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Optometric assessment and co-management of patients with inner ear disorders

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OPTOMETRIC ASSESSMENT AND CO-MANAGEMENT OF PATIENTS WITH INNER EAR DISORDERS

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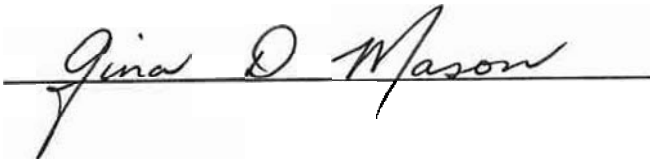
Gina D. Mason 

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Abstract

Patients often present to the optometrist with symptoms of dizziness and imbalance. This article reviews the most common visual signs and symptoms of individuals suffering from peripheral vestibular disorders. It also explains the five most common peripheral vestibular disorders—benign paroxysmal positional vertigo/nystagmus, Meniere's disease, secondary hydrops, perilymph fistula, and vestibular neuritis. A vestibular screening battery that can be performed by optometrists in office is presented. Management and treatment options such as lenses, prisms and vision therapy are explored. In addition, proper referral guidelines to neuro-otologists, physical therapists, occupational therapists, and psychologists are discussed.

Key Words

dizziness, vertigo, nystagmus, vestibular system, VOR, vestibular disorders, vestibular screening battery, vision therapy

It is estimated that one percent of patients over the age of 25 complain of dizziness that interferes with daily living.' Often the cause can be attributed to an inner ear disorder of either peripheral or central origin. Some peripheral vestibular disorders include benign paroxysmal positional vertigo, vestibular neuritis, endolymphatic hydrops, Meniere's, and perilymph fistula. Peripheral vestibular conditions are not the only culprits in dizzy patients. Central nervous system disorders can also cause dizziness and may be life threatening. Therefore, central causes should be ruled out when patients present with dizziness. Some conditions to consider are acoustic neuroma, multiple sclerosis, endocrine disorders, brainstem vascular disease and psychological impairment.[2] Table 1 lists additional causes of dizziness. Individuals suffering from vestibular disorders complain of dizziness, vertigo, imbalance, and syncope.[3] These patients rely heavily on their visual systems because their vestibular systems are impaired. Therefore, optometrists play an important role in the management and co-management of these patients.

Case

A 48-year old Caucasian female presented for an *optometric* examination with complaints of dizziness and blurred vision. She related that words appeared to "jump off the page" and double while reading. The patient also reported increased sensitivity to peripheral motion in shopping malls and large crowds. Walking down stairs had become a challenge for her. The patient had been aware of these symptoms for the last two months and had noted no improvement. Personal and family ocular histories were unremarkable. Her

personal medical history revealed that she had sought care one year ago from her general practitioner because of a spinning sensation she experienced. The primary care provider diagnosed a viral infection that resolved spontaneously within six weeks. The dizziness returned a few months ago following an airplane flight. Her family medical history included one sister with Meniere's disease.

Visual acuities were 20/20-3 OD and 20/20-1 OS. Underaction of the left eye in inferior gaze and overaction of the right eye in superior gaze were noted. The patient showed an abnormal right endpoint nystagmus. Stereopsis was decreased to 200 seconds of arc. Decreased binocular fusion skills were noted as well as a left hyperphoria of 7.5 prism diopters. Pupillary reaction, intra-ocular pressure, slit lamp and dilated fundus exam were unremarkable.

After reviewing the case history and the persistent symptoms, a vestibular screening battery was performed. Table 4 summarizes how to perform these tests. Romberg testing was normal with eyes open. However, with eyes closed and in the sharpened position, the patient had a tendency to fall toward the right. Tandem walking was normal with eyes open. The patient was unable to perform the test with eyes closed. The stepping test was positive with 20 degrees of rightward rotation and a 50 cm forward movement. The head impulse and head shaking tests were negative. Results were obtained using a screening battery checklist. Subsequently, a referral was made to a neuro-otologist to confirm a suspected vestibular condition.

Visual Complaints

Patients with inner ear disorders may present to the optometrist with visual complaints. They may describe difficulty with reading, jerky eye-movements and blurry vision. Patients may also complain of photophobia, double vision and sensitivity to motion in the periphery.[4] A comprehensive list of visual symptoms is given in Table 2. An optometric examination may reveal decreased saccadic eye movements with an increase in fixation duration, EOM restriction, gaze instability, image size differences, binocular conflicts (such as convergence insufficiency), field reductions, skew deviation, and nystagmus.[1]

Skew deviation is a vertical misalignment of the eyes that is not explained by an ocular muscle palsy. Patients with skew deviations complain of vertical and/or torsional diplopia. Cyclorotation of both eyes (ocular counter roll) may be seen due to the patient's illusion of the tilted visual world. Optometrists may also see a head tilt away from the hyperphoric eye (ocular torticollis) and will objectively detect the skew deviation with the alternating cover test and subjectively with the Maddox rod or the red lens test.[5]

Patients with inner ear disorders may present to the optometrist with varying degrees of nystagmus, an involuntary oscillating movement of both eyes. Nystagmus consists of a slow drift of the eyes followed by a rapid flick back. The slow drift is the abnormal phase while the fast flick is the normal phase that restores eye positioning.[6]

The optometrist can test the vestibulo-ocular reflex. The vestibule-ocular reflex (VOR) generates eye rotations that compensate for head position changes

so that an image of the environment is stationary on the retina.[5] Head rotation in one direction stimulates an eye rotation equal in amplitude but opposite in direction so that the angle of gaze remains the same. Eye movements are used to compensate for errors in direction of gaze and to bring the image to the fovea in the shortest amount of time. VOR gain is a ratio of the amount of eye movement compared to the amount of the head movement. A ratio of 1 indicates the two fully compensate for each other. VOR gain of less than or greater than 1 illustrates under and over compensation, respectively. The result of an abnormal gain can be sensory conflict as seen in many vestibular patients.[7]

Sensory conflict occurs when the brain processes conflicting information from various sensory systems. When the visual and vestibular systems send opposing signals to the brain, vertigo and motion sickness may result. When sensory conflicts occur, the autonomic nervous system is activated resulting in sweating, pallor, nausea, and vomiting.'

Anatomy of the Vestibular System

Three senses that help maintain balance are vision, proprioception, and the vestibular system. Two of these three senses must be intact in order to maintain balance.[8] People with vestibular problems depend heavily on vision because the vestibular system is impaired.[9] These three senses feed into the brainstem where sensory integration occurs. Eye movements and postural control are the result.[10] Refer to Figure 1.

The vestibular system consists of five organs located within the labyrinthine cavities of the temporal bones. Refer to Figure 2. The membranous

labyrinth includes two otolithic receptors called the utricle and saccule, and three paired semicircular canals all located within the bony labyrinth. Each otolith organ has a sensory receptor area called the maculae, which is comprised of 20,000 to 30,0000 hair cells. Calcium carbonate crystals called otoconia that rest on the gelatinous membrane cover the utricular and saccular maculae. The otolith organs function primarily as sensors of linear acceleration but also sense changes in the gravitational forces when the head is tilted.[5]

The three paired semicircular canals, each named for their orientation in space (superior, posterior, and lateral) are approximately perpendicular to each other. The semicircular canals have a vestibular sensory receptor area called the cristae ampullaris. The hair cells of the cristae detect angular acceleration.

The vestibular labyrinth contains two distinct fluids. Inside the membranous labyrinth is a fluid composed of potassium and sodium called endolymph. The space between the membranous and bony labyrinth is filled with perilymph, a fluid that resembles cerebrospinal fluid.[11]

Vestibular Disorders

The major vestibular disorders associated with symptoms of dizziness and imbalance are benign paroxysmal positional vertigo, vestibular neuritis, endolymphatic hydrops, Meniere's disease, and perilymph fistula. A complete listing of these diseases can be found in Table 3. Benign paroxysmal positional vertigo (BPPV-N) is the most common cause of vertigo in adults. It is believed to be due to the otoconia displacing from the utricle and moving to the posterior semicircular canals.[12] This displacement can occur with otitis media, trauma,

upper respiratory infection, or normal aging. Turning the head to a particular position such as when getting out of bed or bending over brings on vertigo. The episodes of vertigo usually last less than 30 seconds. Although vertigo is usually the predominant symptom, prolonged unsteadiness and light-headedness may also occur.[10] Diagnosis is based on finding the characteristic fatigable positioning nystagmus using the Dix-Hallpike positional procedure. This procedure, also called canalith repositioning, is the most common form of treatment.[11] Anti-vertigo and anti-nausea medications may be prescribed.[3,10] A diagram of the Dix-Hallpike positional procedure can be found in Figure 3.

Vestibular neuritis is the second most frequent diagnosis among patients with vertigo.[5] Patients experience a sudden unilateral loss of vestibular function and auditory symptoms such as aural fullness, tinnitus, and hearing loss.[3,10] This can be associated with upper respiratory infections such as herpes simplex, cytomegalovirus, or influenza.[10] Vestibular neuritis is characterized by a vertigo attack lasting several days and gradually improving over several weeks.[3,10] Spontaneous nystagmus (horizontal or rotary) is usually evident during a vertiginous attack.[6] Vestibular suppressants, such as beta-blockers, muscle relaxants, and anti-cholinergics may be prescribed to lessen the symptoms of these attacks.[1] In chronic forms of vestibular neuritis, vestibular rehabilitative therapy is recommended.[3] This condition is benign and self-limiting in most cases.

The etiology of endolymphatic hydrops is a dysfunction of the normal mechanism of endolymph volume regulation. This may result from

hypersecretion or hypoabsorption of endolymph or blockage of a duct between the secretion and resorptive areas. Individuals with the diagnosis of endolymphatic hydrops experience episodic symptoms of hearing loss, tinnitis, aural fullness, and vertigo.[5,6] Attacks can occur without warning and may last several minutes to several hours.[3] They can be associated with feelings of nausea, pallor, and sweating.[6] Patients with endolymphatic hydrops are instructed to consume a low sodium diet to reduce the risk of an attack. Some patients are given diuretics to moderate symptoms.[12]

Meniere's disease is defined as idiopathic or primary endolymphatic hydrops.[5] The exact mechanism is thought to be due to increased pressure in the inner ear that leads to a membranous rupture of the endolymphatic duct and sac." Symptoms include hearing loss and multiple attacks of spontaneous unprovoked vertigo along with either tinnitis or aural fullness, all in the same ear.[13] These patients are usually managed with a low sodium diet and a diuretic. Surgery may be an option if other forms of management are ineffective.[**] Surgeries to the inner ear include endolymphatic shunt surgery to drain excess fluid and vestibular nerve sections to stop motion sickness. [9]

Perilymph fistula is difficult to differentially diagnose from Meniere's disease because of similar symptoms such as hearing loss, dizziness, tinnitis, vertigo, and aural fullness.[3,12] The classical presentation of acute perilymph fistula occurs with a sudden audible pop in the ear due to coughing, sneezing, exercising, or head trauma. Perilymph fistulas are caused by an abnormal communication between the middle and inner ear due to defect in the round or

oval window.[12] Management of these patients includes bed rest, head elevation, medications, and surgery.[3,11] Medications given to control symptoms include Meclizine, Scopolamine, anti-depressants and anti-anxiety agents.'

Vestibular Screening Battery

If a patient has symptoms of dizziness or imbalance, a screening battery may be used to determine whether the vestibular system is involved. The screening battery includes five tests that the optometric physician can perform in-office. These are the Romberg, tandem walking, stepping, head impulse, and head-shaking tests. Refer to Table **4** for a quick reference to procedures and interpretations.

The standard Romberg test is an assessment of balance in which the patient stands with feet together and arms crossed. The test is first performed with eyes opened (vestibular, visual, proprioception all play a role) and then closed (vestibular and proprioception only). A positive test is indicated when the eyes are closed and the patient exhibits uncontrollable falling within 15 seconds.[3,12] A more demanding balance assessment is the sharpened Romberg in which the arms are folded against the chest and the feet are in tandem (heel-to-toe) position.[12] Normal patients can hold for thirty seconds, however patients with vestibular impairment are usually unable to sustain the position.'' An alternative approach, which minimizes proprioception, is to have the patient stand on a foam pad versus the tandem feet position. Refer to figure **4.**

Tandem walking is a test of gait imbalance or dynamic balance. The patient walks heel-to-toe with eyes open and then with them closed. A positive

test is indicated if the patient is unable to make ten accurate steps in three trials without swaying or side stepping with the eyes open or closed." Consistent falling to one side usually indicates a vestibular or cerebellar dysfunction on that side.[3,12] With eyes open, tandem walking is primarily a test of cerebellar function because vision compensates for chronic vestibular and proprioceptive deficits. With eyes closed, tandem walking is a test of vestibular function." See figure 5.

In the stepping test (Unterberger/Fukuda), the patient marches in place at a normal walking speed with eyes closed. The patient takes 50 steps while the examiner stands behind to offer protection from falling and prevent localization of voice. After the steps are taken, the examiner estimates the amount of rotation to the left or right and the amount of the forward/backward movement. A rotation greater than 30 degrees or a linear displacement greater than 50cm indicates a positive test.[7,14]

In the head impulse test (Halmagyi), the patient is instructed to fixate the examiner's nose, while the examiner quickly rotates the patient's head 15-20 degrees to the left, right, up, and down at a rapid rate. If the eye movements over compensate or under compensate for the amount of head movement, the test is abnormal. This test is also known as a bedside VOR.

In the head-shaking test, the patient is seated with chin lowered and eyes closed. The patient is then asked to shake the head back and forth in a vigorous manner for 15-20 seconds. Patients with compensated vestibular imbalance due to peripheral or central lesions may develop transient spontaneous nystagmus after head shaking.[11] A positive test is characterized by continuous nystagmus

after head shaking when the eyes are reopened and the patient is directed to fixate a target. A positive outcome indicates an imbalance in the vestibulo-ocular pathway.[7,11] The patient may wear Frenzel glasses (high plus lenses) to aid the examiner in observing the nystagmus. Nystagmus is normal after head-shaking or spinning when Frenzel lenses are worn. The abnormal response is the absence of fixation suppression of the VOR when the patient is allowed to fixate. See Figure 6.

Treatment and Management of Vestibular Patients

As previously mentioned, vision, proprioception, and the vestibular system are necessary for balance. Therefore, if the vestibular system is compromised, the patient depends heavily on visual input. Optometrists play an important role in helping patients cope with vestibular conditions by meeting their visual needs. Lenses, prisms, and vision therapy are all treatment considerations when working with vestibular patients.

Progressive addition lenses (PALS) and lined multifocal lenses should not be prescribed for vestibular patients due to peripheral distortions and problems with VOR gain. PALS contain many different powers. Therefore the brain must recalculate VOR gain for each section, which leads to vestibular symptoms. Separate pairs of glasses should be prescribed for different distances and occupational demands.

Many vestibular patients are sensitive to motion in the periphery. These patients experience relief with a slight reduction of minus power in the distance Rx. This helps to maintain a better balance between magno and parvo cellular

inputs. Anti-reflective coatings should be put on all lenses in order to reduce disturbing reflections off the back and front surfaces of the lenses. These coatings should be recommended for all vestibular patients since they help to reduce glare, distortion, and motion in the periphery by providing more transmitted light and fewer reflections. A tint may be helpful to reduce photophobia and glare to which vestibular patients are extra sensitive. Patients should also be advised to use adequate lighting because vision plays an important role in their stability.

Patients with dizziness or imbalance may present in an optometric office with vertical deviations that can be measured with careful evaluation. Vertical relieving prism may be helpful for these patients. The amount of vertical prism prescribed should be based on the associated phoria determined through fixation disparity testing. The measured prism amount should then be placed in a trial framed for the patient to wear a minimum of twenty minutes. During this period, the patient should engage in reading or other active tasks. The associated phoria measurements should be taken immediately following the trial period to make sure the patient has not adapted to the prism amount. Prism adaptation would be indicated if the original measured phoria increases after it has been neutralized by prism.

Rehabilitative vision therapy should progress from tasks that are easily accomplished to tasks that are more difficult. Therapy begins by training eye movements and treating any diagnosed binocular vision disorder. In the early stages of therapy, the patient is seated to maximize proprioception and ensure

stability. Initially, slow pursuits using large targets are performed. The patient controls the speed and range of target movement. For example, the patient can visually track his/her own thumb. As therapy progresses, less tactile feedback is given as target movements become controlled by external devices such as a Marsden ball.

Likewise, small saccadic eye movements are trained while gradually increasing speed and maintaining accuracy. As the patient progresses, larger saccadic eye movements are trained, possibly incorporating a metronome for pacing.

More challenging vision training may be introduced by combining pursuits and saccades with head movement. The patient makes a saccade toward a rightward target while moving his head to the left. Due to the VOR, this is often a difficult task for the vestibular patient. As the patient is able to achieve this, tasks are made progressively harder by adding the dimension of balance. The patient moves from a seated to upright position and eventually stands on a foam pad, balance board or marches in place. An effective technique is to have the patient fixate a beach ball while moving it in large circles. As the patient gains confidence, more complex visual backgrounds, such as checkerboards or stripes, may be used. In the final stages of a vision rehabilitative program, the vestibular patient is loaded cognitively through questions and memory tasks.[15]

Vision rehabilitative programs for vestibular patients also work on developing vergence and fusional abilities. Training begins in real space progressing from smooth vergences to jump vergences using fixed tranaglyphs.

Generally, sequences of the BC-920 tranaglyph, clown, then spirangle vectrograms are used. Prism flippers with distance rock activities may also be incorporated into training.

Through exercises, optometrists help vestibular patients to improve gaze stabilization. These training techniques help to increase VOR gain. Enhancement of gaze stabilization consists of several exercises as explained in Table 5.

A number of professionals can help in the management and treatment of vestibular patients. A neuro-otologist can confirm a suspected vestibular condition. The examination he or she conducts includes a hearing test, cranial nerve assessment, auscultation of head and neck, vestibular testing, and a dizziness stimulation battery. Vestibular testing includes the vestibular screening tests and electrocochleography (ECOG). The ECOG accesses the response to different tones in the form of clicks from a probe placed in the ear canal; certain disorders like Meniere's disease have a distinctive wave-form from different tones. The dizziness stimulation battery also includes electronystagmography (ENG). This test includes four parts: testing rapid eye movements, eye tracking, dizziness associated with positions of the head, and the caloric test that determines responses to warm and cold water or air.[9] After a diagnosis is confirmed by the neuro-otologist, referrals to physical therapists, occupational therapists, and psychologists are considered.[3]

Referrals to physical therapists may be necessary when training balance recovery in patients with chronic dizziness. Vestibular exercises have proven to

be an effective treatment in improving balance. Physical therapists assess and train postural deviations, static standing balance, dynamic balance, strength, range of motion, and gaze stabilization.[5,11] The physical therapist assists the patient in developing higher levels of volitional control over vestibular compensatory responses.[16] An exercise program is personalized for each patient to improve balance and reduce anxiety and depression.[5,11]

A referral to an occupational therapist is necessary when vestibular patients are no longer able to perform ordinary tasks such as shopping in grocery stores and malls.[17] Occupational therapists suggest ways that patients can reorganize their living environments to better aid them in recreational, work, and home activities."

The psychological status of vestibular patients should be evaluated when patients exhibit symptoms of anxiety, depression, panic disorders and agoraphobic avoidance. Psychiatrists often treat these disorders with drugs and behavioral treatments.[5,11]

Case Conclusion

The patient returned from the neuro-otologist with a diagnosis of perilymph fistula and secondary hydrops. Her neuro-otologist recommended vestibular rehabilitation with a physical therapist. When she returned to her optometrist, she inquired about progressive addition lenses (PALS). This was discouraged because PALS increase distortion in the periphery and a separate pair of glasses for distance and near was dispensed. One prism diopter BD OS was prescribed

for both pairs of glasses to compensate for the vertical deviation. Anti-reflective coatings were placed on the lenses.

A vision rehabilitative evaluation was performed and orthoptics were recommended to help manage her condition. Her vision rehabilitative training emphasized gaze stabilization techniques and methods for improving saccades, pursuits, and vergences. Upon completion of ten vision rehabilitative sessions, the patient reported a decrease of symptoms. However, she reported continued difficulty in daily living tasks and dealing with stress and anxiety. Therefore, the optometrist suggested the patient consultation with an occupational therapist and psychologist. The optometrist also recommended a vestibular support group called VEDA (Vestibular Disorders Association).

*CPT #'s 99244-21 (office visit), **99354** (extended assessment), and **95881** (vestibular screening) were billed. The **99244** is a high consultation code. The **21** is a modifier of this code and indicates extra office time was needed. The **99354** refers to extended duration evaluation services.*

The optometrist can make a significant impact on the life of a vestibular patient by recognizing a suspected vestibular disorder, performing a screening battery, and providing indicated treatments. The optometrist can also refer and co-manage the patient with other professionals. In addition, lenses, prism, and vision therapy can be used to effectively moderate symptoms and improve the patient's quality of life. By helping these patients, optometrists provide a valuable service and also benefit by creating a special niche within their practice.

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Table 1: Causes of Dizziness*

Cause	Percentage
Peripheral vestibular disorders	38%
Hyperventilation	23%
Multiple sensory defects	13%
Psychiatric disorders	9%
Uncertain	9%
Brainstem vascular disorders	5%
Other neurological	4%
Central nervous system	4%
Multiple sclerosis	4%
Visual	2%
Endocrine	1%
Decreased sensory awareness	1%

Modified** from ***Handbook** of Vestibular **Rehabilitation."

Table 2: Common Visual Signs and Symptoms of Vestibular Disorders[4]

Signs	Symptoms
• Nystagmus • General binocular dysfunction • Vertical phoria • Vertical tropia • Contrast difficulty • Tendency to look down • EOM restriction • Ocular torticollis • Gaze instability	• Hypersensitivity to peripheral motion • Poor depth perception • Hypersensitivity to moving/flickering lights • Photophobia and/or intensified glare • Ocular discomfortleyestrain • Oscillopsia (perceived movement of stationary objects) • Jumping objects • Difficulty reading and/or writing • Headaches • Dizziness • Diplopia

Table 3: Peripheral Vestibular Diseases

Disease	Description
Benign Paroxysmal Positional Vertigo/Nystagmus	• An inner ear syndrome, often idiopathic, caused by displacement of otoconia from the utricle into the posterior semi-circular canal • Episodes of vertigo induced by changes in body position
Meniere's Disease also know as Primary Endolymphatic Hydrops	• Idiopathic syndrome of endolymphatic hydrops caused by an increase in volume of endolymph • Recurrent episodes of vertigo, hearing loss, tinnitis, and aural fullness
Secondary Hydrops	• Chronic inner ear syndrome caused by an increase in volume of endolymph • Chronic vertigo, hearing loss, tinnitis, and aural fullness May ensue after perilymph fistula
Perilymph Fistula	• Caused by abnormal communication between the middle and inner ear • Hearing loss, dizziness, tinnitis, vertigo, and aural fullness
Vestibular Neuritis	• Sudden unilateral loss of vestibular function associated with viral and upper respiratory conditions • Prolonged vertigo attacks lasting days

Table 4: Vestibular Screening Tests

Name	Procedure	Interpretation
Standard Romberg	• Patient stands with feet together and arms crossed • Patient tested with eyes open and eyes closed	Positive test: uncontrolled falling when eyes are closed; instability does not indicate a positive test
Sharpened Romberg	Patient stands with one foot in front of the other and arms crossed • Patient tested with eyes open and eyes closed	Positive test: falling when eyes closed
Tandem Walking	• Patient walks heel to toe • Patient tested with eyes open and closed	Positive test: inability to make 10 accurate steps with or without eyes open
Stepping Test	Patient takes 50 steps in place with eyes closed	Positive test: rotation greater than 30 degrees to the affected side or 50 cm forward or backward
Head Impulse Test	• Patient views the examiner's nose while the examiner quickly rotates the head to the left and right	Positive test: patient re-fixates following the head rotation
Head Shaking Test	• Patient shakes head vigorously for 15-20 seconds • Patient is seated with chin lowered to chest	Positive test: spontaneous nystagmus after head shaking

Table 5: Enhancement of Gaze Stability*

1 Enhancement of cervico-ocular reflex

- Tape a business card on the wall in front of patient
- Keep words in focus while moving head back and forth sideways
- Instruct to move faster, keep letters in focus and continue 1-2 minutes
- Move head up and down
- Continue exercises using a large checkerboard stimulus

2) Active eye-hand movements between two targets

- View target directly with head in alignment
- Look at other target with eyes and then turn head
- Keep targets in focus
- Repeat in opposite direction

Vary speed

Vertical orientation of targets can be used

3) Imaginary targets

- Look at target directly
- Close eyes, turn head slightly, and imagine still looking at target
- Open eyes to see if eyes are still on the target
- Repeat in opposite direction
- Vary the speed of head movement
- Practice for 5 minutes, rest if necessary

*Modified from ***Handbook*** of *Vestibular Rehabilitation."*

Figure 1: Organization of the Balance System[14]

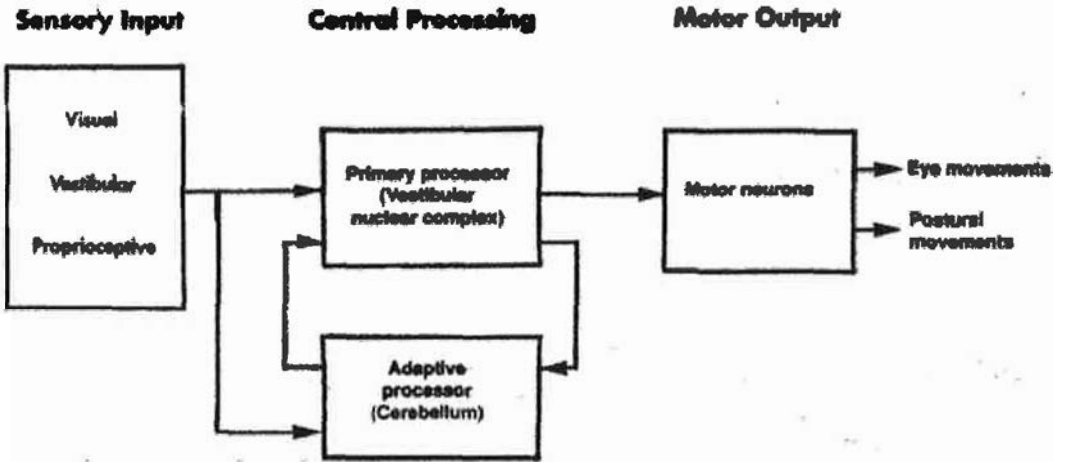

Figure 1 Vision, vestibular, and the proprioceptive system feed into the brainstem where sensory integration occurs. Eye movements and postural control are the result of a feedback loop with the cerebellum.

Figure 2: Anatomy of the Peripheral Vestibular System[14]

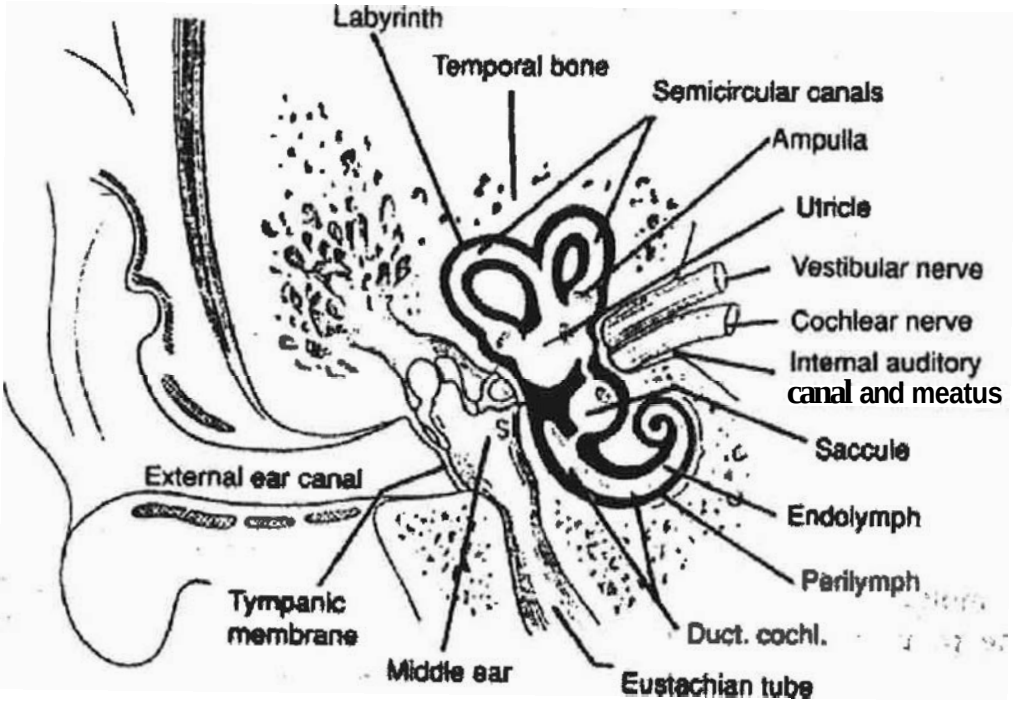

Figure 3: Dix-Hallpike Positional Test[16]

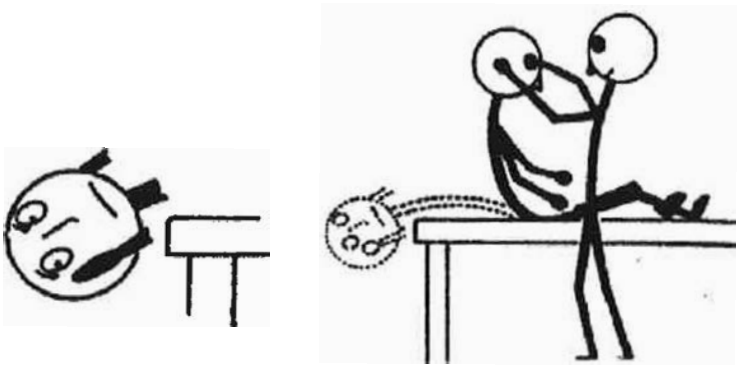

Figure 3 This procedure is performed by rapidly moving the patient from a sitting to head hanging position.

Figure 4: Romberg Test[11]

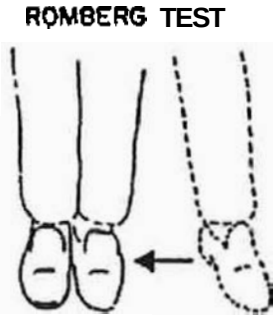

Figure 4 Romberg test performed with feet together, an alternative is the sharpened Romberg with the feet one in front of the other heel to toe.

Figure 5: Tandem walking[1]

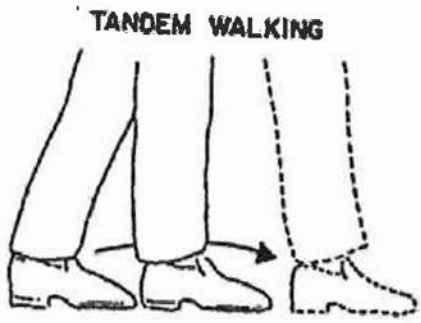

Figure 5 Patients place one foot in front of the other heel to toe for tandem walking.

Figure 6: Fresnzel Glasses[11]

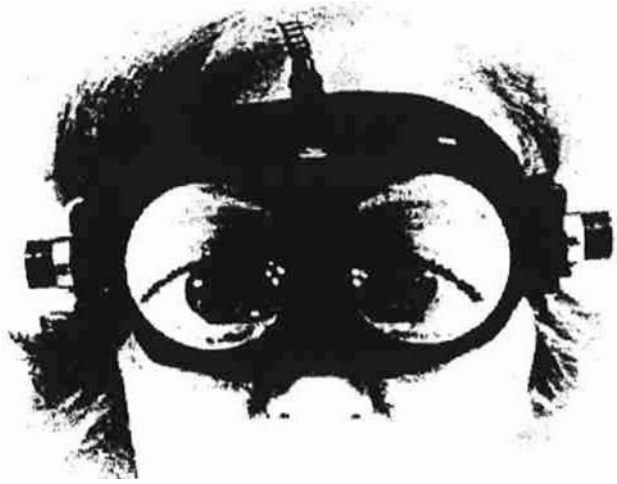

Figure 6 Frenzel glasses. These glasses are 30 diopter plus lenses mounted in a frame with an internal light source so the patient's eyes may be seen.