Vestibular Rehabilitation

Examination and Treatment

VestibularFirst

Introduction: Course Instructor

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- Emory-trained vestibular clinician
- Neurologic Clinical Specialist since 2018
- Teaches at Harcum College, St. Joseph University, and Arcadia University
- Co-Founder of Vestibular First

Introduction: Disclosures

Helena is Chief Clinical Officer and Co-Founder of Vestibular First.

Conflict of Interest Statement: The speakers are employed at Vestibular First, a company that makes infrared video goggles. This lecture does include a discussion of the clinical benefits of infrared video goggles in general as demonstrated in the academic literature, but this lecture does not specifically recommend any particular brand.

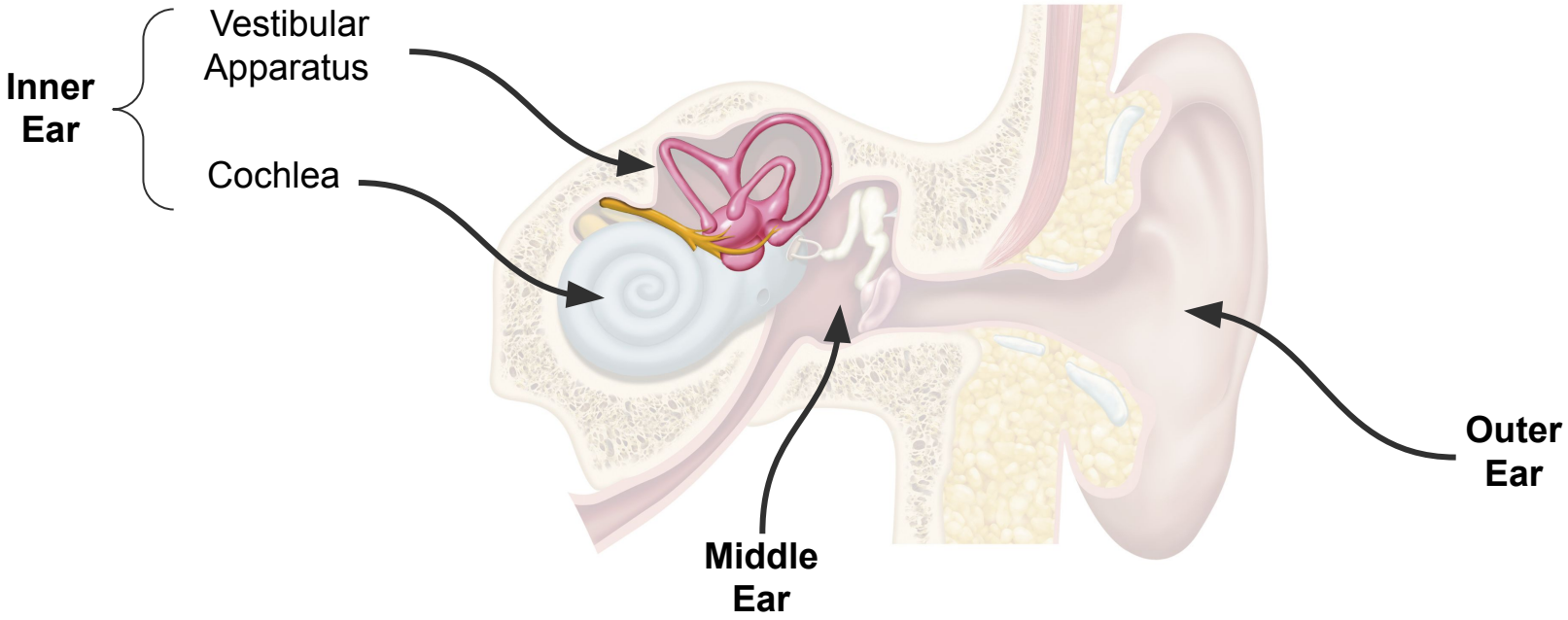
Objectives

1. Oculomotor and vestibular examinations and tests and their interpretation
2. Differential diagnosis including peripheral and central vestibular conditions
3. Planning of intervention - including dose and specific and functional training

Peripheral vs Central Anatomy Review

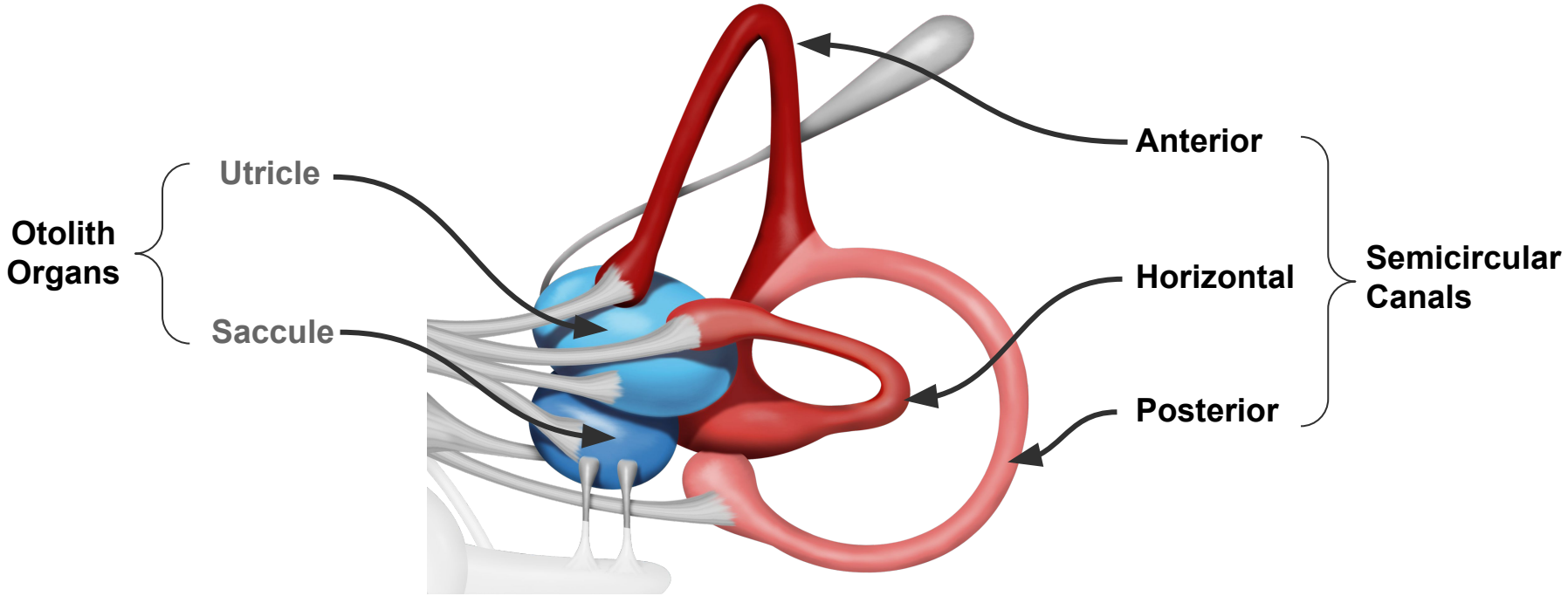
Peripheral Vestibular Anatomy

The inner ear is comprised of two connected organs: The vestibular apparatus and the cochlea. These membranous organs are well protected inside a cavity in the temporal bone.



Johnson Chacko et al., 2018

Organs of the Vestibular Apparatus

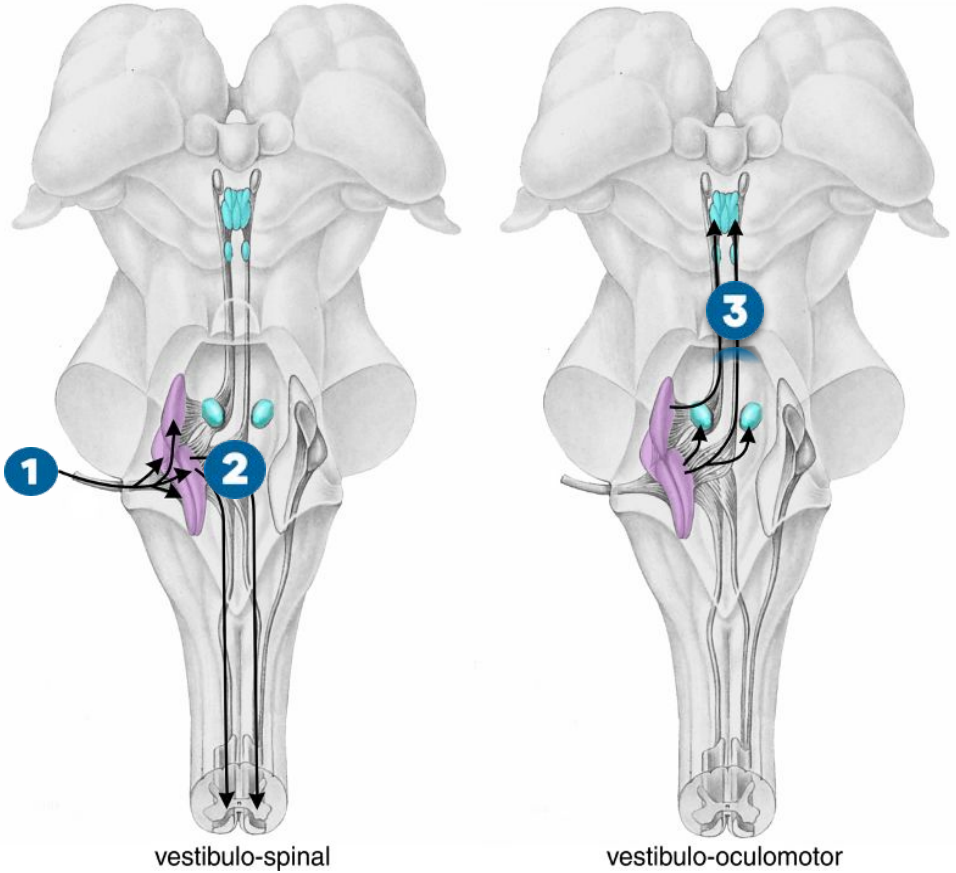


Herdman and Clendaniel, 2014

Brainstem Vestibular Pathways

Vestibulo-Oculomotor Pathways

1. Incoming pathways from the peripheral vestibular system
2. Pathways to the cerebellum and the cerebral cortex
3. Outgoing pathways to motor nerves in the eyes

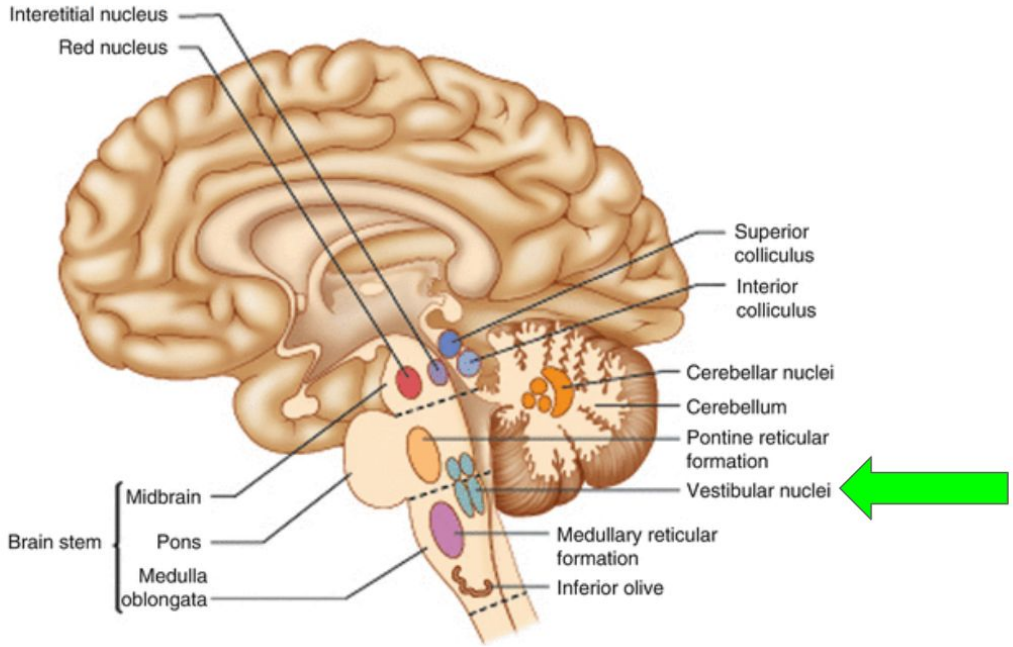


Dieterich et al., 2017

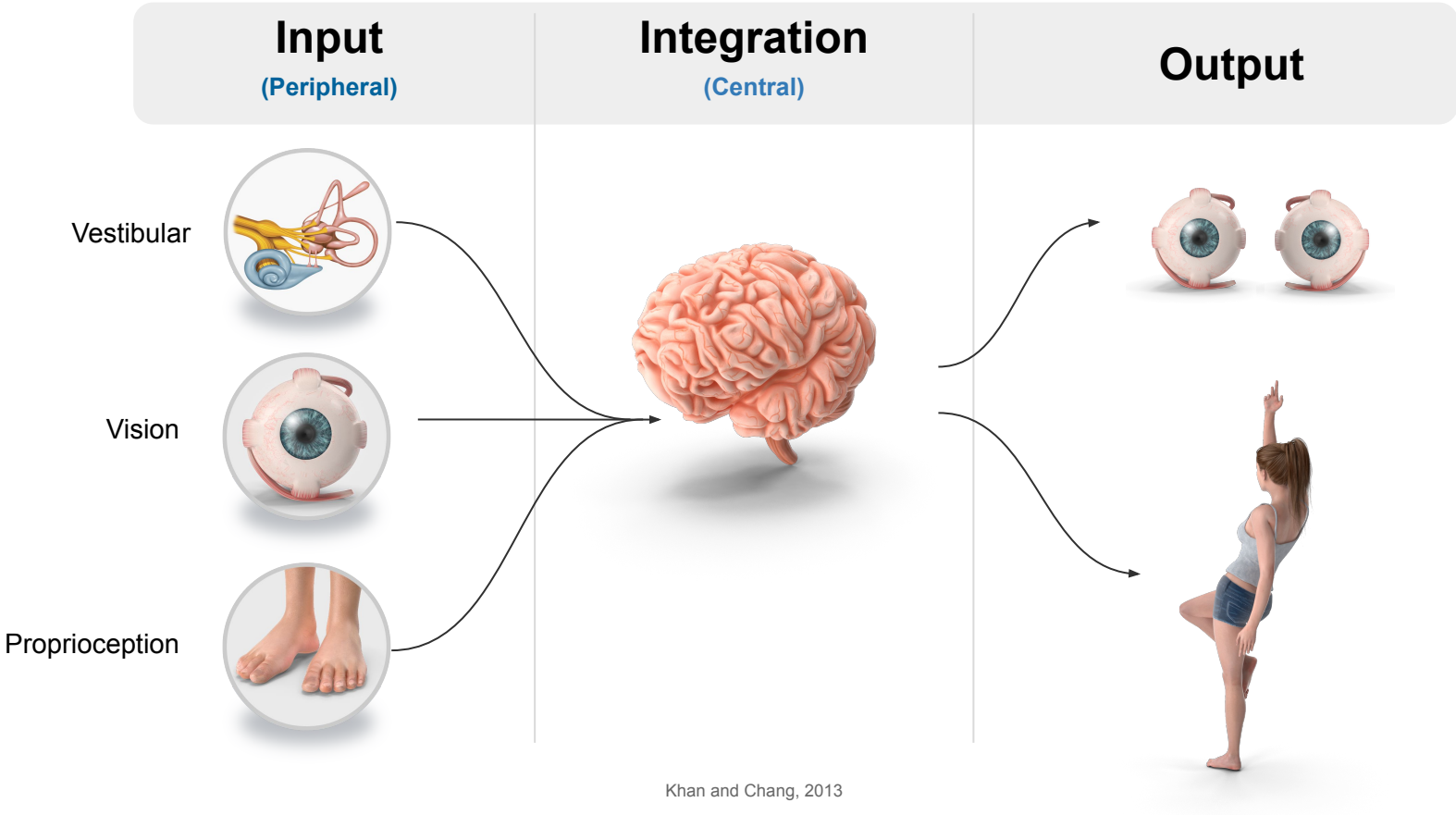
Central Vestibular Anatomy

Major areas of the brain with vestibular pathways:

- brainstem - pons/medulla
- direct projections into the cerebellum



Vestibular System Overview

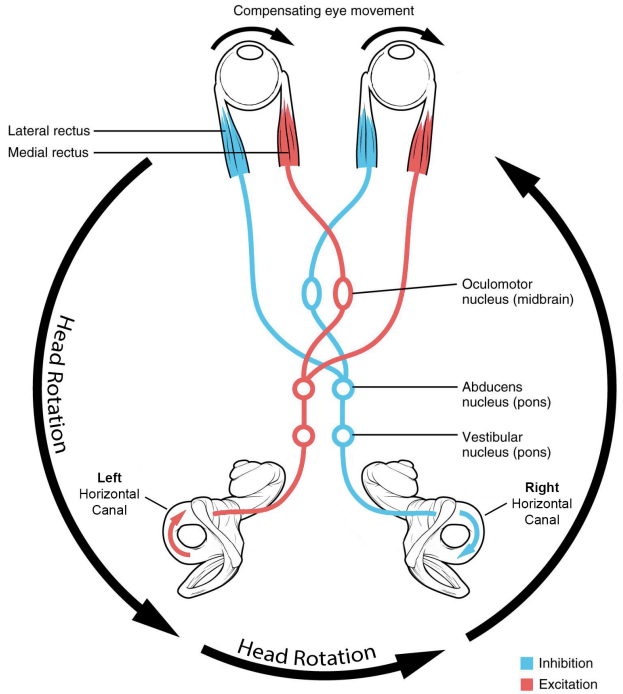


Khan and Chang, 2013

How to Observe Eye Movements and Instrumented Vestibular Testing Primer

The Eyes Have It

The eyes and inner ear have an important relationship thanks in large part to the vestibulo-ocular reflex, which is why observing eye movements is key to identifying vestibular pathologies

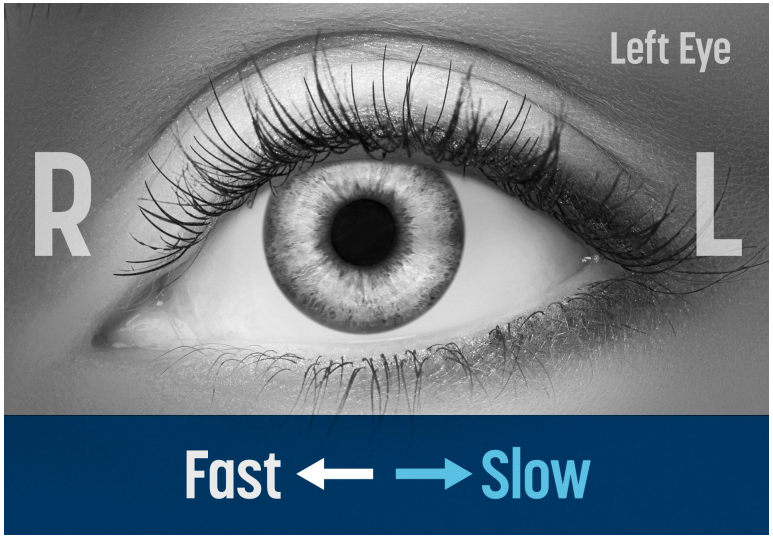


Herdman and Clendaniel, 2014

Nystagmus Basics

Nystagmus is an involuntary, rapid, rhythmic, oscillatory eye movement with at least one slow phase (Bárány Society)

- **Involuntary** - cannot be controlled/caused consciously
- **Rapid -** fast
- **Rhythmic** - occurring regularly
- **Oscillatory** - back and forth



This nystagmus has a **fast** phase to the patient's right and a **slow** phase to the left.

Eggers et al., 2019

Methods for Observing Eye Movements

Room Light

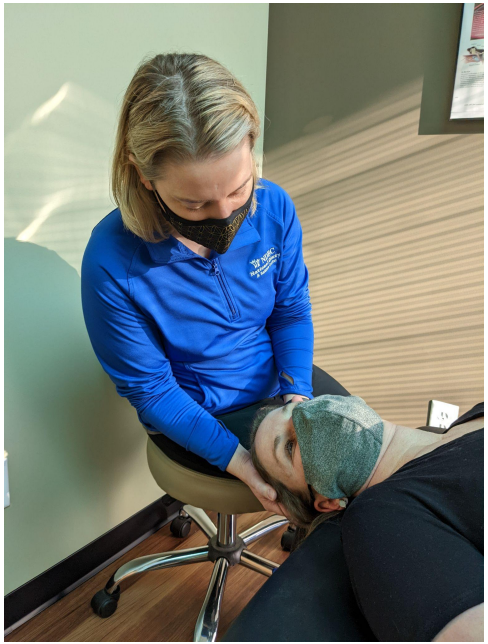
Frenzel Lenses

Infrared Video Goggles

Chang et al., 2018

Room Light Observation

- Inexpensive method of observation for nystagmus
- Eye movements can be missed since visual fixation is not removed
- 66% of abnormal eye movements missed in patients with BPPV
(Ozel et al., 2022)
- Allows direct observation of eye movements when a target is used such as convergence or optokinetic nystagmus/moving visual field induced nystagmus
- Starting with room light observation is a first step in looking at eye alignment



Observing with Frenzel Lenses

- Thickened lenses, with or without a light, used to magnify the eyes
- Able to partially block fixation
- Does not record eye movements
- More modern versions can use a cell phone to record but again often do not fully block fixation and can have logistical challenges

Gold D.Dix-Hallpike Maneuver in Posterior BPPV with Reversal of Nystagmus on Sitting Up.

https://collections.lib.utah.edu/ark:/87278/s6ng8nbm

Observing with Infrared Video Goggles

- Infrared cameras inside of light-blocking goggles allow for viewing and recording eye movements with visual fixation removed (in the dark)
- Turning on a visual fixation light can be used to help determine central vs peripheral vestibular source of any nystagmus viewed
- Research has shown that 100% of abnormal eye movements can be seen with infrared video goggles, as opposed to 33% with Frenzel lenses

Ozel et al., 2022

Baba et al., 2004

How to Observe Eye Movements Summary

- Before any testing is completed, observe a patient's eyes in room light to observe for any abnormalities of alignment in primary gaze
- There are 3 main ways to observe for nystagmus - room light, Frenzel lenses, and infrared video goggles
- Abnormal eye movements are missed about 66% of the time if a clinician is not using visual fixation removed conditions via infrared video goggles

Eye Movements Seen with Oculomotor Testing

Oculomotor Testing

- **Oculo** means eye and **motor** implies movement, so these tests are designed to examine eye movement responses to various stimuli
- The purpose is to assist clinicians in identifying eye movements that may be indicative of central and/or peripheral vestibular pathology

Note: It may be helpful to have a patient remove their glasses if the rims are very thick, since otherwise the patient may appear to have abnormal eye movements when actually the eye movements are interrupted by viewing the rim edges

Stoddart et al., 2000

Spontaneous Nystagmus

Spontaneous Nystagmus is a pathologic eye movement viewed when the person is looking straight forward (in primary gaze)

- **Central vestibular pathology** - direction of the nystagmus may be vertical, horizontal, or torsional
- May not be present at all in central vestibular conditions, but more common with acute or significant lesions (stroke, multiple sclerosis exacerbation, severe brain injury)

Jeong et al., 2022; Jacobson et al., 2008

Spontaneous Downbeating Nystagmus

Spontaneous Downbeating Nystagmus

Hain, TC.
https://www.dizziness-and-hearing.com.

https://dizziness-and-balance.com/practice/movies/vertical/downbeating.mp4

Gaze-Evoked Nystagmus

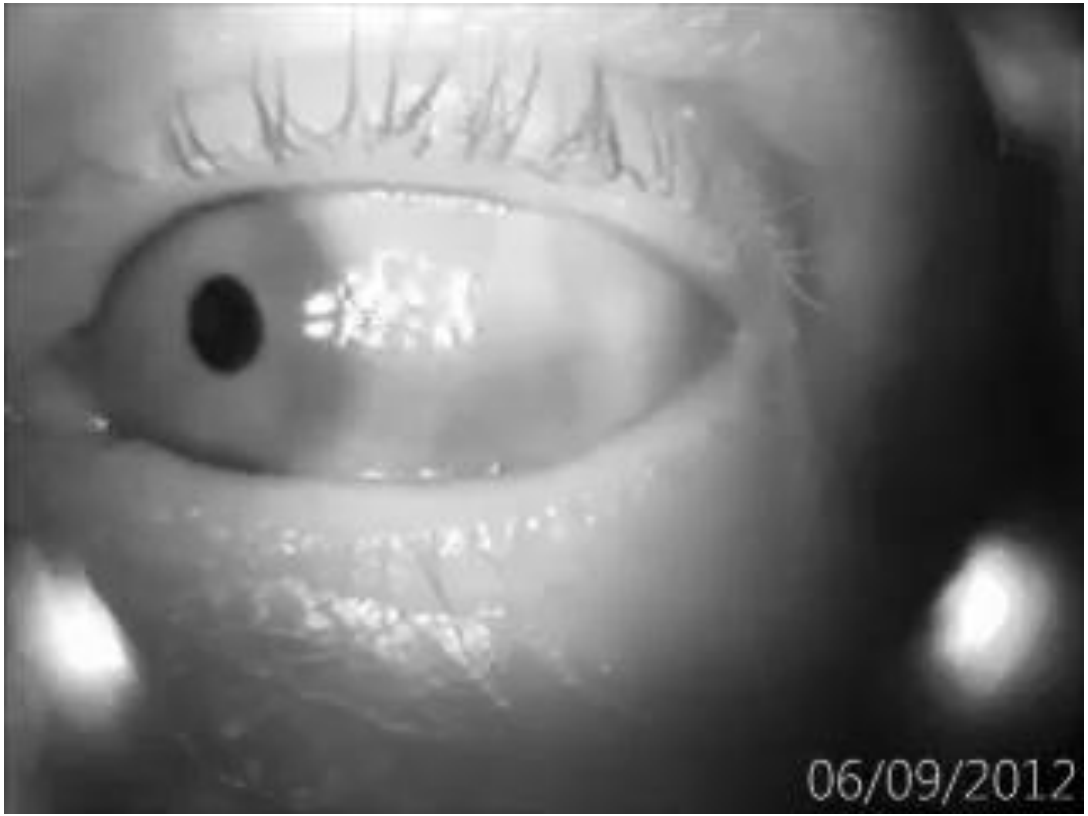
Gaze-Evoked Nystagmus is a pathologic eye movement induced by moving the eye into an eccentric or non-forward 30 degree position in the orbit (not end-range gaze)

- **Central vestibular pathology** - direction of the nystagmus may occur in whichever direction the patient is gazing and may be horizontal and/or vertical
- Overall, nystagmus in central conditions does not follow rules

Jeong et al., 2022; Jacobson et al., 2008

Gaze-Evoked Nystagmus

Gaze-Evoked Nystagmus



Hain, TC. Gaze Evoked Nystagmus.

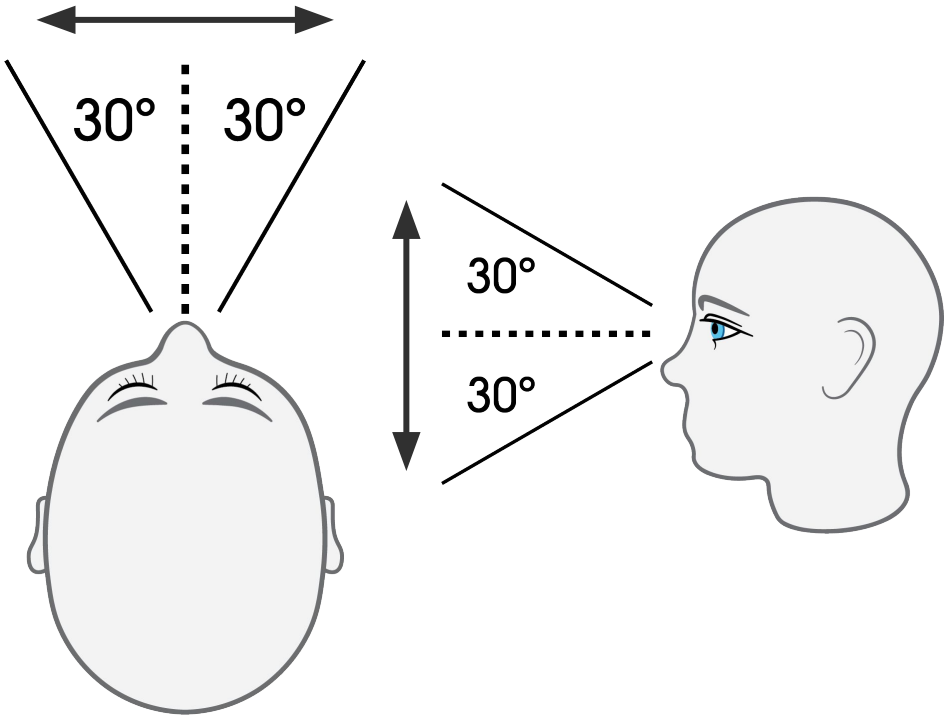
https://dizziness-and-balance.com/practice/movies/gaze/Gaze%20evoked%20nystagmus%20short.mp4

VOMS

- The Vestibular Ocular Motor Screening Tool (VOMS) Assessment is used as a brief 5-10 minute concussion screening tool.
- It is designed to look at both ocular and vestibular function post concussive injury.

Smooth Pursuit

- Clinician is seated about 1.5 ft (0.46 meters) away from the patient
- Patient's eyes **remain fixed** on a **moving target** AKA "follow the end of my finger with your eyes, but don't move your head"
- Target (finger or pen) must be **moving** less than 30 degrees/sec - don't go too fast!
- Target must be **discrete point** (end of finger or pen pointing toward patient)
- Presence of saccadic intrusions found in various **central vestibular disorders**



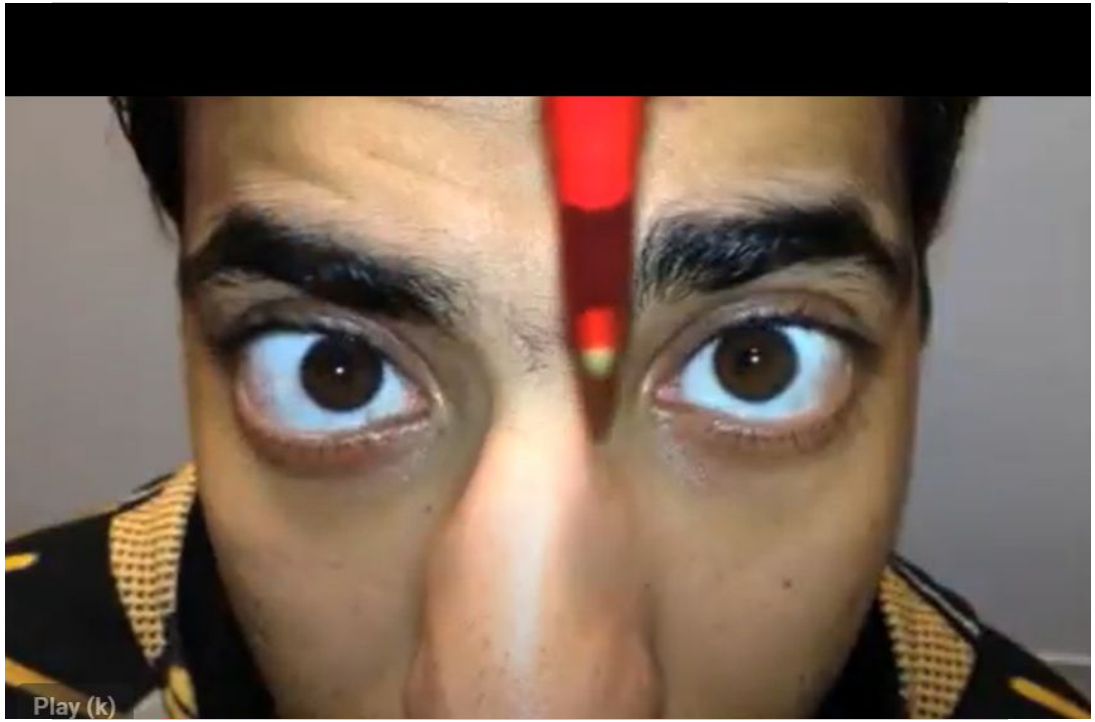
Balaban et al., 2016

Smooth Pursuit

https://youtu.be/Pl7epQ8hW_4?si=mYIceO01y9eh9rQW

Abnormal Smooth Pursuit

Abnormal Smooth Pursuit



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Gold DR. Saccadic smooth pursuit and vestibulo-ocular reflex suppression (VORS)

Saccades

Saccades are eye movements that change the point of fixation such as “look at the end of my finger, now look at the end of my pen”

- Targets must be on the **same plane** (the end of the pen is not closer to patient than the finger)
- Targets must be **discrete points** (end of finger or pen that is held parallel to the floor with an end pointing towards the patient)
- Presence of abnormal saccades found in various **central vestibular disorders**

Terao et al., 2017

Normal Saccades

https://youtu.be/T2k1n7GmMoQ?si=87xKv39ie_SSlKoO

Abnormal Saccades

Dysmetric saccades - general term to state that the eyes do not reach their intended target

Types of abnormal saccades

- **Hypermetric**
  - Overshoot of the target
  - Eyes will go past the target then come back to it
- **Hypometric**
  - Undershoot of the target
  - Eyes stop short of the target and then go to it

Termsarasab et al., 2015

Abnormal Saccades - Overshoot / Hypermetric

https://collections.lib.utah.edu/ark:/87278/s65176w6

Abnormal Saccades - Undershoot / Hypometric

Gold D. Unidirectional nystagmus in lateral medullary syndrome.

https://collections.lib.utah.edu/ark:/87278/s6h4514n

VOR Cancellation

VOR Cancellation acts to **override** the Vestibular Ocular Reflex (VOR)

- Observed by asking a person to follow a **moving** target while the patient's head moves as well (eyes/head move together)
- Eyes should move **smoothly** with no saccadic intrusions
- Abnormal VOR cancellation found in **central vestibular pathology**

Belton and McCrea, 2000

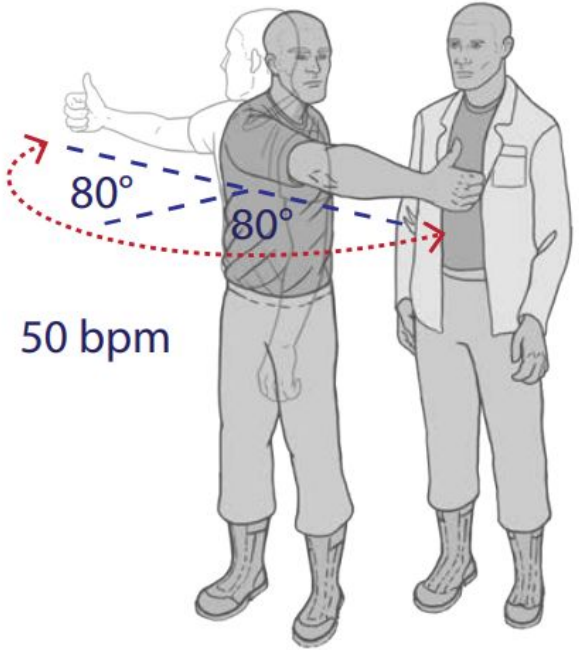
Normal VOR Cancellation

https://youtu.be/7Nw3TgieAjI?si=4YOSViWTXaZATJej

Alternative for VOR Cancellation Test

Visual Motion Sensitivity - metronome 50 bpm

- Have the patient stretch out their arm in front of them and focus on their thumb.
- Ask the patient to twist their head and trunk as a unit from 80° right to 80° left in time to the metronome beat. Perform 5 times.
- Have the patient rate HDNF on a scale of 0 to 10. Record the results.

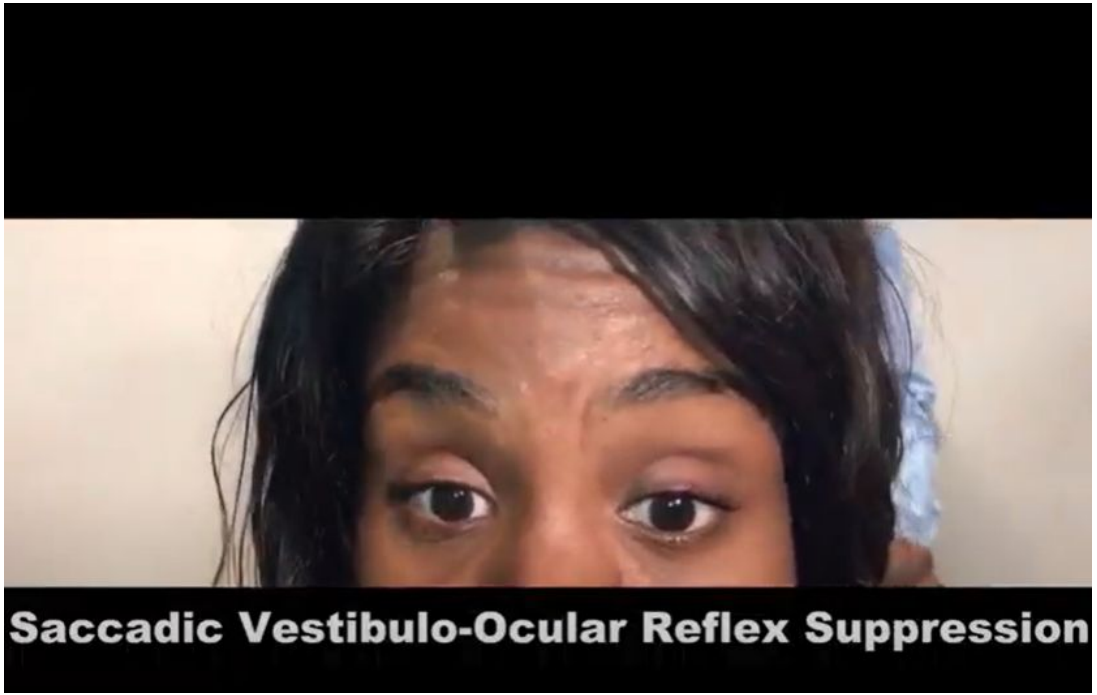


Short on time? Try the mVOMS!

Smooth pursuits, horizontal saccades, horizontal vestibulo-ocular reflex, and visual motion sensitivity

(Ferris et al., 2022)

Abnormal VOR Cancellation



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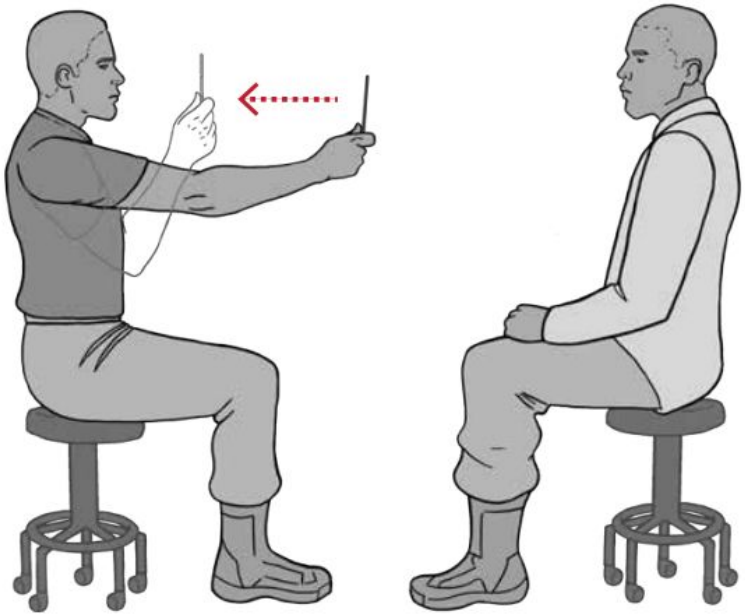
Gold D. Ocular Motor Signs of Cerebellar Ataxia - Gaze-Evoked Nystagmus, Saccadic Pursuit, and VOR suppression.

Convergence



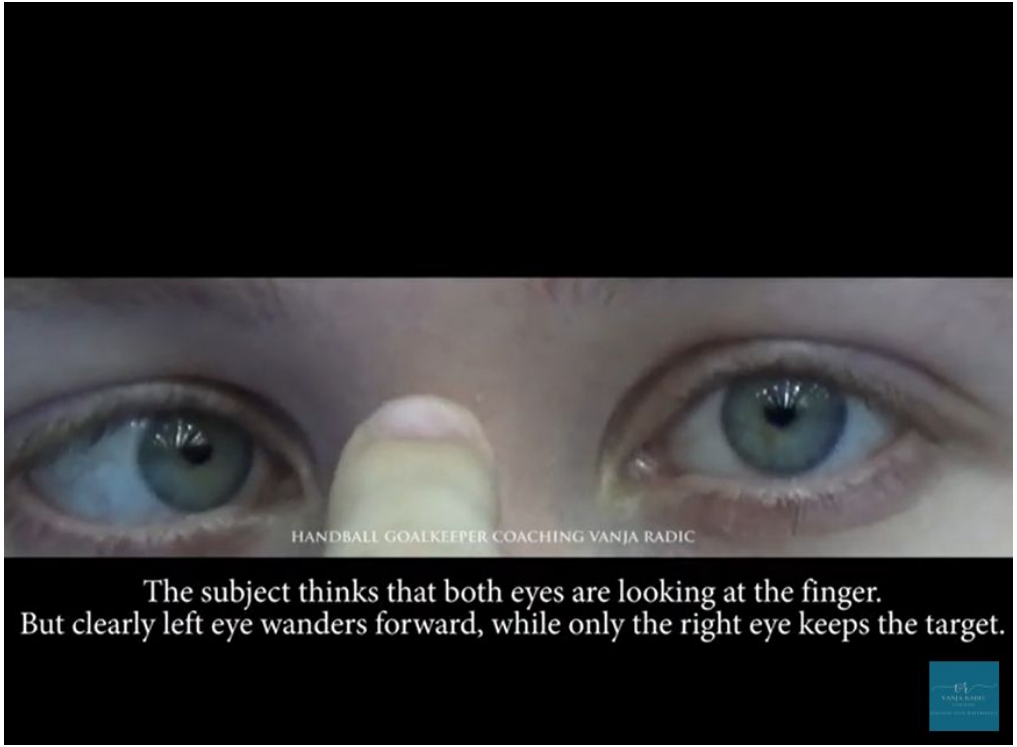
- Ask the patient to slowly move the target toward the tip of their nose and stop when they see two distinct images, or when you see an outward deviation of the eye.
- Measure the distance between the nose and the target, and record it in centimeters. Repeat 2 more times.
- Convergence points greater than or equal to 5 centimeters are considered abnormal.
- Have the patient rate HDNF on a scale of 0 to 10. Record the results.

(Korda et al., 2022; image Rainer et al., 2017)

Convergence

- While performing the test, the examiner should observe both eyes of the patient because some patients do not notice diplopia when one of the eyes is not fixating to the object

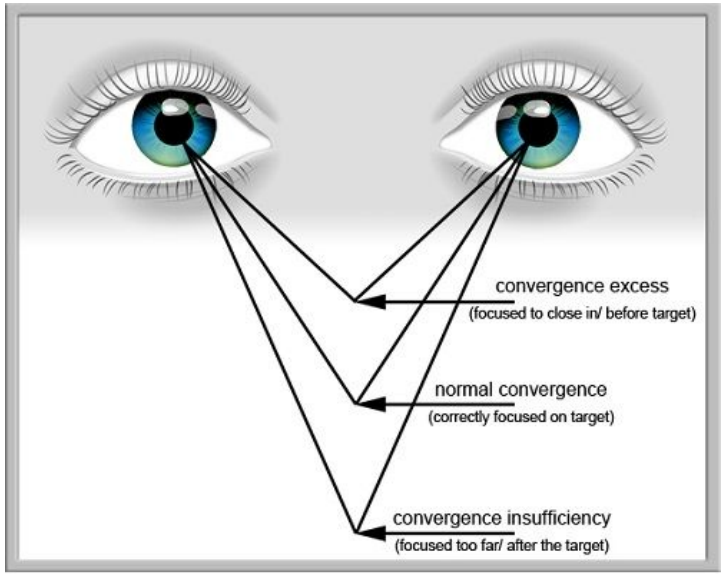
- This point is the near point of the convergence (NPC) and can be measured the same as when a patient sees the fixation object double



https://youtu.be/3IellKJnOJA?si=pAhxJfvYOUynILm3

Convergence

- A number of studies suggest that vergence system abnormalities are the most common dysfunction observed in mild traumatic brain injury, with the majority of cases exhibiting convergence insufficiency
- Convergence insufficiency = inability of the eyes to draw together sufficiently at a given distance to bring an object into focus, particularly the nearer the object is
- Convergence insufficiency may develop after migraine



Nisted et al., 2024; Singman et al., 2014

Vestibulo-oculomotor Screening

VOMS SCORING SHEET

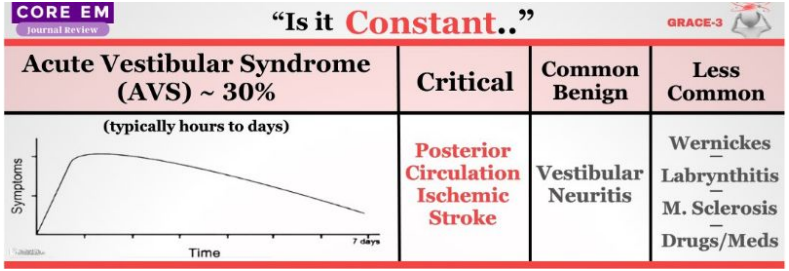
Symptoms on a 0-10 point scale

Vestibular/ Oculomotor	Type	Not Tested	Headache	Dizziness	Nausea	Fogginess	Comments
Baseline Symptoms							
Smooth Pursuit							
Saccades (Horizontal)							
Saccades (Vertical)							
Convergence (Near Point)							Score#1_____cm Score#2_____cm Score#3_____cm
VOR Horizontal							
VOR Vertical							
Visual Motion Sensitivity							

GRACE-3: Guidelines for the ED

HINTS protocol is a cluster of clinical tests used to better differentiate the presence of posterior circulation stroke in acute vestibular syndrome

- Head Impulse test
- Nystagmus - qualities of spontaneous nystagmus
- **T**est of **S**kew - assessment of signs of new eye misalignment potentially consistent with central neurologic issue such as posterior circulation stroke



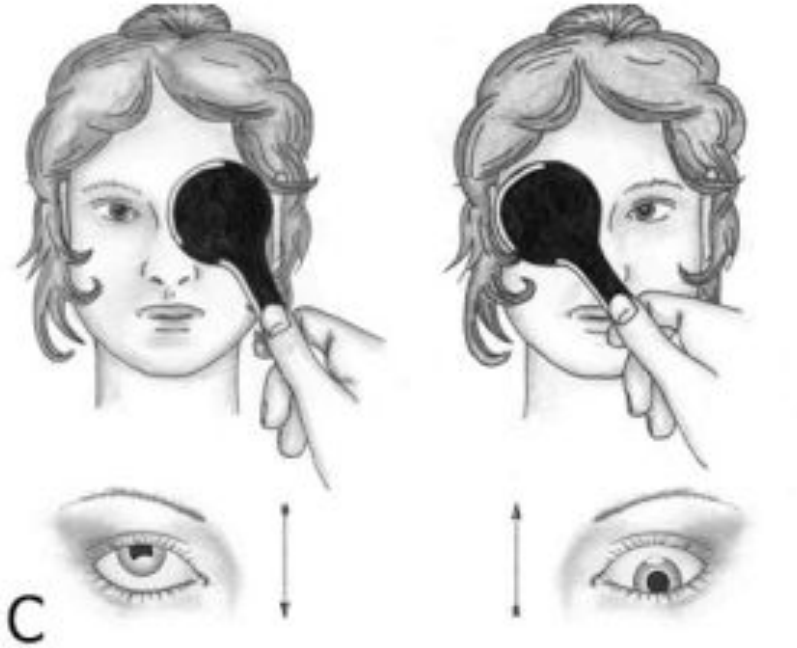
(Edlow et al., 2023)

Test of Skew

- Ask the patient to look forward, then cover one of their eyes, then switch the cover to the other eye

- Watch for the recently uncovered eye for a horizontal or vertical eye alignment shift

- Skew deviation in patients with AVS occurs in every fourth patient with acute unilateral vestibulopathy, but large skew deviations (> 3.3 deg) point toward a central lesion



(Korda et al., 2022; image Rainer et al., 2017)

Abnormal Test of Skew

https://youtu.be/zgqCXef-qPs?si=n7-i8CZ4QuNt5Nip

Johns, P. Abnormal test of skew. Used with permission.

When to Refer

Report hearing symptoms

- **Constant tinnitus, gradual hearing loss, etc. -** need a hearing test (audiogram)
  - Could be symptom of vestibular schwannoma, third window syndrome, Meniere's disease, etc.
  - Get a baseline in case of changes that can help with diagnosis over time (example: after a few episodes of Meniere's attacks)
- **Hearing symptoms can be due to central vestibular issues** - monitor for sudden hearing loss (can be a sign of stroke) or could be a symptom of migraine (rule out ear)

Worsening symptoms despite vestibular rehab or new neurologic signs

- **May need additional testing to rule out a gradual onset pathology**
  - Example: CANVAS - cerebellar ataxia, neuropathy, and vestibular areflexia syndrome presents with gradual onset cerebellar signs, limb sensory deficits, and bilateral vestibular loss

Eye Movements Seen with Oculomotor Testing Summary

- Oculomotor testing assists clinicians in identifying eye movements that may be indicative of central and/or peripheral vestibular pathology
- Abnormal Smooth Pursuit, Saccades, VOR cancellation, OPK Nystagmus, and Skew Deviation (particularly in context of acute vestibular syndrome) are central signs and may warrant referral to another provider
- Gaze evoked can also indicate central pathology if the direction changes with each direction of gaze

Oculomotor Testing Lab

Testing for Signs of Central Vestibular Dysfunction

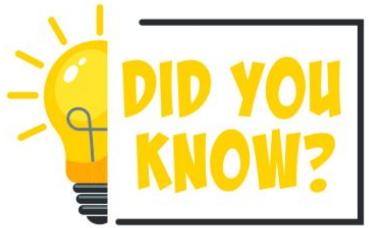
- Spontaneous and gaze-evoked nystagmus
- Saccades
- Smooth Pursuit
- VOR Cancellation
- Convergence (may be abnormal with concussion or migraine)
- Test of skew (cross cover or alternating cover test)

Testing For Peripheral Vestibular Hypofunction

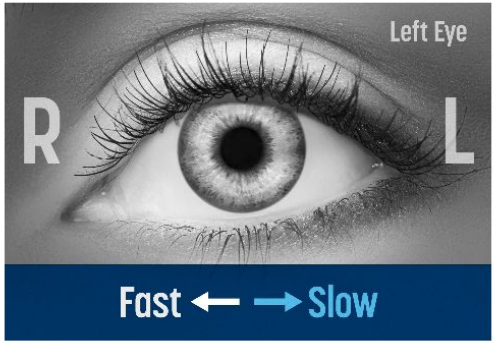
Spontaneous Nystagmus

Spontaneous Nystagmus is a pathologic eye movement viewed when the person is looking straight forward (in primary gaze)

- **Peripheral vestibular pathology** - direction of nystagmus stays consistent with fast beat towards a single direction (left or right, never vertical; rarely downbeat torsional if inferior branch of vestibular nerve only one affected)
- Only usually present for the first 1-2 weeks in room light



Why do I use infrared video goggles daily?



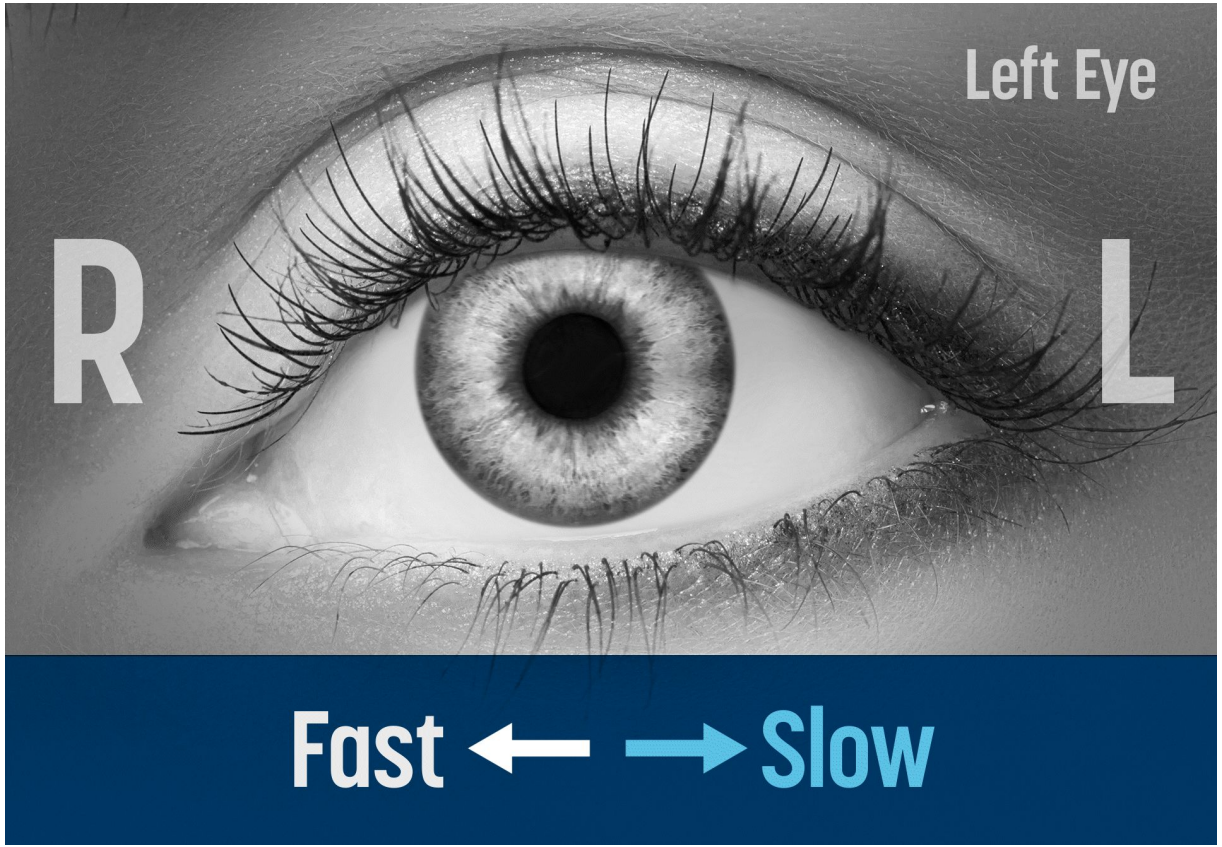
Right beat nystagmus consistent with left unilateral vestibular loss

Weak nystagmus in the dark persists for >30 days in 77.8% of patients after acute unilateral vestibular loss

(Chen, Bery, and Chang, 2023)

Jeong et al., 2022; Jacobson et al., 2008

Spontaneous Right-Beating Nystagmus



Spontaneous Unidirectional Horizontal Nystagmus

Ochitwa K. North 49 Physio. Used with permission.

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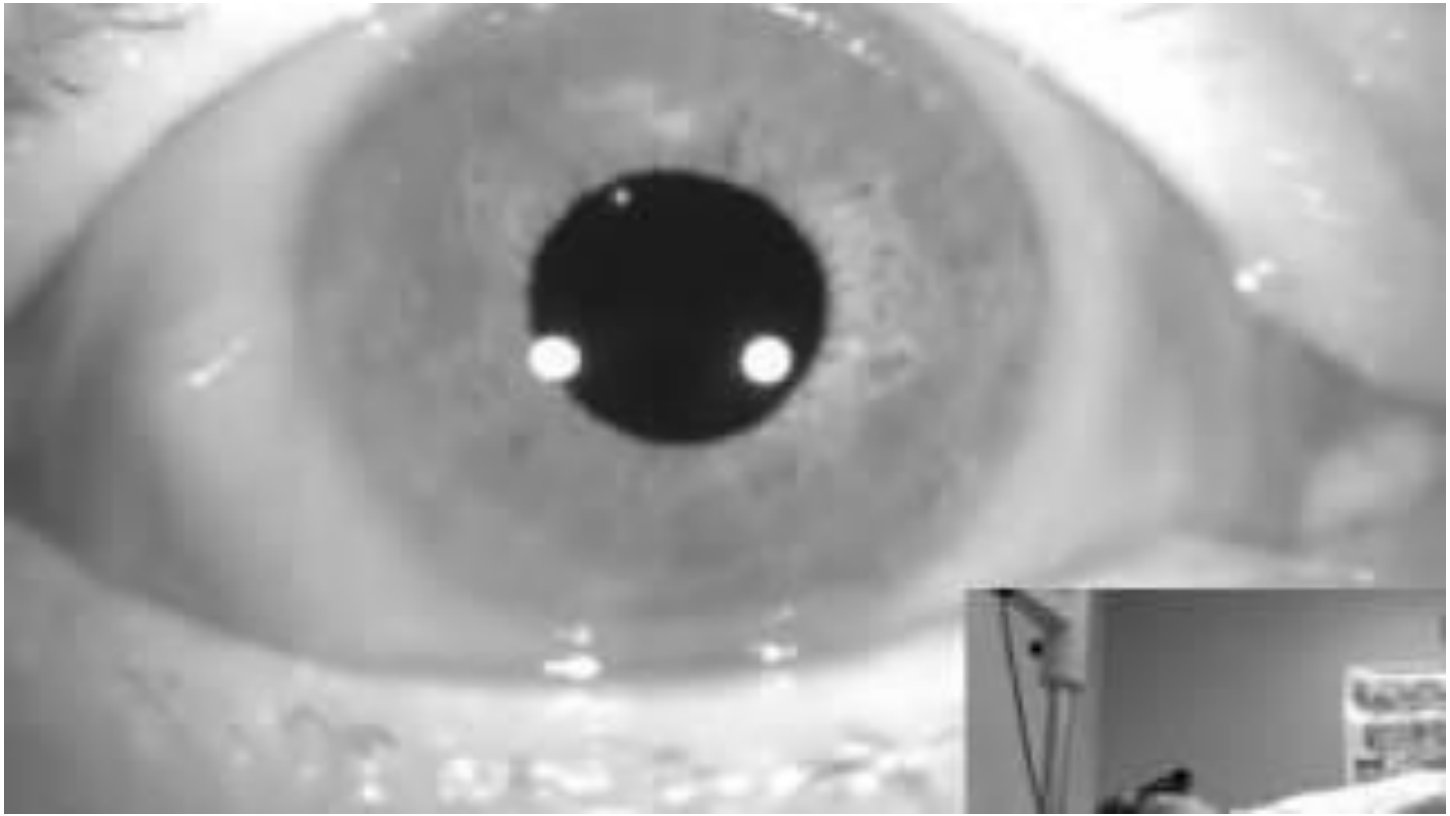
Peripheral Nystagmus Suppression with Visual Fixation



Teixido M. Used with permission.

https://youtu.be/-5Pd15V47Ow?si=NbJRkbMuIiiYnIJF

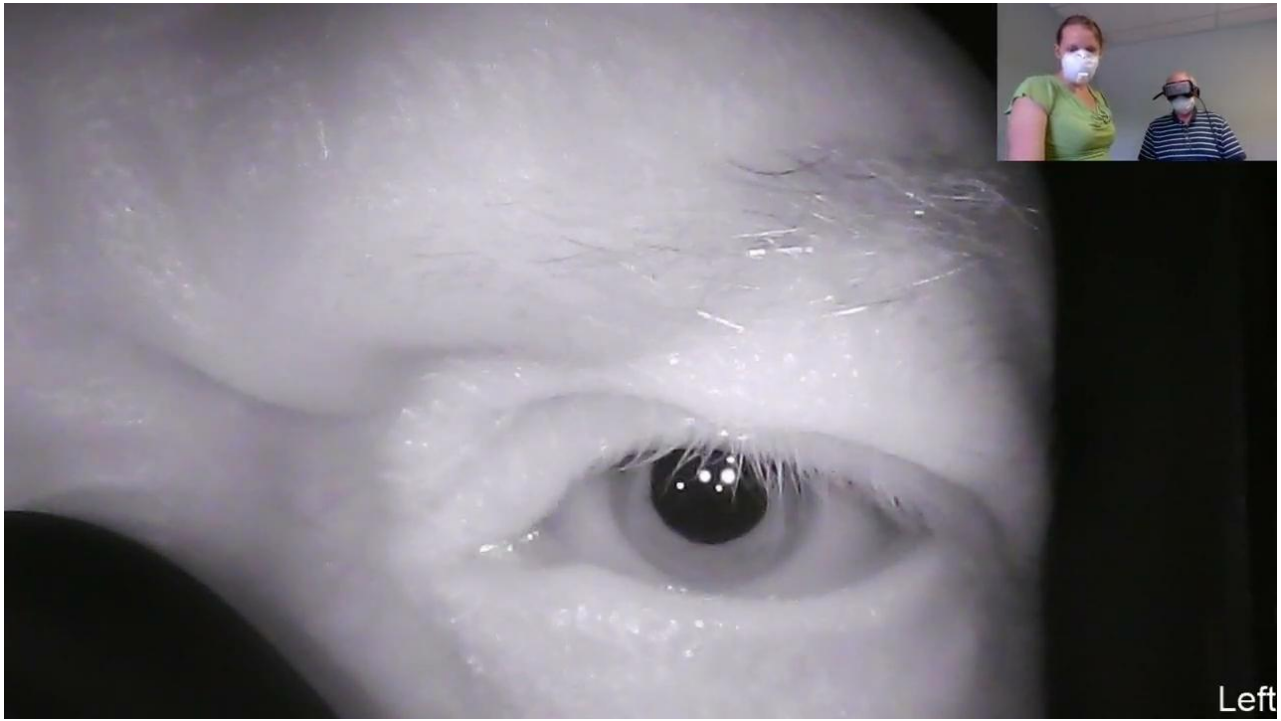
Gaze-Evoked Nystagmus

Gaze-Evoked Nystagmus is a pathologic eye movement induced by moving the eye into an eccentric or non-forward 30 degree position in the orbit (not end-range gaze)

- **Peripheral vestibular pathology** - direction of nystagmus stays consistent with fast beat towards a single direction (left or right, never vertical)
- **Follows "Alexander's Law"** - gazing in direction of the fast beat should increase the strength of that nystagmus, and gaze away from the fast beat should reduce or eliminate the nystagmus

Jeong et al., 2022; Jacobson et al., 2008

Left Beating Nystagmus Increased Left Gaze



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Head Impulse Test

- Assesses the **Horizontal Canal** and **Superior Vestibular Nerve Function**
- Small amplitude high acceleration head movement to test the **VOR**
- The direction in which you are moving the head quickly is the side you are testing
- Person's eyes remain **fixed** on the examiner's nose while the **head is moved quickly** to either side. Instructions: "Keep your eyes on my nose while I move your head"
- Abnormal if a **compensatory** or **catch-up saccade** is seen

Weber et al., 2008

Normal Head Impulse Test

https://youtu.be/yda8gQWRiDQ?si=XLs4tC-aZe4IRw1B

Abnormal Head Impulse Test

Johns, P. Positive Head Impulse Test.

https://youtu.be/rr-MFxDcwWs?si=s3IwiHHBx5bU5hZV

Horizontal Head Shake Test

Nystagmus Provoked by Test

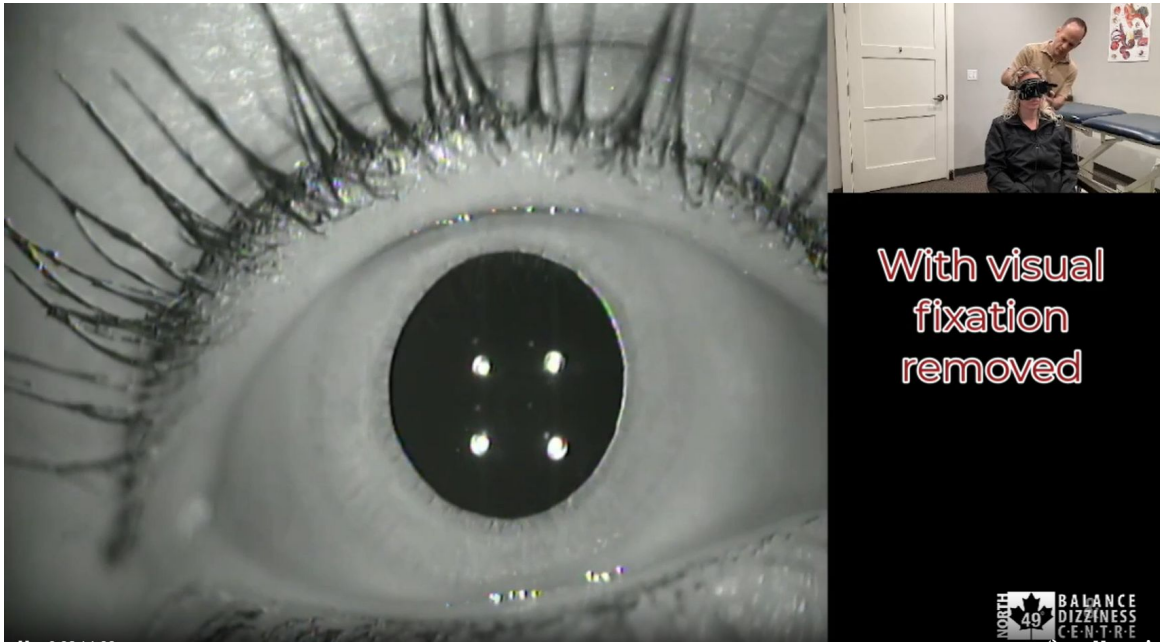
https://youtu.be/LuWnB5xjuJc?si=KOfhM1Sxzej5ZD8_

Skull Vibration-Induced Nystagmus Test

Vibration-Induced Nystagmus (Dumas et al., 2020)

Utility	Benefits	Challenges
Identifies unilateral vestibular hypofunction	Useful when unable to get a good head thrust/impulse test ● Pt is guarding motion ● Post-trauma or post-surgical c-spine precautions	Not able to identify a true bilateral vestibular loss
Simple bedside examination	Useful when neck pain is limiting motion tolerance	Does not provide % weakness for the less active (weaker) side

Skull Vibration-Induced Nystagmus Test



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Dynamic Visual Acuity Test (DVA)

How to perform the dynamic visual acuity test (DVA)

- Get a clinical eye chart (be sure it is properly sized)
  Example: ETDRS Chart

- Ask the patient to read the lowest line that they can read clearly (wearing any usual distance eyewear) while their head is not moving

- Shake their head continuously to a range of 20-30 deg to each side at 2 Hz

- Ask the patient to start at least 6 lines up from where they read when their head was not moving and keep having them read lower on the echart line by line until the letters too blurry for them to read (when they make an error or stop)

Dynamic Visual Acuity Test

https://youtu.be/f6eFoNRMUj4?si=M9DF6SZBy9ARaIAy

Dynamic Visual Acuity Test

DVA test is a functional evaluation of gaze stability which involves central and peripheral vestibular nerve pathways

- Can be abnormal in both central and peripheral conditions
- Helpful to identify persons more likely to benefit from gaze stabilization (VORx1 and x2) exercises

Condition	Anticipated DVA Findings
Unilateral vestibular hypofunction	Acute: likely >2 line difference Compensated: May be normal or mildly abnormal 3 line difference Uncompensated chronic: Often abnormal >2 line difference
Bilateral vestibular hypofunction	Acute: can be 5 line difference or greater Chronic: May improve but often >3 line difference
Central vestibular dysfunction	Can be normal or abnormal (example: multiple sclerosis, cerebellar ataxia)

Dankova et al., 2021; Starkov et al., 2020; Mañago et al., 2016; Herdman 2003

Balance Assessment Tools

Test	Purpose	Falls Risk
Modified Clinical Test for Sensory Interaction in Balance	Standing still balance with feet together on floor then foam with eyes open and then closed	No specific cut-off for falls; reasonable goal is 30 sec each condition
Dynamic Gait Index	Walking balance (easier): more appropriate if uses a walker/rollator, sometimes cane or forearm crutches	Cut-off ≤19/24 indicative of falls risk
Functional Gait Assessment	Walking balance (harder): more appropriate if uses no device, sometimes cane or forearm crutch	Cut-off ≤ 22/30 indicative of falls risk

Eye Movements Seen with Head Impulse Testing Summary

- The head impulse test is a vestibular test that involves a small amplitude, high acceleration head movement to test the VOR
- The direction in which you are moving the head quickly is the side that is being testing
- The head impulse test is abnormal if a compensatory saccade is seen
- An abnormal finding indicates a likely peripheral vestibular hypofunction (damage to the horizontal canal/superior vestibular nerve) on that side

Peripheral Vestibular Testing Lab

Testing for Peripheral Vestibular Hypofunction

- Spontaneous and gaze-evoked nystagmus (acute/subacute 1-2 weeks post event) with beat toward the “good” or “better” side
- Head Impulse Test (head thrust)
- Horizontal head shake test

Differential Diagnosis

Peripheral Vestibular Deficits

Stable Disorders

- **Vestibular Neuritis**
- **Bilateral Vestibular Hypofunction**

Fluctuating Disorders

- Third Window Syndromes such as Superior Canal Dehiscence
- Meniere's Disease

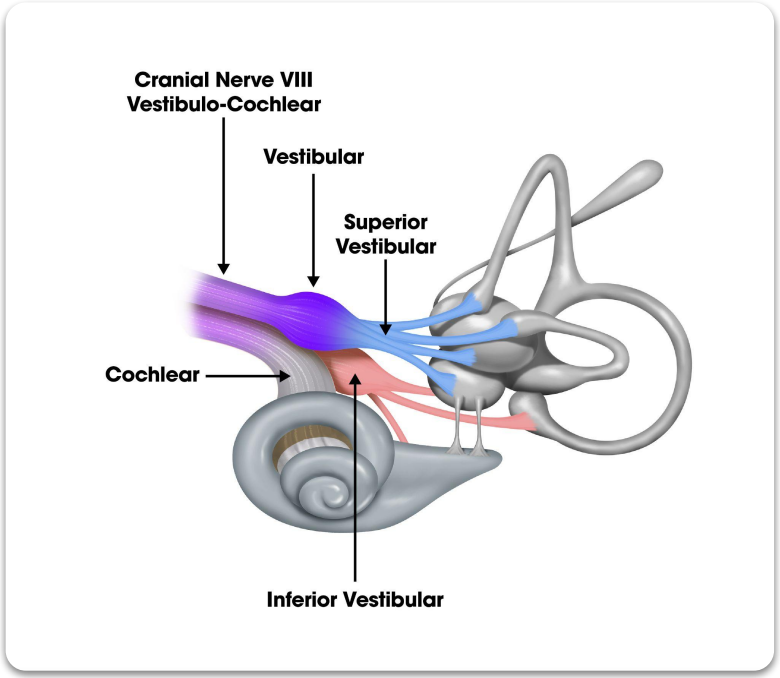
Mechanical Disorders

- **Benign Paroxysmal Positional Vertigo (BPPV)**

Vestibular Neuritis

Pathophysiology

- Usually viral inflammation of the inner ear
  - Reactivation of herpes simplex virus, upper respiratory virus
  - Can occur up to 2 weeks past active infection
- Commonly affects Superior Vestibular Nerve
  - Horizontal & Anterior Canal
  - Utricle
- Often results in concurrent BPPV
- Result is termed a **Unilateral Vestibular Hypofunction (UVH)**



Strupp, 2009, Jeong 2013

Unilateral Vestibular Hypofunction Pathology

Imbalance in signals where the right and left sides don't agree makes the brain say "wait, where are we?"

Recovery:

(1) Peripheral structures try to heal (adaptation)

(2) Brain may need to "take over" job of impaired peripheral system to some degree (compensation) particularly in case of bilateral damage

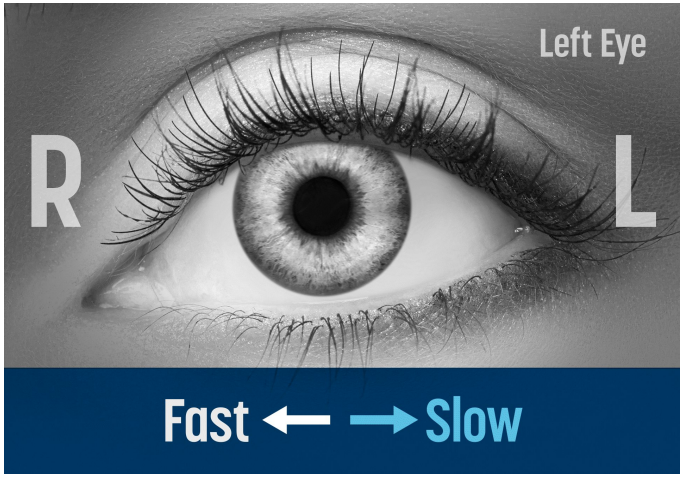
Vestibular Hypofunction Pathology

Condition	Details
Infection (neuritis)	Viral or bacterial; Labyrinthitis - hearing structures are also affected; “vestibular crisis”
Blood clots	Affecting vestibular arteries or their proximal/distal branches
Tumor e.g. vestibular schwannoma	Can be gradual onset (imbalance and hearing)
Diabetes or alcohol-related or B12 deficiency	Damage to vestibular blood supply/nerves
Meniere’s disease	Episodic inner ear swelling appears to cause damage; may be genetic at least in some cases
Degeneration of hair cells with aging	Lose 40% by age 75 (Maes et al., 2010)
Toxic drugs	Can result in bilateral loss (chemo, strong antibiotics)
Genetic and degenerative	Family history; usually gradual onset; w/ or w/o hearing loss
Trauma	Damage to peripheral structures during event
Third window syndromes such as superior semicircular canal dehiscence	Abnormal opening in a structure of the inner ear; symptoms such as pressure or sound-induced dizziness

Clinical Findings

Oculomotor Examination

- **Spontaneous Nystagmus** - nystagmus beats towards unaffected side
- **Gaze-Evoked Nystagmus** - non-direction changing, beats towards unaffected side, increases in strength when gaze is toward the fast beat
- **Abnormal Head Impulse Test (HIT)** - abnormal/positive on affected side
- **Horizontal Head Shake Test** - resultant nystagmus beats towards unaffected side
- **Skull Vibration-Induced Nystagmus Test** - resultant nystagmus beats towards unaffected side

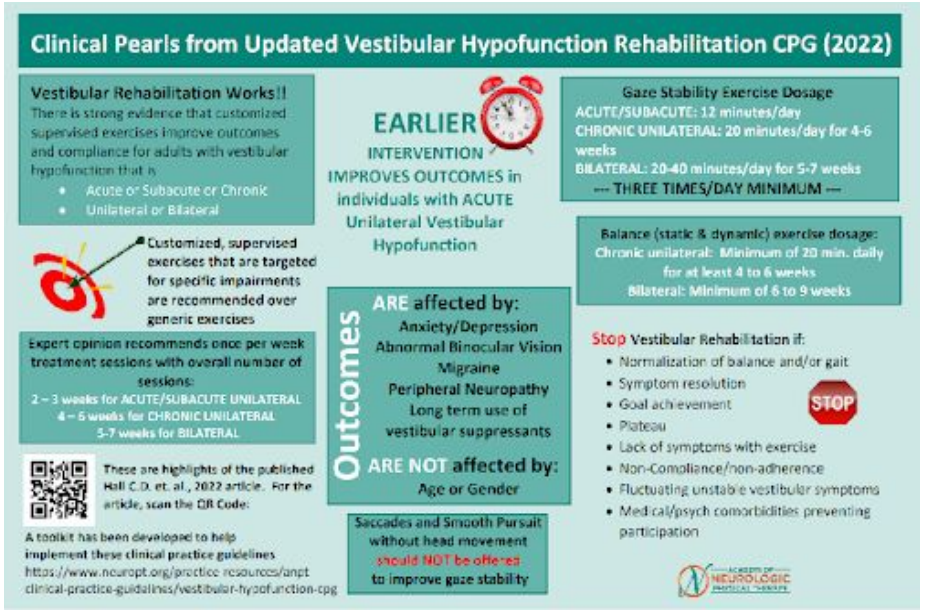


Herdman, 2014

Vestibular Neuritis / Unilateral Vestibular Hypofunction

Rehab Interventions

- Vestibular Rehabilitation
  - improved outcomes with compliance and earlier intervention (ideally by 2 weeks post-injury)
  - sometimes slower/more limited success in rehab if prolonged use of vestibular suppressants, migraine, anxiety, depression
  - any age can benefit from rehabilitation



Hall et al., 2022

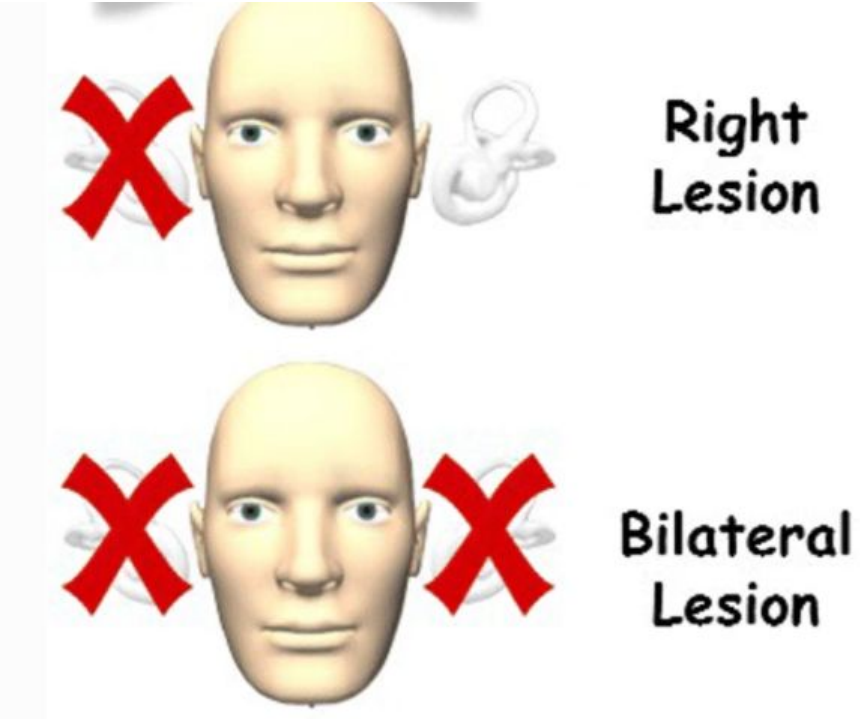
Vestibular Neuritis

Medical Interventions

- Vestibular Suppressants
    - Meclizine, Valium
    - Should only be used acutely - first few days
    - Can interfere with vestibular rehabilitation with continued use
- Antiemetic (medication for nausea such as Zofran) generally do not interfere with therapy

Hall et al., 2022

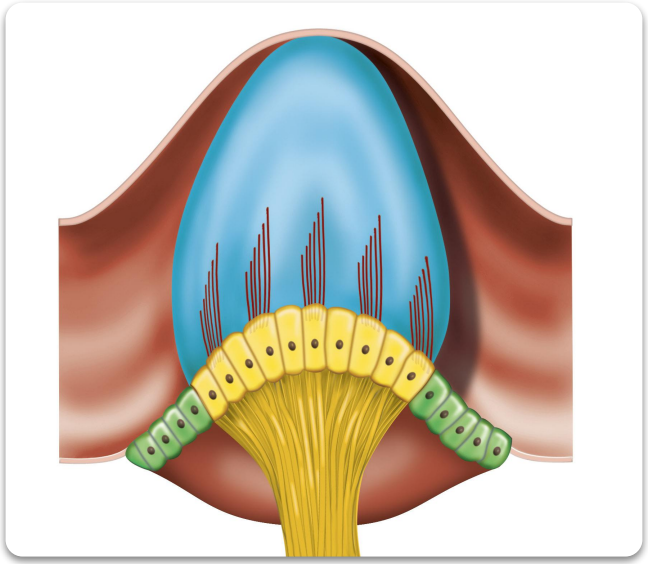
Bilateral Vestibular Hypofunction



Bilateral Vestibular Hypofunction

Causes

- Ototoxicity
- Aging
  - 40% loss of vestibular hair cells and nerve cells by 70 years of age
  - saccule and utricle experience approximately a 25% reduction in hair cells
- Children with sensorineural hearing loss
- Repetitive ear infections
- Bilateral Meniere's Disease, UVH
- Neurodegeneration
- Autoimmune Disease



Herdman, 2014

Bilateral Vestibular Hypofunction

Symptoms

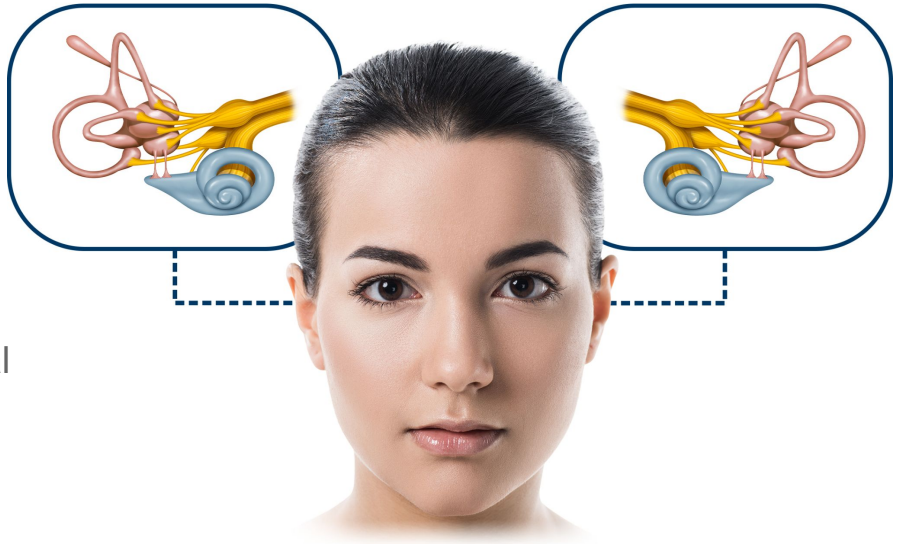
- Often gradual onset of symptoms
- Dizziness - if the damage is not complete/equal on both sides
- Oscillopsia or “jumping” vision with head movement
- 31 fold increase in falls!

Ward et al., 2013

Bilateral Vestibular Hypofunction

Examination

- **Spontaneous Nystagmus** - no nystagmus, minimal to no neuronal firing
- **Abnormal Head Impulse Test (HIT)** - abnormal catch-up saccade on both sides
- **Head Shake Test** - no nystagmus
- **Impaired balance** - especially with eyes closed



Herdman, 2014

Abnormal Head Impulse Test

https://youtu.be/EmCQK6TWqqg?si=37biqoAkpr_Jvel3

Tolman D. Positive Head Impulse Test. Used with permission.

Peripheral Vestibular Deficits - Stable Lesions Summary

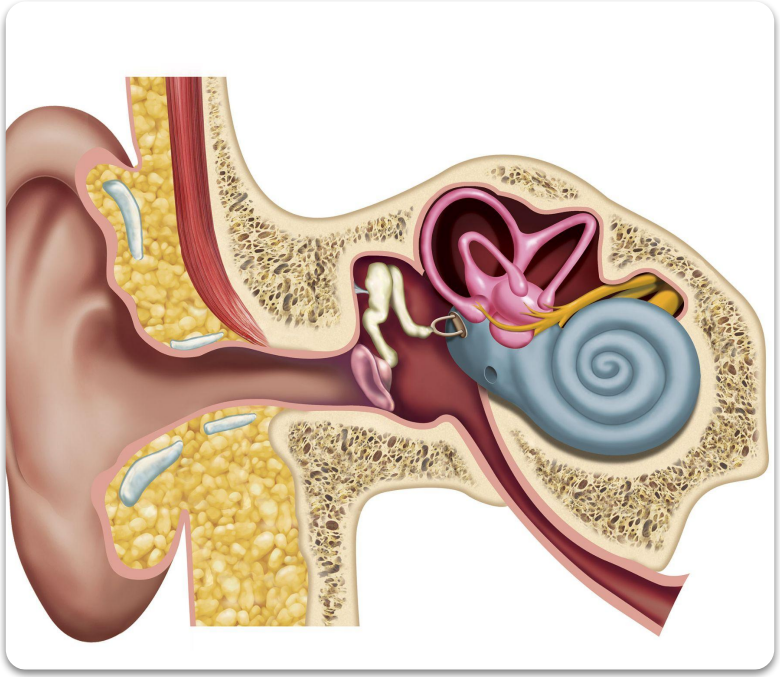
- Vestibular neuritis is the most common cause of acute spontaneous vertigo and results in a unilateral vestibular hypofunction
- Those with bilateral vestibular hypofunction have far worse imbalance than those with unilateral hypofunction
- The Clinical Practice Guidelines support adaptation and balance training for both unilateral and bilateral vestibular hypofunction

Peripheral Vestibular Deficits - Mechanical Disorder

Benign Paroxysmal Positional Vertigo

Epidemiology

- Most common cause of vertigo in adults
- Cause of 50% of all dizziness in adults > 65 yrs
- Associated with head trauma, aging, acute neuritis, and migraines
- Risk factors include low vitamin D levels, osteoporosis, total cholesterol
- Recurrence rates increase with diabetes, and hypertension in addition to above risk factors

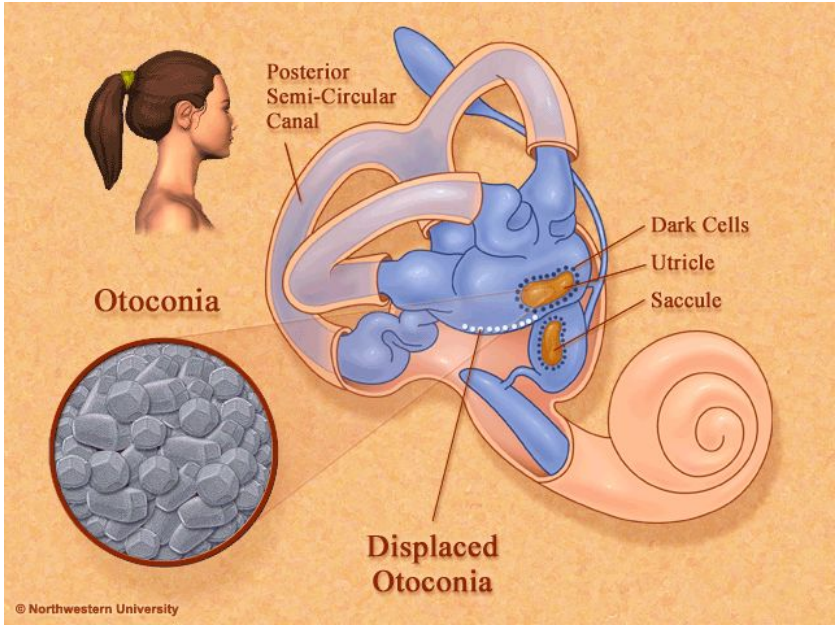


Chen et al., 2020, Chen et al., 2021

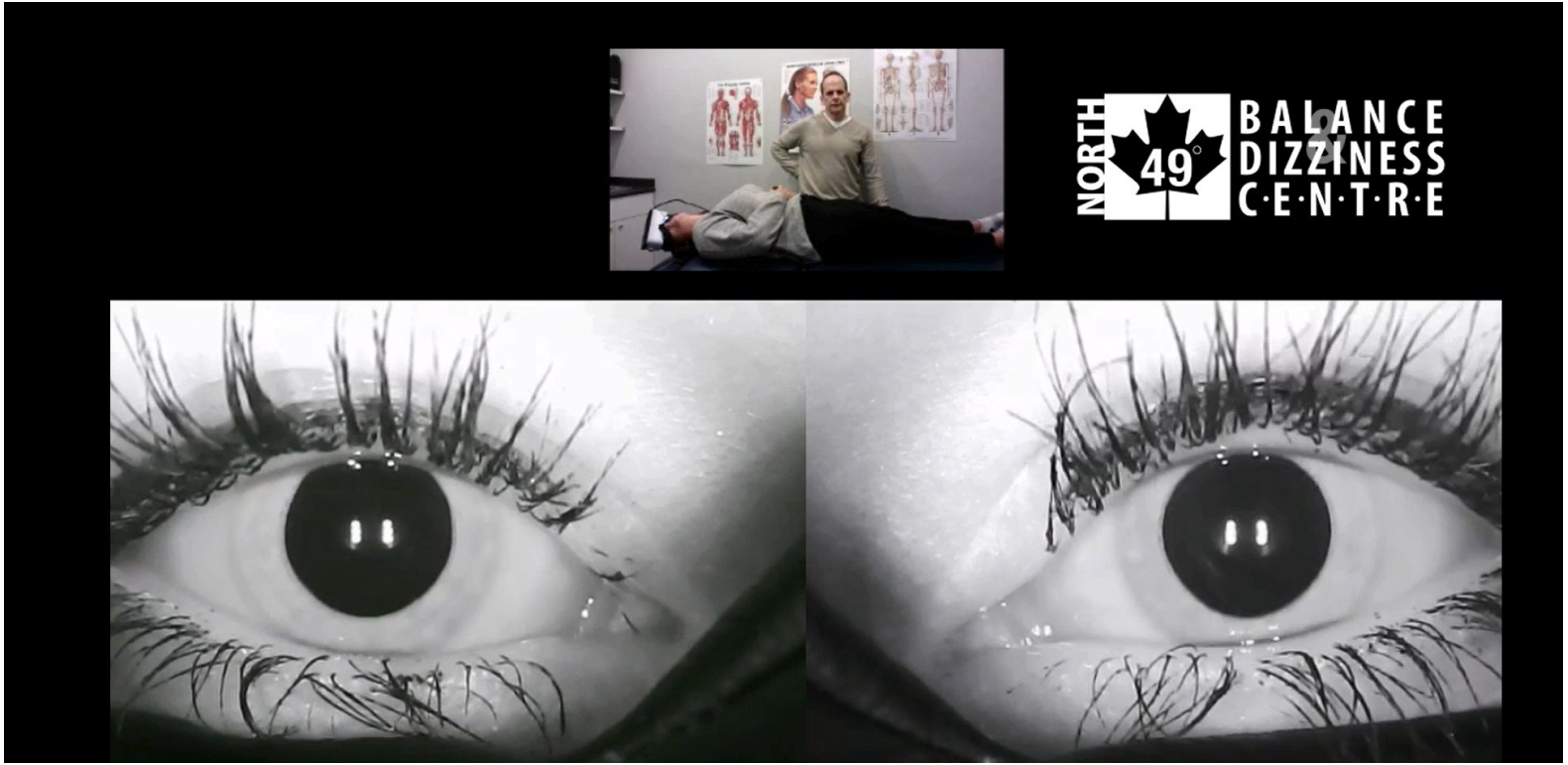
Benign Paroxysmal Positional Vertigo

Symptoms

- Patients will feel dizzy most commonly with position changes such as **laying down, rolling over, looking up, and bending**.
- Dizziness generally lasts **less than a minute** but in less common cases can persist the whole time they are in the position
- The **direction** of the eye movement as well as the **length** of the nystagmus tells the clinician where the otoconia are loose, leading to effective treatment



BPPV



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BPPV

Nystagmus in Dix-Hallpike	Diagnosis	Treatment Options
Upbeat torsional nystagmus lasting <60 seconds with associated vertigo	Posterior canalithiasis	1. Modified Epley/canalith repositioning maneuver 2. Semont/Liberatory 3. Li for posterior canal 4. Gans, Foster, Dias, Brandt Daroff
Upbeat torsional nystagmus lasting >60 seconds with associated vertigo	Posterior cupulolithiasis	1. Semont/Liberatory 2. Brandt Daroff
Downbeat torsional nystagmus lasting <60 seconds with associated vertigo	Anterior canalithiasis or short arm posterior canalithiasis	1. Deep head hang/Yacovino 2. Demi Semont 3. Modified Epley
Downbeat torsional nystagmus lasting >60 seconds with associated vertigo	Anterior cupulolithiasis (rare - suspect central pathology)	1. Semont/Liberatory for anterior canal 2. Brandt Daroff

BPPV

Nystagmus in Supine Roll Test	Diagnosis	Treatment Options
Geotropic nystagmus (stronger symptoms occur on affected side); can use bow/lean test to confirm	Horizontal canalithiasis	1. Gufoni 2. 180 deg quick roll/Li 3. BBQ roll/Log roll/Lempert 4. Forced prolonged positioning 5. Modified Brandt Daroff
Apogeotropic nystagmus (stronger symptoms occur on unaffected side); can use bow/lean test to confirm	Horizontal cupulolithiasis	1. Gufoni/Zuma (lie on affected side, head turned up, optional roll away from affected side) 2. Casani (lie on affected side with head turned down) 3. Cupulolith repositioning maneuver, CuRM, AKA Kim 4. Forced prolonged positioning 5. Modified Brandt Daroff

Peripheral Vestibular Deficits - Mechanical Disorders

- BPPV is the most common cause of vertigo in adults
- Otoconia Normally slough and regenerate, but with excessive numbers of displaced otoconia BPPV occurs
- Risk factors include low vitamin D levels, osteoporosis, total cholesterol, head trauma, migraine, and neuritis
- Treatment for BPPV is very effective using canalith repositioning maneuvers
- If no change in nystagmus or symptoms after 2-3 sessions of well-applied maneuvers, strongly consider alternative diagnoses e.g. vestibular migraine, fistula, etc.

Central Vestibular

Central Vestibular Conditions

Genetic Central Vestibular Conditions

- **Vestibular Migraine**
- Genetic Ataxias (Example: CANVAS)

Brain Lesions and Vascular Disorders

- **Stroke**
- Multiple Sclerosis
- Tumor

Other Neurologic Conditions

- **Persistent Postural Perceptual Dizziness**
- Concussion and Traumatic Brain Injury
- Non-genetic Degenerative Cerebellar Ataxias

Vestibular Migraine - Pathophysiology

Chronic genetic neurologic condition:

- "Cranky brain"
- Brain is neurologically sensitive to certain triggers which can lead to dizziness, sometimes headache, light sensitivity and/or sound sensitivity, and/or visual aura

Dieterich et al., 2016;
Li et al., 2022

Vestibular Migraine Diagnostic Criteria

	Vestibular Migraine
# of episodes fulfilling criteria?	5
Observed and documented..	History of migraine with or without aura
Episode length	5 min to 72 hours
Symptoms	Moderate to severe dizziness; may have headache, light and/or sound sensitivity, and/or visual aura

Lempert et al., 2022

Clinical Findings

Examination

- Could have **abnormal or normal central oculomotor findings**, even between migraine episodes
  - Spontaneous nystagmus, especially vertical and slow
  - Abnormal saccades and abnormal smooth pursuit
  - Beh et al found neuro-otologic examination between vestibular migraines abnormal in 42.7% of patients with the following tests most likely abnormal
    - Headshake test
    - Positional nystagmus - prolonged, may or may not be symptomatic, and not matching BPPV patterns
    - Vibration-induced nystagmus

Beh et al., 2019; Waissbluth et al., 2023

Lifestyle Modification

Ice Down

Peppermint & Ginger

Vibes

Theraspecs

Aerobic, Yoga, and Resistance Exercise

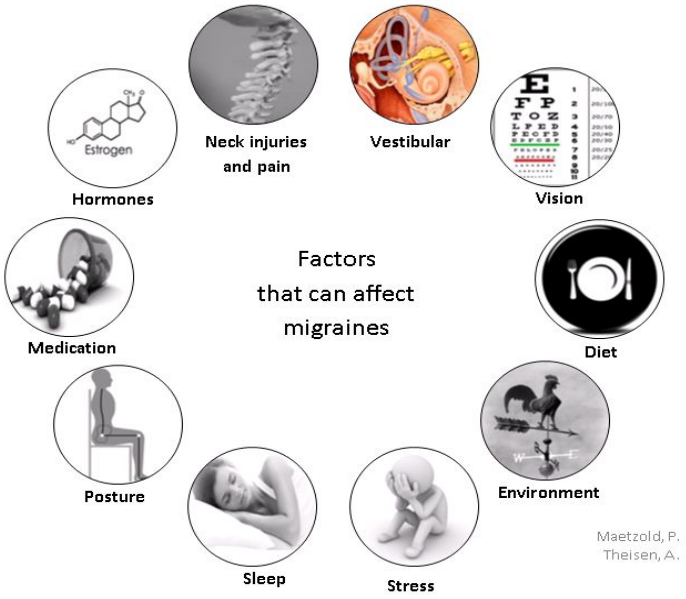
Calm App

Vestibular Migraine

Medical Interventions

- Medication
  - metoprolol, amitriptyline, venlafaxine, qulipta
- Medical management
  - Botox injections
  - Cefaly - trigeminal nerve stim
  - Vagus nerve stim
  - Hormone management
- Nutritional support/supplementation
  - Magnesium, B2 and B12, Vitamin D, possibly CoQ10

*Always instruct the patient to consult their physician before implementing



Persistent Perceptual Postural Dizziness

Pathophysiology

- “Learned Dizziness”
    - Acute vertigo event, other medical event, other life stressor triggers
    - Brain rewires to perceive constant imbalance/dizziness
- “Visually dependent” - Tendency to overestimate importance of visual information
- Increase postural threat awareness “like you’re on a high balance beam”

Holmberg, 2020

Persistent Perceptual Postural Dizziness Diagnostic Criteria

Yes	PPPD History Checklist: Adapted from Bárány Criteria
✅	Dizziness, non-spinning vertigo, unsteadiness (vague: “off” feeling for example)
✅	Duration at least 3 months
✅	Timing: Persistent, prolonged (hours), present most days, wax/wane
✅	Provoking factors: complex visual motion or patterns, active/passive head motion without directional preponderance, most notable upright
✅	Onset: trigger event (either distinct or gradual worsened symptoms to persistent level) including peripheral vestibular conditions, migraine, concussion, or psychiatric (anxiety/stress ex: loss of spouse)
✅	Significant distress or life impairment such as impaired daily activities
❓	Not better accounted for by other neuro-otologic disease or disease cannot fully explain all symptoms/level of disability

Staab et al., 2017

Clinical Findings

Examination

- Normal findings on oculomotor and vestibular exam unless you can find root cause (example: chronic vestibular hypofunction
- May be dizzy with VOR cancellation testing

Imaging

- Normal findings in general

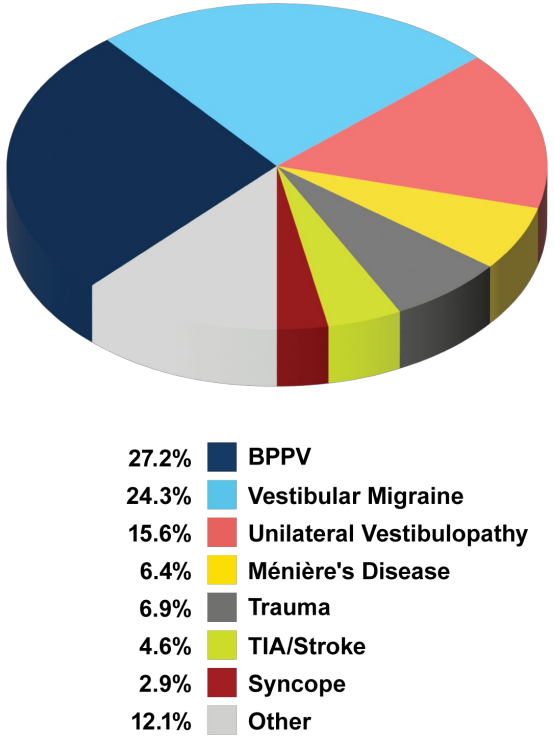
Questionnaires

- Dizziness Handicap Inventory (DHI) - DHI often scores greater than 60
- Modified Motion Sensitivity Quotient
- Situational Vertigo Questionnaire and/or Visual Vertigo Analogue Scale
- The Niigata PPPD Questionnaire (NPQ) - Specific to PPPD

Clinical Findings

The most common triggers for 3PD are BPPV and Vestibular Migraine

Treat BPPV, vestibular migraine, and other conditions (concussion) promptly to reduce incidence of PPPD



Habs et al., 2020,

Summary of Central Vestibular Disorders

- Criteria for vestibular migraine include at least 5 episodes of vestibular symptoms of moderate or severe intensity, lasting between 5 minutes and 72 hours and at least half of episodes are associated with at least one of the following three migrainous features: headache, photophobia and phonophobia, or visual aura
- Treatment for vestibular migraine can include the identification of triggers along with associated lifestyle modifications, vestibular therapy, cervical spine care, and referrals for medical management such as medications, botox, vagus or trigeminal nerve stimulation, and hormone management if needed
- 3PD is a complication to healing after an acute vertigo event, other medical event, where the person has increased attention towards motion with decreased ability to process or integrate the information.
- Treatment for 3PD involves Vestibular Rehabilitation, SSRI / SNRI and cognitive behavior therapy

Vestibular Rehabilitation: Essential Tips

Vestibular Treatment Planning

Condition	Treatment
BPPV	Repositioning maneuvers; habituation/balance as needed
Unilateral peripheral hypofunction	Fast, quick head movements e.g. VORx1 and x2; balance; dual tasking; habituation as needed; medical management e.g. Meniere's disease
Bilateral peripheral hypofunction	VORx1 and x2 unless complete bilateral loss; balance; gaze substitution; imaginary targets; dual tasking
Central Vestibular Dysfunction	1. Treat underlying condition when able (e.g. meds for migraine or MS; manage blood pressure in someone with stroke/TIA)
	2. Treat presenting symptoms a. Dizziness - gentle habituation; neck care b. Headache - medical management; treat neck if contributing to headache c. Imbalance - balance training; BalanceWear vest for involved/degenerative cases at times d. Dual tasking for cognitive training with balance tasks e. Address any limiting factors e.g. sleep, stress management, vision care

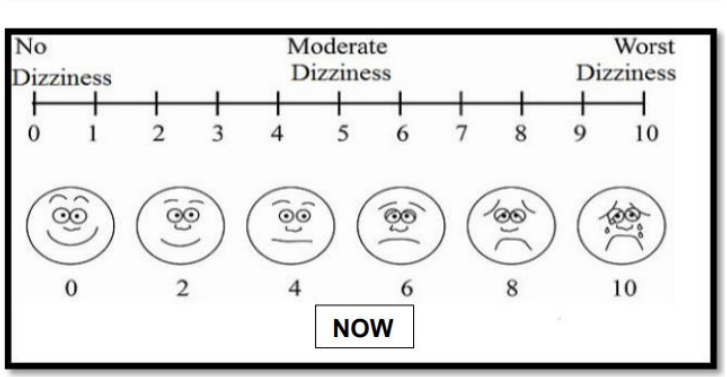
Symptom Management

The “2 unit” rule:

If a patient is doing a vestibular rehabilitation activity, the goal is to have the patient be aware that the activity may cause some symptom increase BUT

Try not to allow the symptom elevation exceed 2 units from baseline on a 0 to 10 scale of dizziness, nausea etc.

If yes, take a break!



Note: Recovery time is also important. Goal is to recover to baseline level of symptoms after a few minutes (<5 minutes) of rest.

We can use time to recovery as a goal as well.

For example, initially patient took 3 minutes to recover after a rehabilitation activity, and after 4 weeks of training they are back to baseline in <10 seconds.

Sensory Reweighting

<u>Offer tools to reduce symptoms of dizziness/imbalance between activities</u>

“Grounding”

- Seated (or standing with back on a wall) feet planted, posture upright, eyes closed or open and looking at fixed object on a blank wall (patient preference)

- Emphasis on relaxed breathing and increased body awareness, like you’re “plugged in” to the floor

Use of Visual Fixation as a Bridge

Offer tools to reduce symptoms of dizziness/imbalance with movement

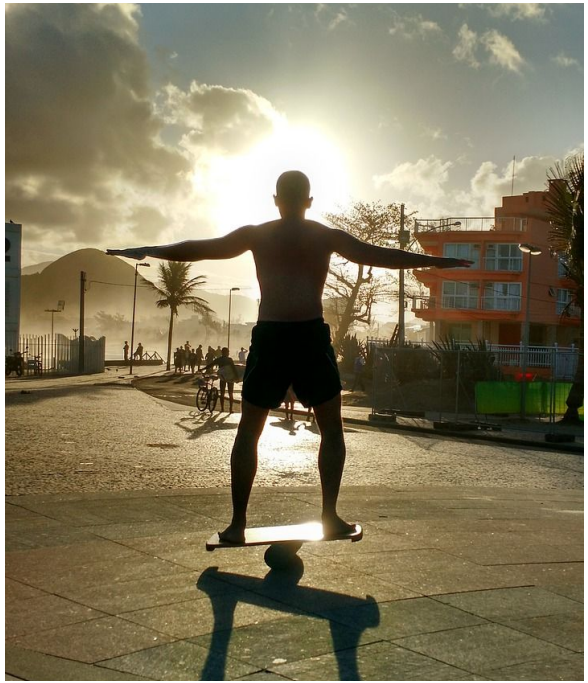
“Look at objects”

Teach the patient to switch their gaze from one stationary object to another in their environment during head or body turns

Sensory Reweighting

Offer tools to reduce symptoms of dizziness/imbalance with movement

Somatosensory /proprioceptive training: “feel where you are” with slightly flexed knees, press feet into floor, and body scan



Cognitive Challenge Tips

What if a patient has difficulty following commands for formal vestibular rehabilitation or balance activities?

Functional training often works well!

- Step into a narrow space and reach to put cups or a box on a shelf in a cupboard
- Seek and find “Where is something red in the room” or “Let’s pick up all of the weights on the ground”

Plan of Care

Treatment should be:

- Focused on patient goals
- Example: Bowling
- Appropriate plan of care in relation to duration of patient's history of symptoms (ex: patient with >20 years history of motion sickness likely to take 12+ weeks of 1-2x/week therapy)

Home Exercise Program

- Often give only 3 focused exercises for home, progress as able
- Emphasis on integrating rehab strategies into daily home, work, and leisure activities
- As with all physical therapy, success often relies on adhering to the home exercise program given as well as overall health/wellness, stress care

Vestibular Rehabilitation: Vestibular Hypofunction

Treatment for Vestibular Hypofunction

CPG Resource Toolbox

The ANPT Knowledge Translation Task Force has put together a ***toolbox of resources*** to help physical therapists implement the Guidelines. **CLICK ON THE LABELS** on the tool box drawers to obtain these resources:

https://www.neuropt.org/practice-resources/anpt-clinical-practice-guidelines/vestibular-hypofunction-cpg

Vestibular Treatment Planning

Condition	Treatment
BPPV	Repositioning maneuvers; habituation/balance as needed
Unilateral peripheral hypofunction	Fast, quick HEAD MOVEMENT e.g. VORx1 and x2; balance; habituation as needed; dual task training; medical management e.g. Meniere's disease
Bilateral peripheral hypofunction	VORx1 and x2 unless complete bilateral loss; 2 targets; BALANCE; dual task training
Central Vestibular Dysfunction	1. Treat underlying condition when able (e.g. meds for migraine or MS; manage blood pressure in someone with stroke/TIA)
	2. Treat presenting symptoms a. Dizziness - gentle habituation; neck care b. Headache - medical management; treat neck if contributing to headache c. Imbalance - balance training; BalanceWear vest for involved/degenerative cases at times d. Dual tasking for cognitive training with balance tasks e. Address any limiting factors e.g. sleep, stress management, vision care

Treatment for Vestibular Hypofunction

Clinical Pearls from Updated Vestibular Hypofunction Rehabilitation CPG (2022)

Vestibular Rehabilitation Works!!
There is strong evidence that customized supervised exercises improve outcomes and compliance for adults with vestibular hypofunction that is

- Acute or Subacute or Chronic
- Unilateral or Bilateral

Customized, supervised exercises that are targeted for specific impairments are recommended over generic exercises

Expert opinion recommends once per week treatment sessions with overall number of sessions:
2 – 3 weeks for ACUTE/SUBACUTE UNILATERAL
4 – 6 weeks for CHRONIC UNILATERAL
5-7 weeks for BILATERAL

These are highlights of the published Hall C.D. et. al., 2022 article. For the article, scan the QR Code:

A toolkit has been developed to help implement these clinical practice guidelines
https://www.neuropt.org/practice-resources/anpt-clinical-practice-guidelines/vestibular-hypofunction-cpg

EARLIER INTERVENTION IMPROVES OUTCOMES in individuals with ACUTE Unilateral Vestibular Hypofunction

Outcomes

ARE affected by:
Anxiety/Depression
Abnormal Binocular Vision
Migraine
Peripheral Neuropathy
Long term use of vestibular suppressants

ARE NOT affected by:
Age or Gender

Saccades and Smooth Pursuit without head movement should NOT be offered to improve gaze stability

Gaze Stability Exercise Dosage
ACUTE/SUBACUTE: 12 minutes/day
CHRONIC UNILATERAL: 20 minutes/day for 4-6 weeks
BILATERAL: 20-40 minutes/day for 5-7 weeks
--- THREE TIMES/DAY MINIMUM ---

Balance (static & dynamic) exercise dosage:
Chronic unilateral: Minimum of 20 min. daily for at least 4 to 6 weeks
Bilateral: Minimum of 6 to 9 weeks

Stop Vestibular Rehabilitation if:

- Normalization of balance and/or gait
- Symptom resolution
- Goal achievement
- Plateau
- Lack of symptoms with exercise
- Non-Compliance/non-adherence
- Fluctuating unstable vestibular symptoms
- Medical/psych comorbidities preventing participation

ACADEMY OF NEUROLOGIC PHYSICAL THERAPY

Treatment for Vestibular Hypofunction

Diagnosis	Daily VOR Exercise Dosage (3x/day)	Daily Balance Ex. Dosage
Acute/subacute unilateral vestibular weakness	Total of 12 minutes/day	As needed
Chronic unilateral weakness	Total 20 min/day, 4-6 weeks	20 min/day, 4-6 weeks
Bilateral weakness	Total at least 20 min/day, 5-7 weeks	20 min/day, 4-6 weeks

VOR Goal Speed: 2 Hz or 120 beats per minute

Hall et al., 2022

Treatment for Vestibular Hypofunction

**Eye exercises without head movements, such as eyes tracking a moving object or eyes moving back and forth between objects, are not sufficient treatment for peripheral vestibular hypofunction.

Treatment for Vestibular Hypofunction

https://youtu.be/tjXDyeg3OmU?si=zInBmB-b9El3pcmR

Treatment for Vestibular Hypofunction

https://youtu.be/XS1q0Sh2INc?si=AvnMYSwkReZa9MS5

Treatment for Vestibular Hypofunction

What Songs Could Improve Consistency with VOR Exercises?

- Juice (clean) - Lizzo
- Bad Medicine - Bon Jovi
- This City - Snoop Dogg
- Devil in Disguise - Elvis
- Borderline - Madonna
- We Are Family - Sister Sledge
- Bad Romance - Lady Gaga
- You Turn Me On - Tim McGraw
- Back in My Arms Again - The Supremes
- Cheek 2 Cheek- Fitzgerald/Armstrong
- Whole Lotta Shakin' Going On - Jerry Lee Lewis 🤣

Vestibular Rehab in Patients with Cognitive Issues

Forget about "X" on the post-it note!

To stimulate head turns in VORx1:

(1) Use Meaningful Targets: nod "Yes I love the beach" + shake "No I hate beets"

(2) Play music that is close to goal speed (120 beats per minute) such as Cracklin' Rosie by Neil Diamond which is 127 bpm

Treatment for Vestibular Hypofunction

https://youtu.be/aQBKgYLKr4o?si=vvzQWALr6gjxOHcv

Treatment for Vestibular Hypofunction

What if a patient cannot follow commands to perform VORx1 viewing properly (cognitive limitations)?

The good news is that frequent head motion and body motion as attained by habituation can be equally effective in reducing symptoms and improving gaze stability!
(Clendaniel, 2010)

Treatment for Vestibular Hypofunction

https://youtube.com/shorts/HV2TJW2PIkQ?si=OAGN1QRgj7JlzMcl

Treatment for Vestibular Hypofunction

Videos: Gabrielle Pierce, PT
https://www.youtube.com/channel/UCwDX4UUxFH7BZhs2gFYw6oA

Videos: VRT Technologies

https://www.youtube.com/channel/UCGnpa4v1gS7qBu5lLBc7gZg

Videos: Emory Balance and Dizziness
https://www.youtube.com/playlist?list=PLa1ou4MSMMbdGL_crKduLldxLz7Cq3M3g&app=desktop

Vestibular Rehabilitation: Habituation, Balance, and Dual Task

Vestibular Treatment Planning

Condition	Treatment
BPPV	Repositioning maneuvers; habituation/balance as needed
Unilateral peripheral hypofunction	Fast, quick HEAD MOVEMENT e.g. VORx1 and x2; balance; habituation as needed; dual task training; medical management e.g. Meniere's disease
Bilateral peripheral hypofunction	VORx1 and x2 unless complete bilateral loss; 2 targets; BALANCE; dual task training; gait training with device as needed
Central Vestibular Dysfunction	1. Treat underlying condition when able (e.g. meds for migraine or MS; manage blood pressure in someone with stroke/TIA)
	2. Treat presenting symptoms a. Abnormal eye movements - make it functional with eye and head movements and functional activities/balance (can use 2 targets) b. Dizziness - gentle habituation; can use gentle VORx1 or x2 as well as VOR cancellation c. Imbalance - balance training; BalanceWear vest for involved/degenerative cases at times d. Dual tasking for cognitive training with balance tasks e. Address any limiting factors e.g. sleep, stress management, vision care

Habituation

Habituation - repeated daily exposure to same or similar stimulus that creates symptoms, training the brain to reduce response/sensitivity to the stimulus over time

- Self-motion
- Visual motion

Habituation

*NOTE: not all issues can be “habituated”

For example, a patient with light sensitivity due to migraine may need accommodations such as colored lens glasses to be able to tolerate screens

CONSIDER need for medical management e.g. lifestyle modifications and migraine meds before jumping into habituation in the migrainous population

Habituation to Self-Motion

https://youtu.be/T1NxGBAOO_I?si=iJUalinDfgKHLmZP

Habituation to Visual Motion

- Can assess for visual motion sensitivity with Situational Vertigo Questionnaire and/or Visual Vertigo Analogue Scale

- Treatment can be based of off stimuli that provoke patient symptoms (start mild-moderate provocation, progress to more challenging patterns/videos)

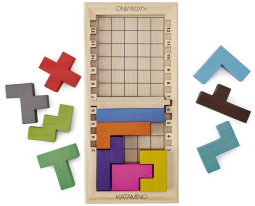
0 Not at all	1 Very slightly	2 Somewhat	3 Quite a lot	4 Very much	N.T. Not tried

Heights	0	1	2	3	4	N.T.
Watching moving scenes on the T.V. or at the cinema	0	1	2	3	4	N.T.
Travelling on escalators	0	1	2	3	4	N.T.
Looking at striped or moving surfaces (e.g. curtains, Venetian blinds, flowing water)	0	1	2	3	4	N.T.
Looking at a scrolling computer screen or microfiche	0	1	2	3	4	N.T.

Habituation to Visual Motion

https://youtu.be/Wh1jEeJQ6nk?si=AAFFTcDp8teMx3Te

Balance Treatment



- Classic balance training
  - Base of support
  - Uneven surfaces - foam, balance disc or tipping board, BOSU, balance beam
  - March in place; Walking forward, sideways, and backwards

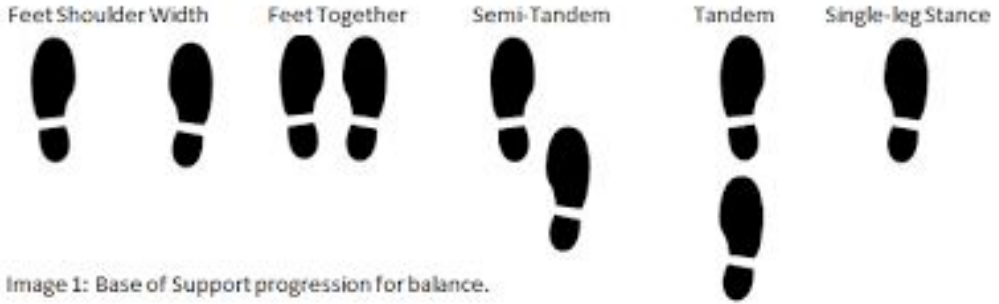


Image 1: Base of Support progression for balance.

Balance Treatment

https://youtube.com/shorts/7DrIaR12t-g?si=Kv1YIAC_mLEiu0rc

Practice with a Partner

1. VORx1
2. VORx2
3. 2 Target VOR (gaze substitution)
4. Habituation

Thank you!

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