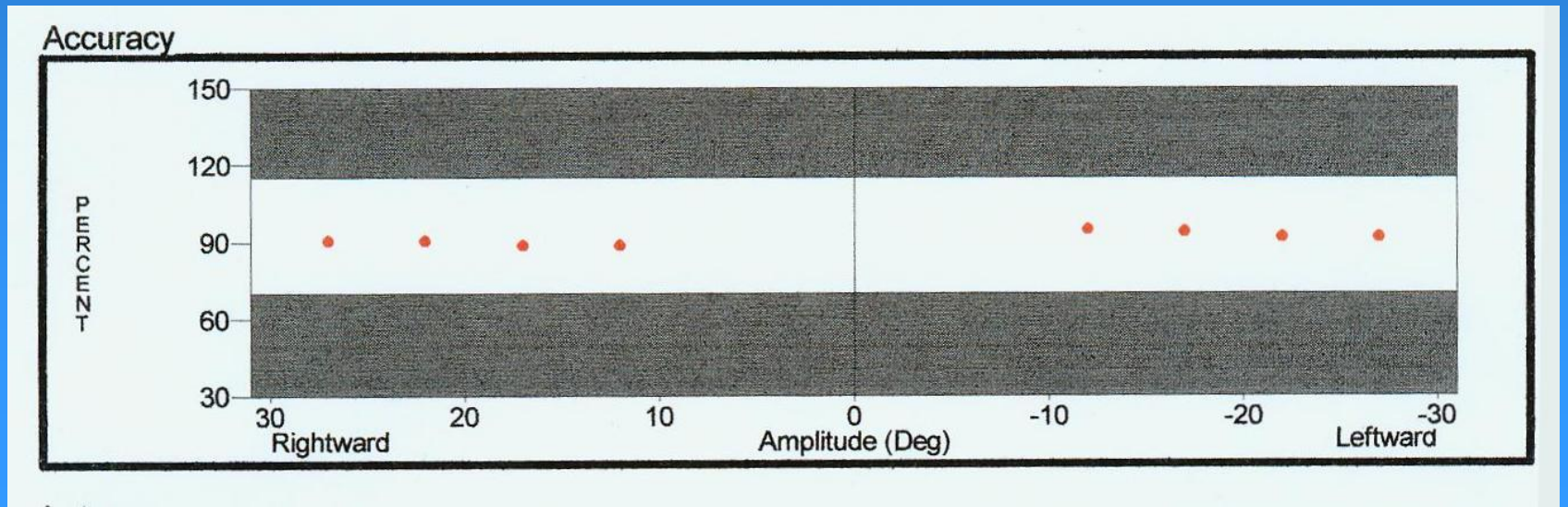
Normal smooth pursuit, saccades, OKN

Normal smooth pursuit



Normal saccades





Examination

General ENT all normal

Cranial nerves intact

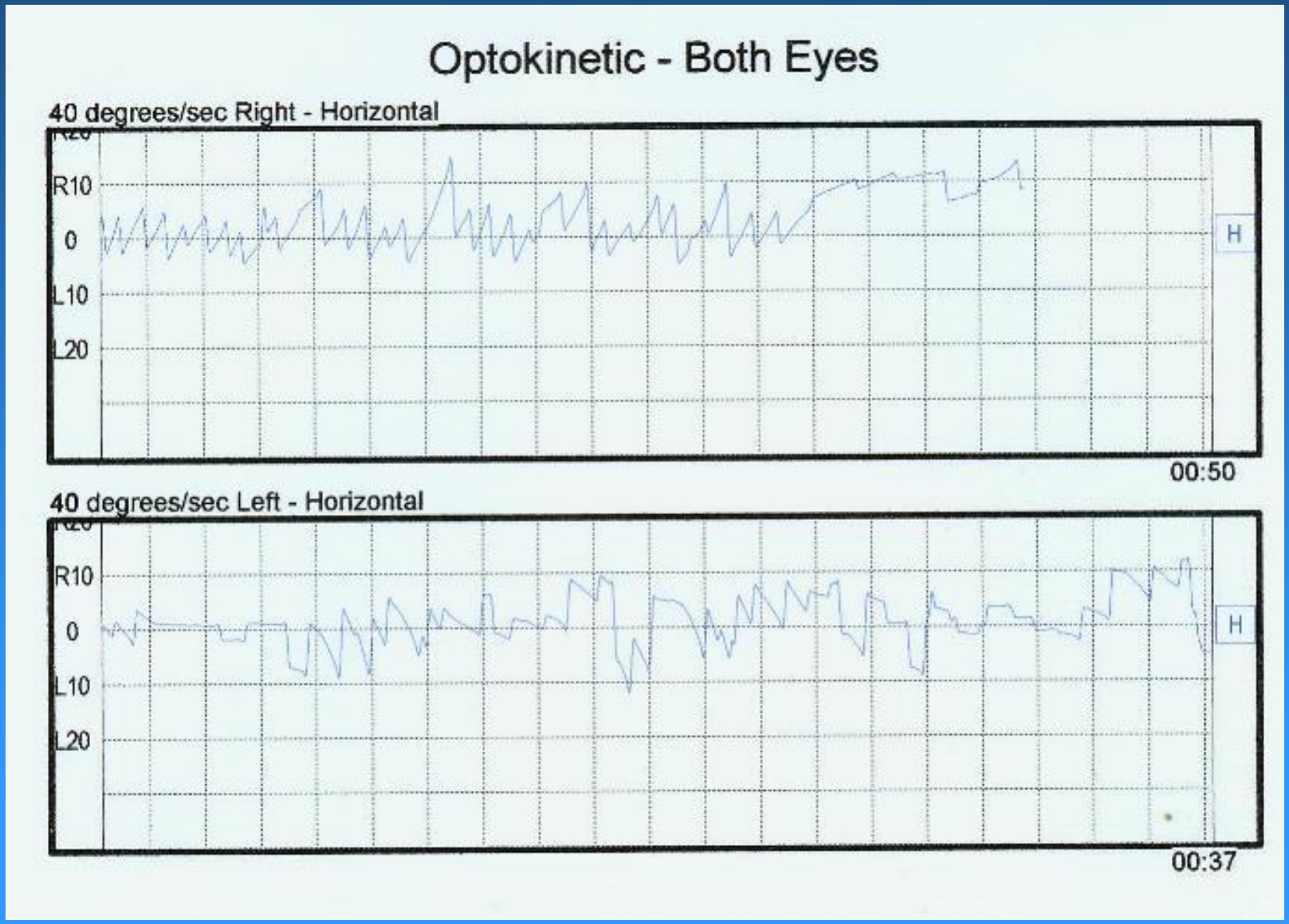
Cerebellar function within normal limits

Audio mild right asymmetric SNHL

Normal smooth pursuit, saccades

Asymmetric optokinetic nystagmus

Asymmetric optokinetic nystagmus



Examination

General ENT all normal

Cranial nerves intact

Cerebellar function within normal limits

Audio mild right asymmetric SNHL

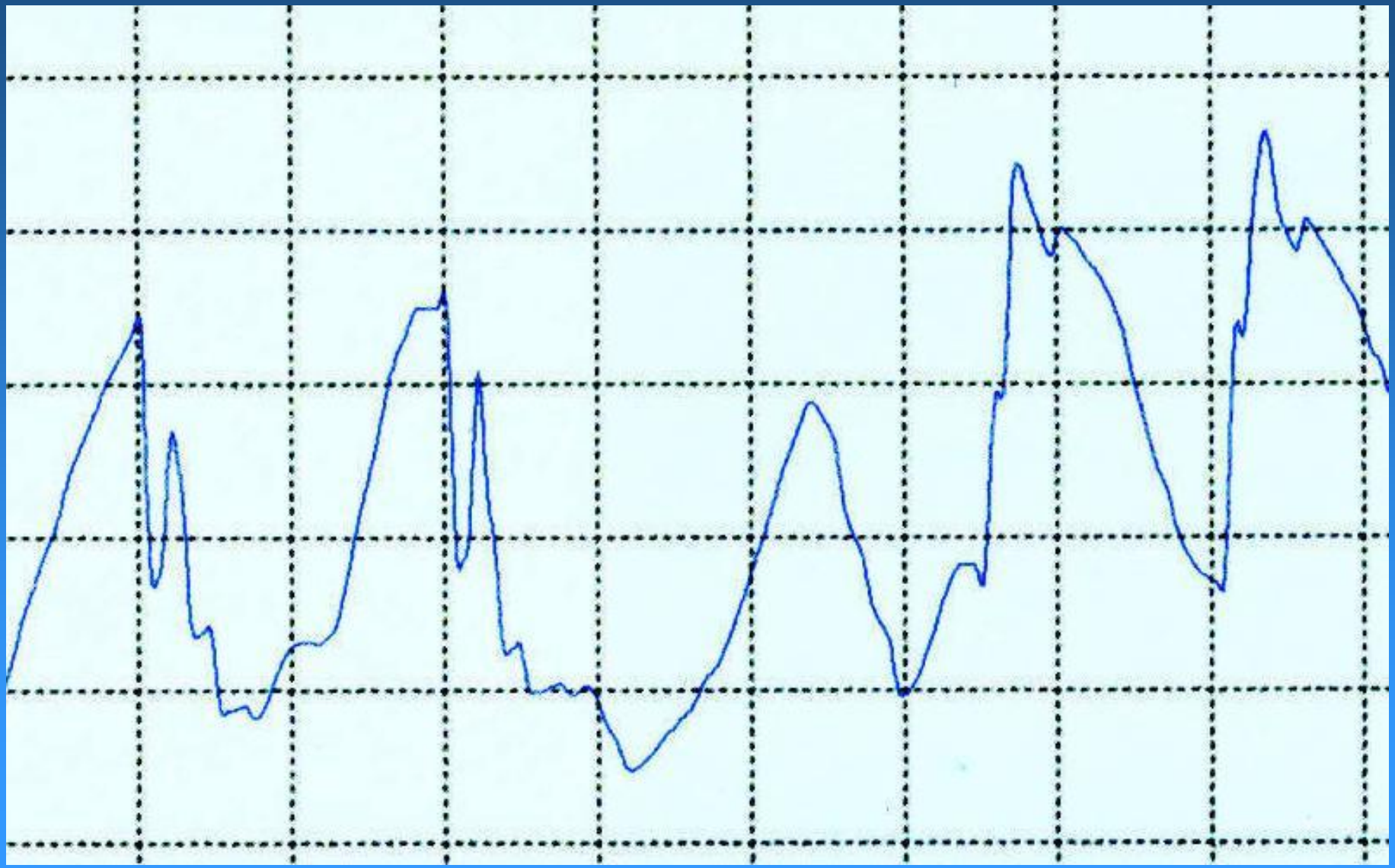
Normal smooth pursuit, saccades

Asymmetric optokinetic nystagmus

Head pulsion test positive for right UVH

Video normal **Video slow**

Head pulsion test positive for R UVH



Examination

General ENT all normal

Cranial nerves intact

Cerebellar function within normal limits

Audio mild right asymmetric SNHL

Normal smooth pursuit, saccades

Head pulsion test positive for right UVH

Grade 2 spontaneous nystagmus

Examination

General ENT all normal

Cranial nerves intact

Cerebellar function within normal limits

Normal smooth pursuit, saccades

Optokinetic nystagmus asymmetric

Grade 2 spontaneous nystagmus

Head shake nystagmus (++ nausea)

Assessment

Vertigo and ataxia

Spontaneous and head shake nystagmus in keeping with R UVH

Head pulsion test positive for R UVH

No CNS signs on eye movement exam

Diagnosis: ?

Diagnosis

Vestibular neuronitis

Plan:

MRI booked through public system

Vestibular rehab exercises

Ataxia

46 yrs male

Active farmer/shearer

Nonepisodic dysequilibrium/ataxia

Especially whilst shearing

Fell from a platform 3 months ago

Slight nausea all the time

Examination

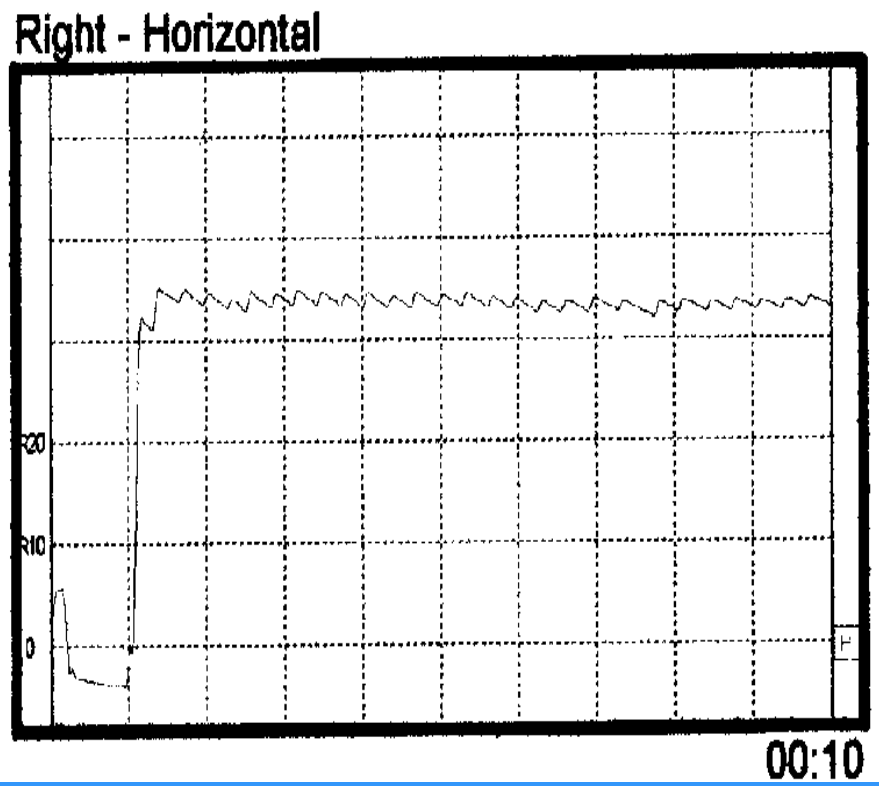
General ENT all normal

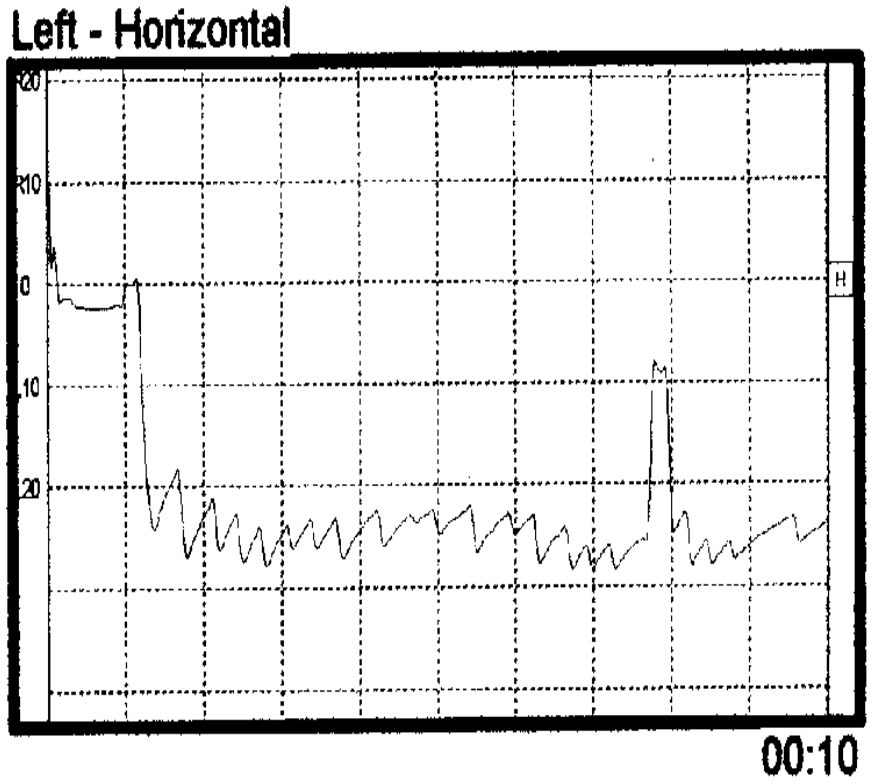
Cranial nerves intact

Cerebellar function within normal limits

Gaze evoked nystagmus

Gaze evoked nystagmus





Examination

General ENT all normal

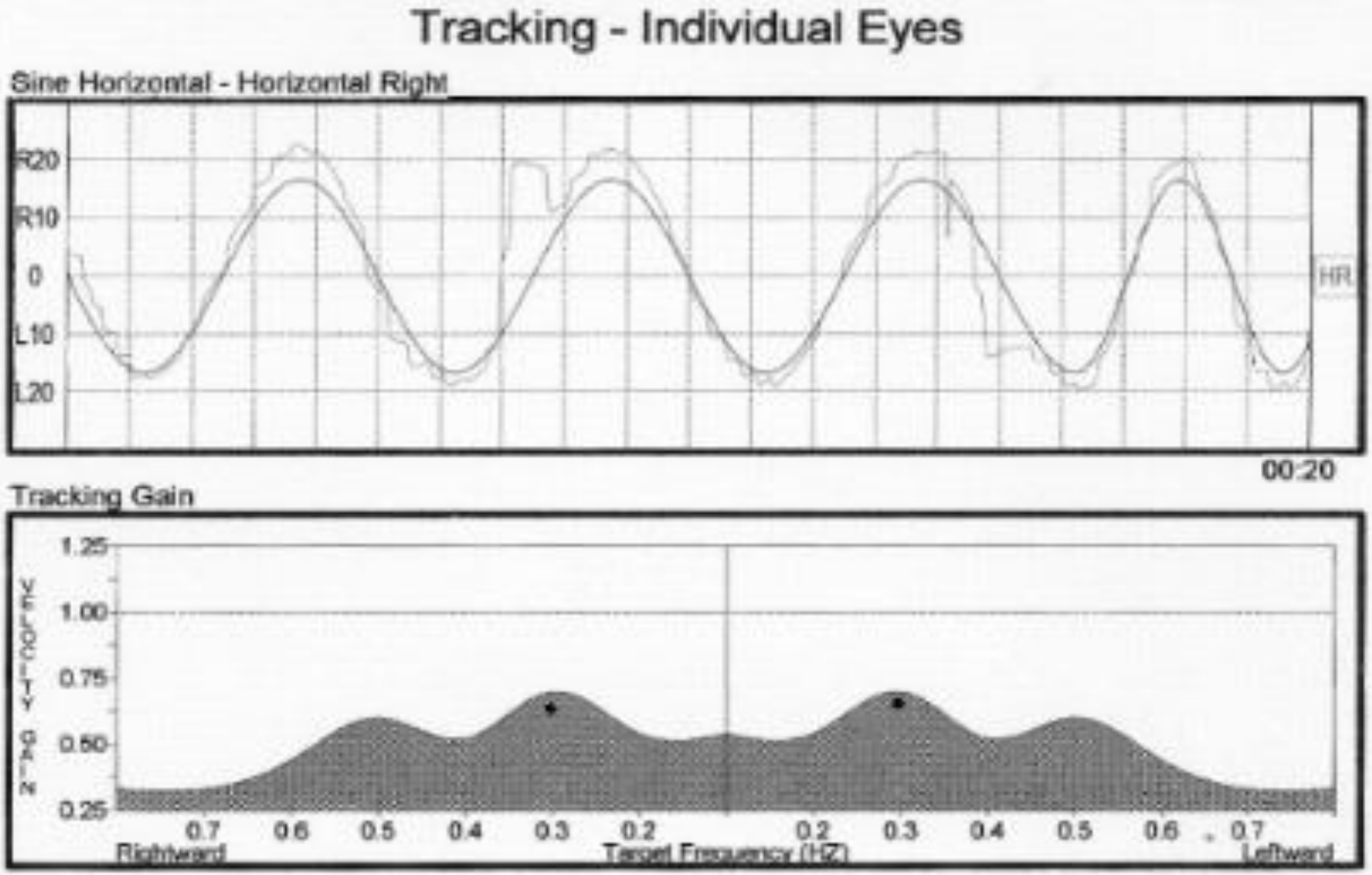
Cranial nerves intact

Cerebellar function within normal limits

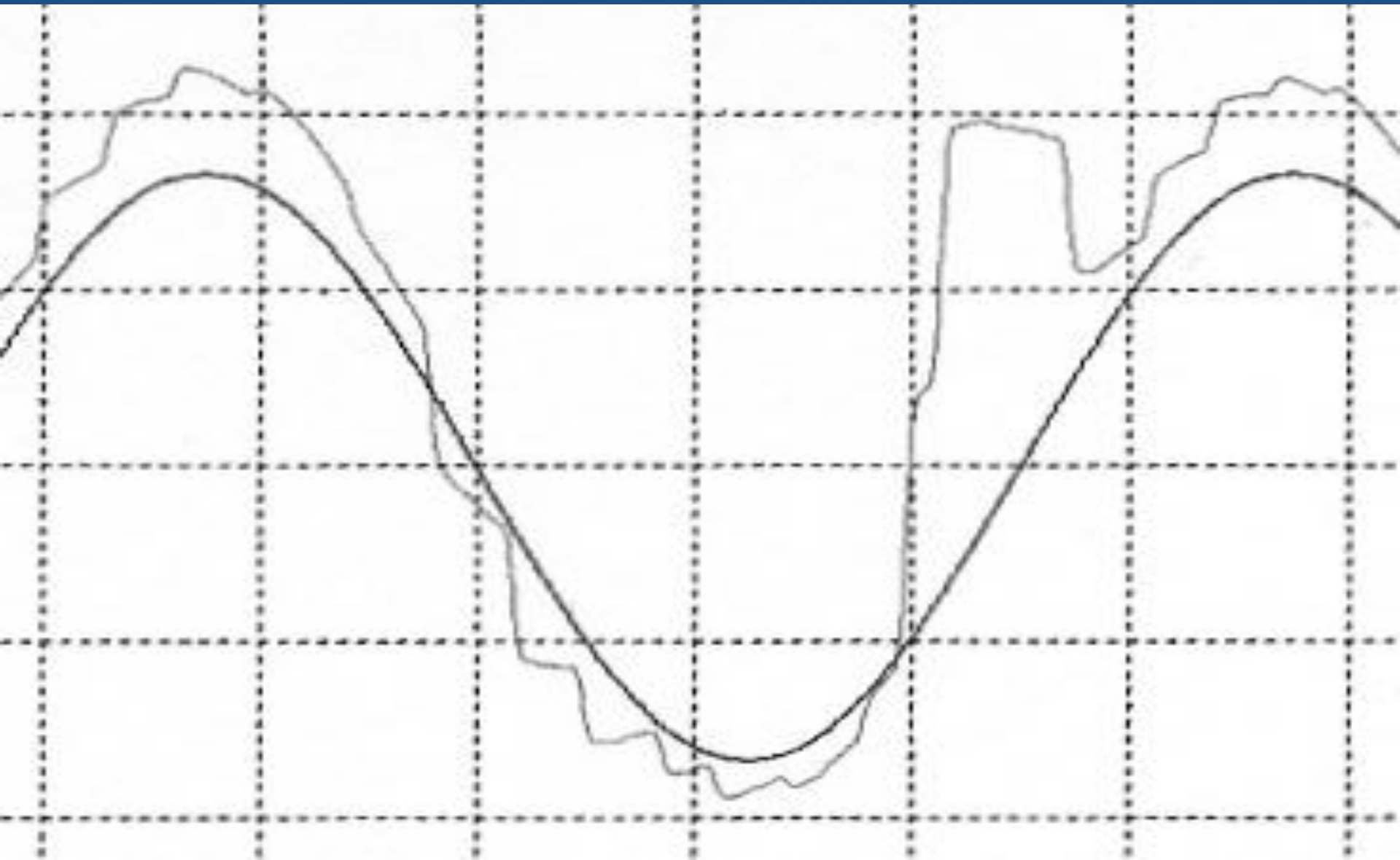
Gaze evoked nystagmus

Saccadic smooth pursuit

Saccadic smooth pusuit



Saccadic smooth pusuit



Examination

General ENT all normal

Cranial nerves intact

Cerebellar function within normal limits

Gaze evoked nystagmus

Saccadic smooth pursuit

Head pulsion test positive for left weakness

Assessment

Ataxia

CNS signs on eye movement assessment

No distinct cerebellar signs

Diagnosis: ?

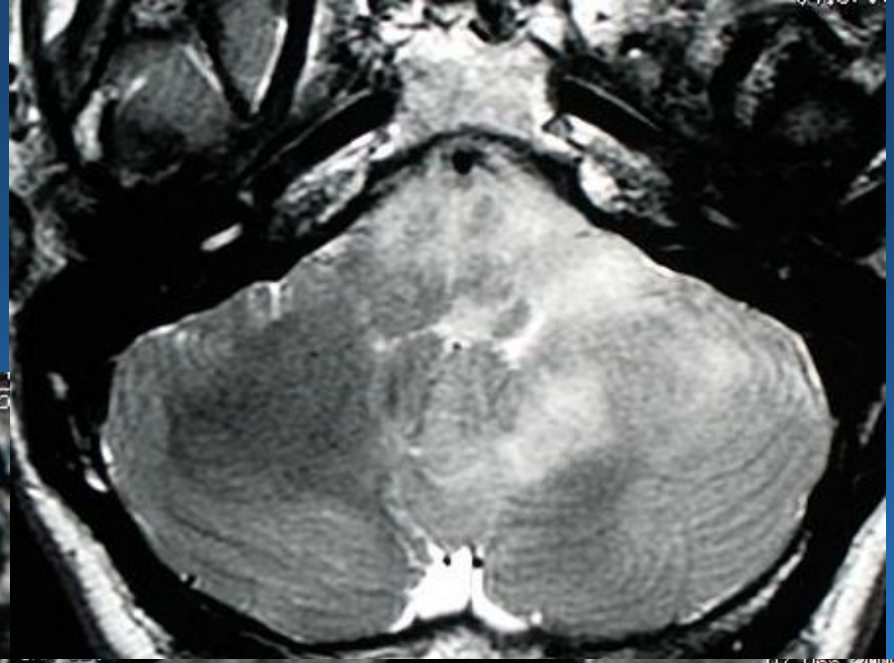
Diagnosis

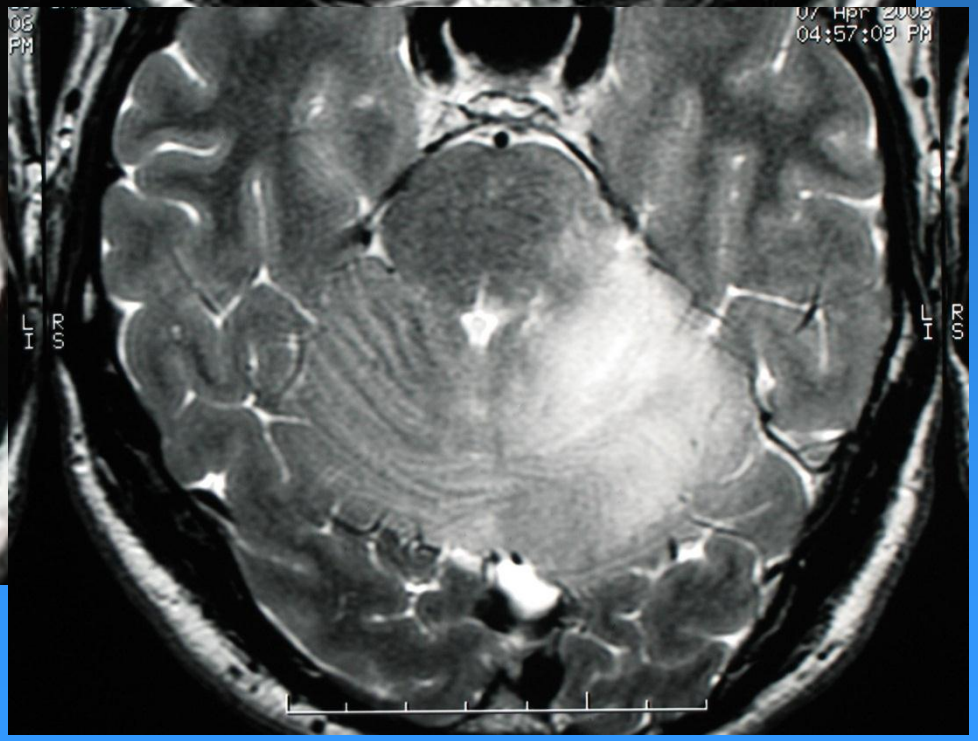
Central not peripheral cause

MRI

MRI scan

Acute disseminated encephalomyelitis





Episodic vertigo

67 yrs male

Retired truck driver

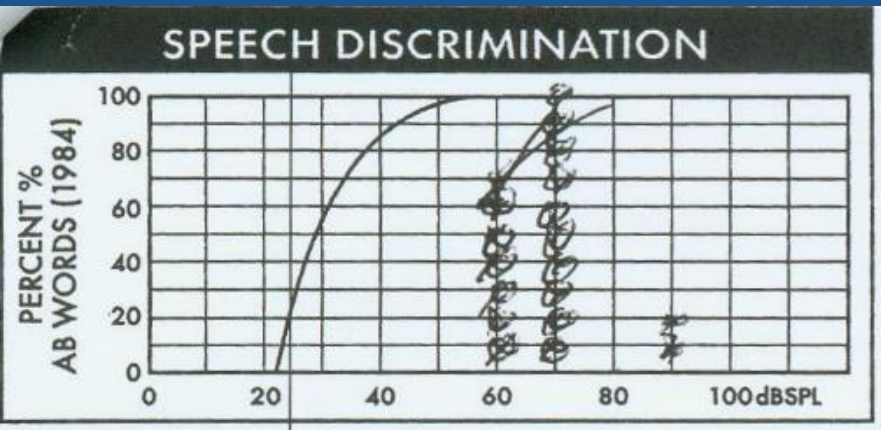
Noise induced sensorineural hearing loss

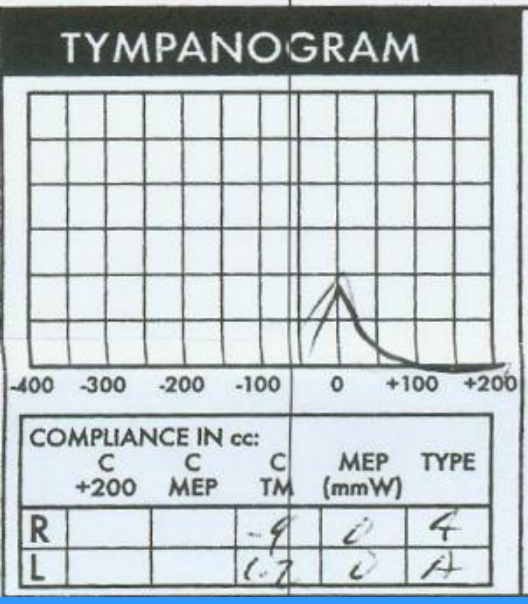
Later episodic prostrating vertigo

- **associated cres/decres right hearing loss**
- **aggravated by head movement**
- **better eyes closed and lying still**
- **lasting a couple of hours**

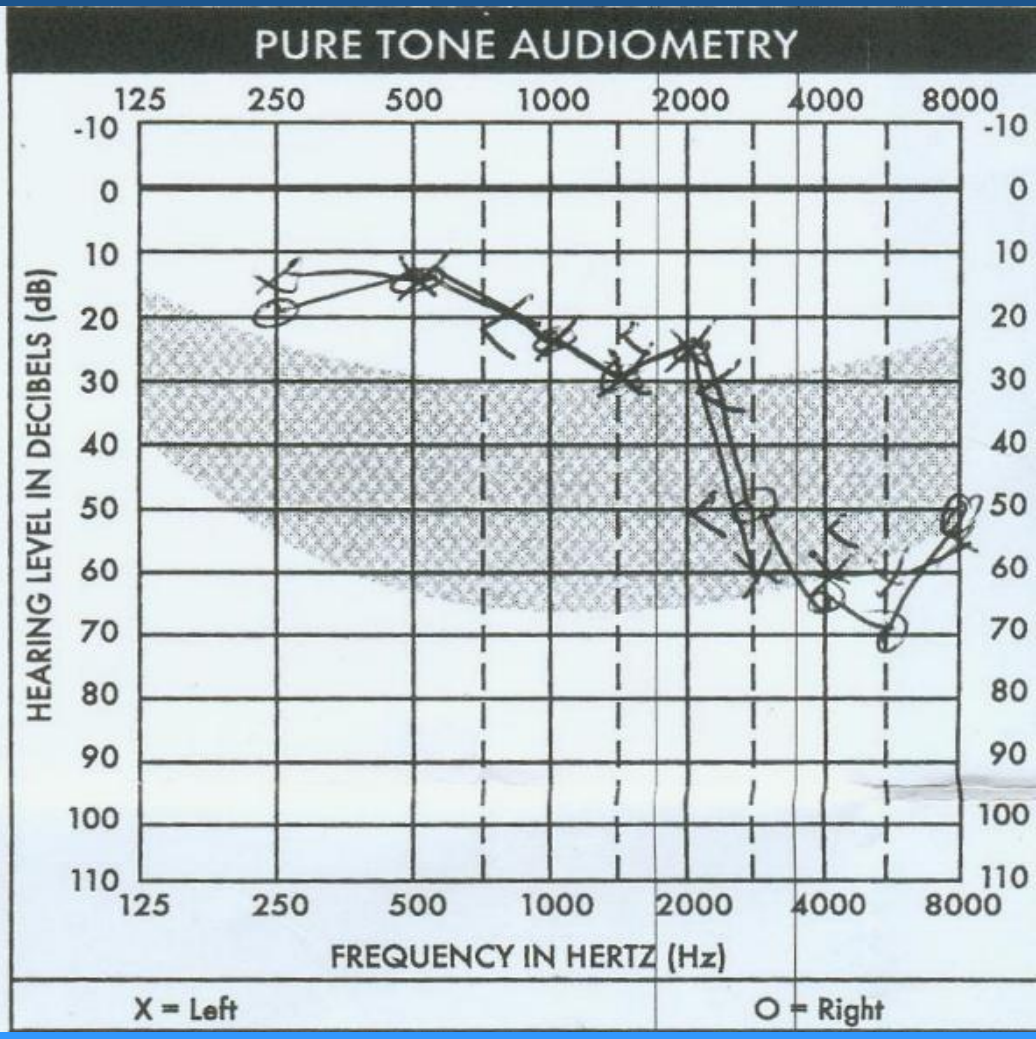
Working diagnosis: Meniere's

Audio


SPEECH DISCRIMINATION
PERCENT % AB WORDS (1984)
100
80
60
40
20
0
0
20
40
60
80
100 dBSPL


TYMPANOGRAM
-400
-300
-200
-100
0
+100
+200
COMPLIANCE IN cc:
C +200
C MEP
C TM
MEP (mmW)
TYPE
R
L


Audiometer
Calibration Date
Head Phones
Insert Phones


PURE TONE AUDIOMETRY
125
250
500
1000
2000
4000
8000
-10
0
10
20
30
40
50
60
70
80
90
100
110
HEARING LEVEL IN DECIBELS (dB)
FREQUENCY IN HERTZ (Hz)
X = Left
O = Right

Later developments

One month later

“Couldn’t read half of what he was looking at”

Words “seem to slip away”

Still transient vertigo

Examination

Examination unremarkable

No neurological signs

Later developments

Another three weeks later

Severe incapaciatating dysequilibrium

Unable to stand/walk unsupported

No vertigo/cochlea sysmptoms

Examination

Wide based gait

Cerebellar exam within normal limits

Gaze paretic nystagmus for rightward gaze

But not for leftward gaze

Examination

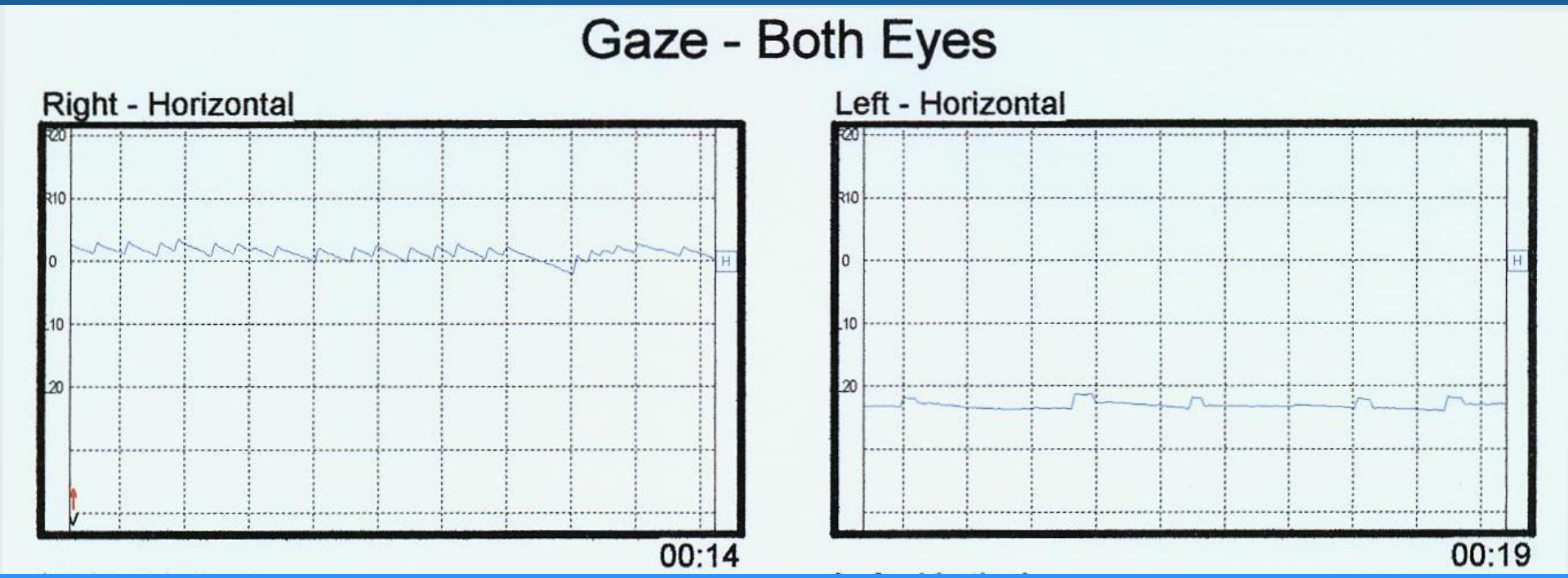
Wide based gait

Cerebellar exam within normal limits

Gaze paretic nystagmus for rightward gaze

But not for leftward gaze (printout)

Gaze paretic nystagmus



Examination

Wide based gait

Cerebellar exam within normal limits

Gaze paretic nystagmus for rightward gaze

But not for leftward gaze (printout)

Saccadic smooth pursuit

Examination

Wide based gait

Cerebellar exam within normal limits

Gaze paretic nystagmus to rightward gaze

Saccadic smooth pursuit

Dysmetric saccades video printout 2

Examination

Wide based gait

Cerebellar exam within normal limits

Gaze paretic nystagmus to rightward gaze

Saccadic smooth pursuit

Dysmetric saccades

Asymmetric OKN right left printout

Examination

Wide based gait

Cerebellar exam within normal limits

Gaze paretic nystagmus to rightward gaze

Saccadic smooth pursuit

Dysmetric saccades

Asymmetric OKN

Head pulsion positive to left printout

Examination

Wide based gait

Cerebellar exam within normal limits

Gaze paretic nystagmus to rightward gaze

Saccadic smooth pursuit

Dysmetric saccades

Asymmetric OKN

Head pulsion positive to left printout

Bithermal calorics no asymmetry

Assessment

No more vertigo

Positive head pulsion implies vestibular involvement peripheral/central

Central signs on eye movement assessment

No unilateral vestibular weakness on calorics

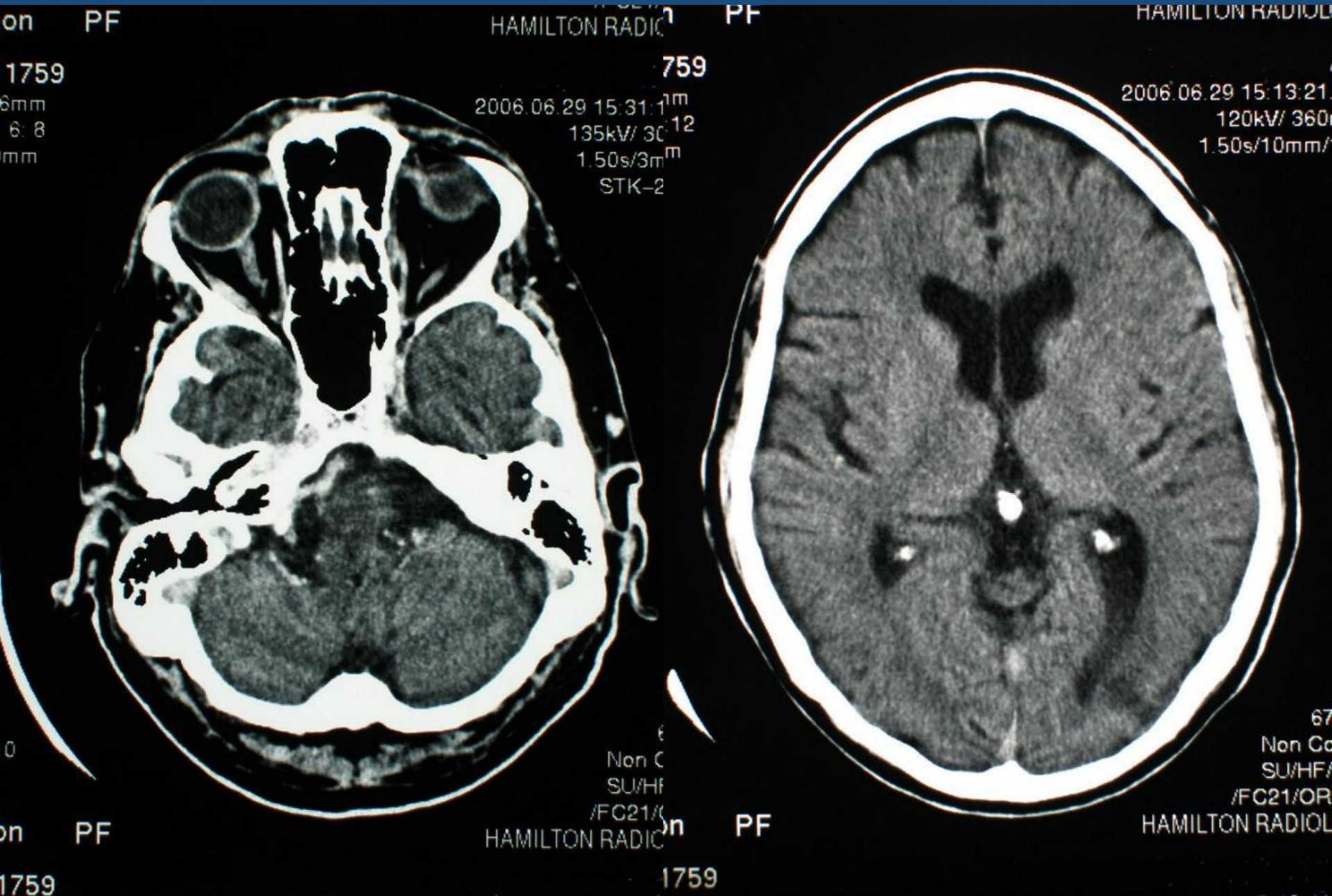
Diagnosis: ?

Diagnosis

Must be central

MRI

Multiple subtle CNS lesions probably ischaemic in origin



Progress

Referred to a neurologist

But admitted to Waikato Hospital with suspected TIA before the appointment

Middle ear disease and Balance dysfunction

AR Currie

Tangmere Clinic
8 Mill Lane
Hamilton

Tel: 07 839 5562
Fax: 07 839 5568
E-mail: tangmere@clear.net.nz