The Association Between Hearing Loss and Vestibular Disorders

The Role of the Audiologist

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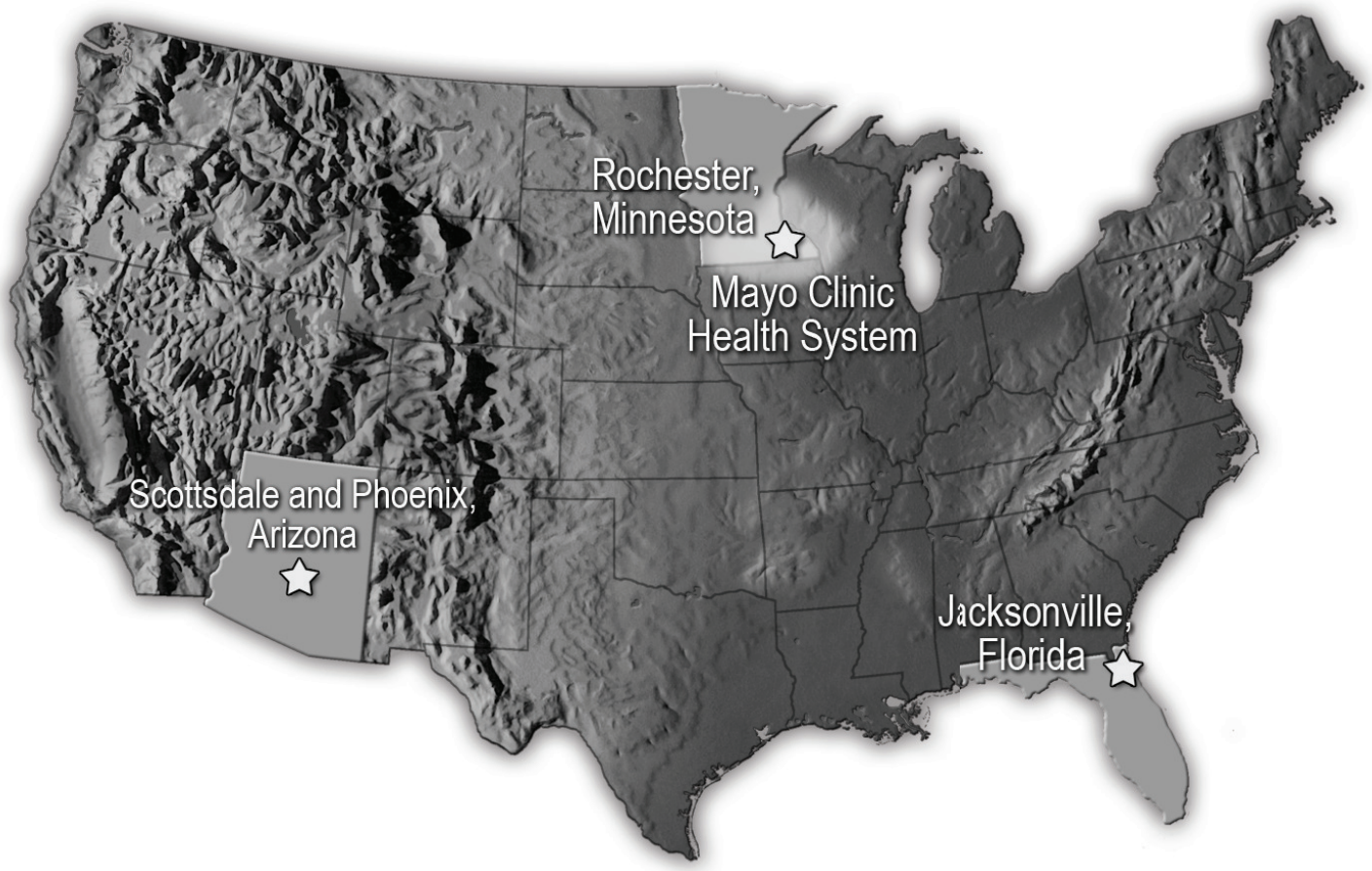
Canadian Academy of Audiology
October 12th, 2017

Mayo Clinic
Locations



Outline

- Case
- Review of Anatomy and Physiology
- Superior Canal Dehiscence
- Pediatrics
- Noise induced hearing loss
- Meniere's Disease

Outline

- Background
- Review of Anatomy and Physiology
- Superior Canal Dehiscence
- Pediatrics
- Noise induced hearing loss
- Meniere's Disease

History

- 59 yo female
- C/O
  - lightheadedness and true vertigo occurring frequently
  - positional vertigo turning head to right
  - dizziness when she blows her nose
  - pain in right ear
  - blurred vision
  - migraine headaches
- First began 8 months ago
- Attacks last ~30 min.

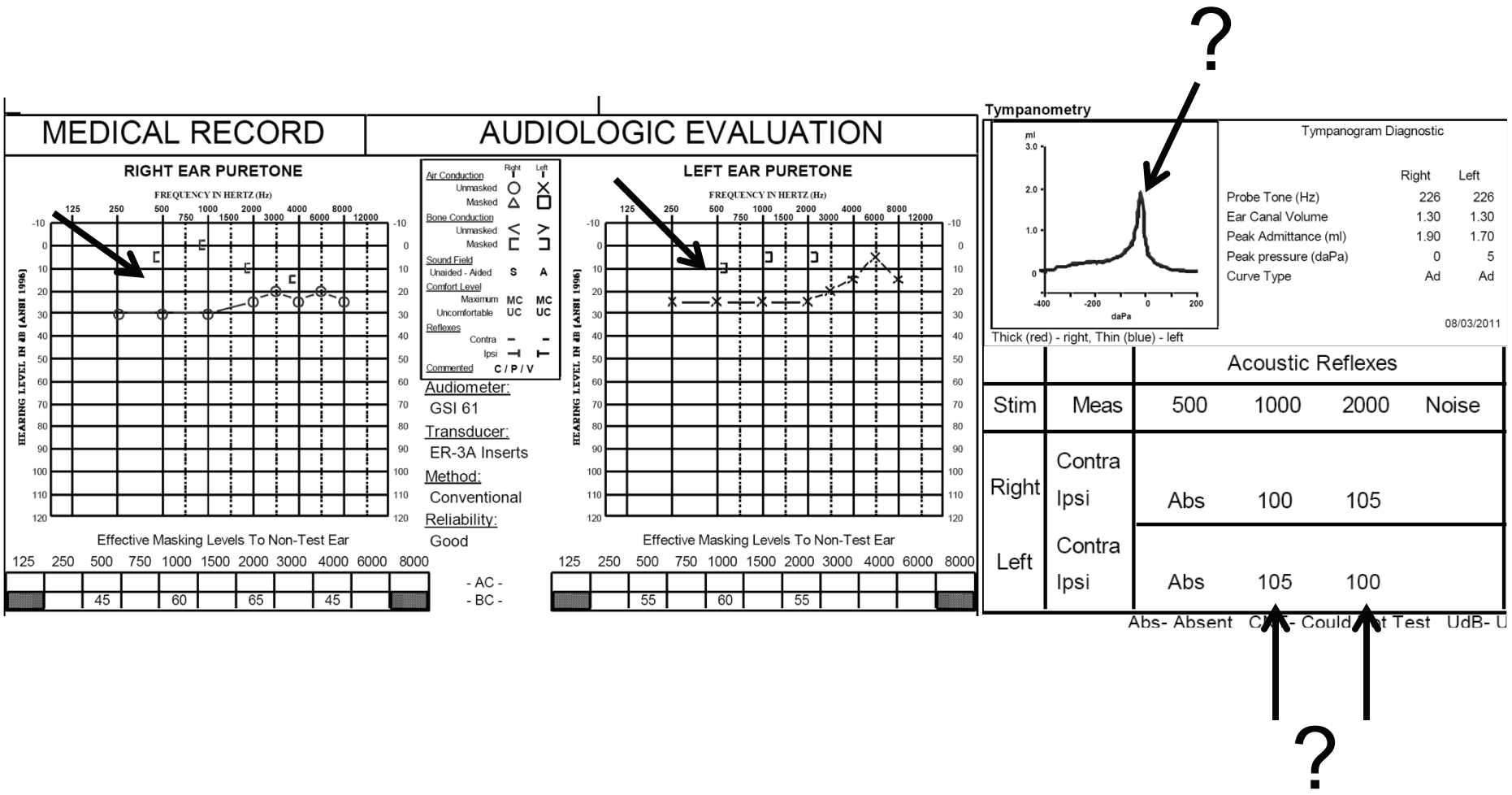
SCD

- 8/100 point total score representing no self-report dizziness disability/handicap.
- Meclizine prn for dizziness
- Paxil for depression

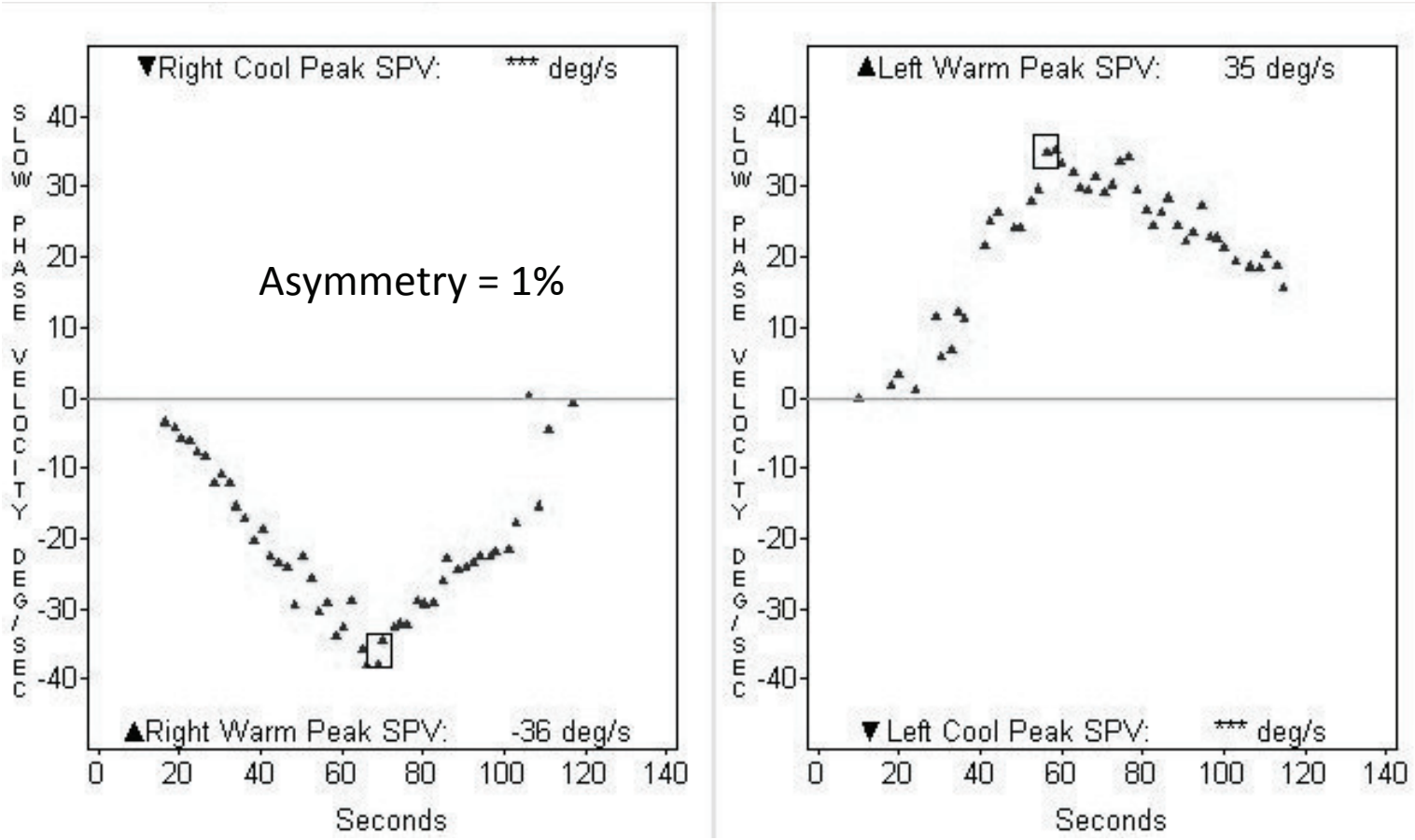
Symptoms

-
-
-
-
-

Audiometry


MEDICAL RECORD
AUDIOLOGIC EVALUATION
RIGHT EAR PURETONE
FREQUENCY IN HERTZ (Hz)
125 250 500 750 1000 1500 2000 3000 4000 6000 8000 12000
HEARING LEVEL IN dB (ANSI 1996)
Air Conduction
Unmasked
Masked
Bone Conduction
Unmasked
Masked
Sound Field
Unaided - Aided
Comfort Level
Maximum
Uncomfortable
Reflexes
Contra
Ipsi
Commented
Right Left
S A
MC MC
UC UC
C / P / V
Audiometer:
GSI 61
Transducer:
ER-3A Inserts
Method:
Conventional
Reliability:
Good
Effective Masking Levels To Non-Test Ear
125 250 500 750 1000 1500 2000 3000 4000 6000 8000
45 60 65 45
- AC -
- BC -
LEFT EAR PURETONE
FREQUENCY IN HERTZ (Hz)
HEARING LEVEL IN dB (ANSI 1996)
Effective Masking Levels To Non-Test Ear
125 250 500 750 1000 1500 2000 3000 4000 6000 8000
55 60 55
Tympanometry
ml
3.0
2.0
1.0
0
-400 -200 0 200
daPa
Thick (red) - right, Thin (blue) - left
Tympanogram Diagnostic
Right Left
Probe Tone (Hz) 226 226
Ear Canal Volume 1.30 1.30
Peak Admittance (ml) 1.90 1.70
Peak pressure (daPa) 0 5
Curve Type Ad Ad
08/03/2011
Acoustic Reflexes
Stim Meas 500 1000 2000 Noise
Right Contra
Ipsi Abs 100 105
Left Contra
Ipsi Abs 105 100
Abs- Absent
?
?

SCD- Monothermal Warm Caloric Examination



SCD Threshold ~60 dB nHL

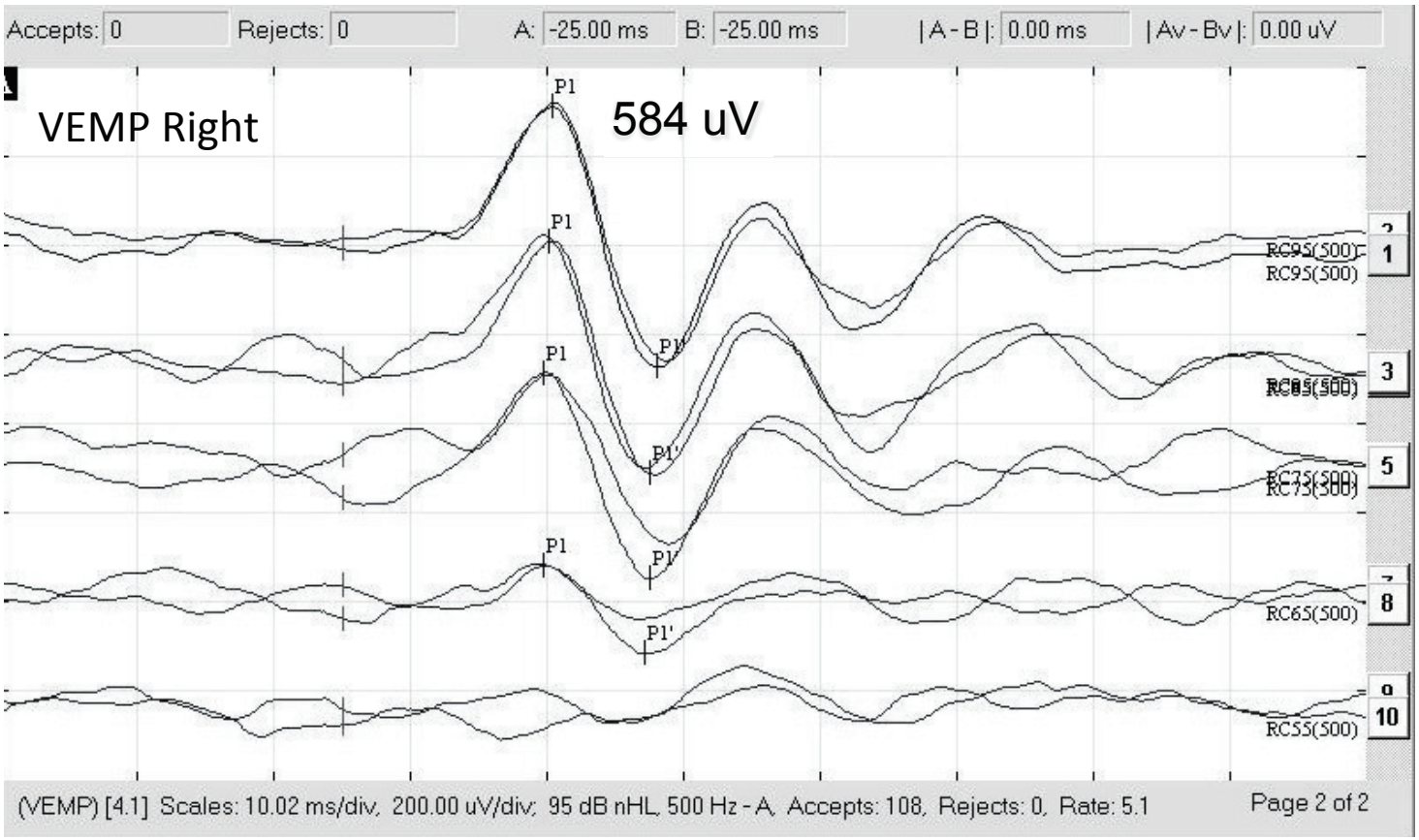
95 dB nHL

85 dB nHL

75 dB nHL

65 dB nHL

55 dB nHL



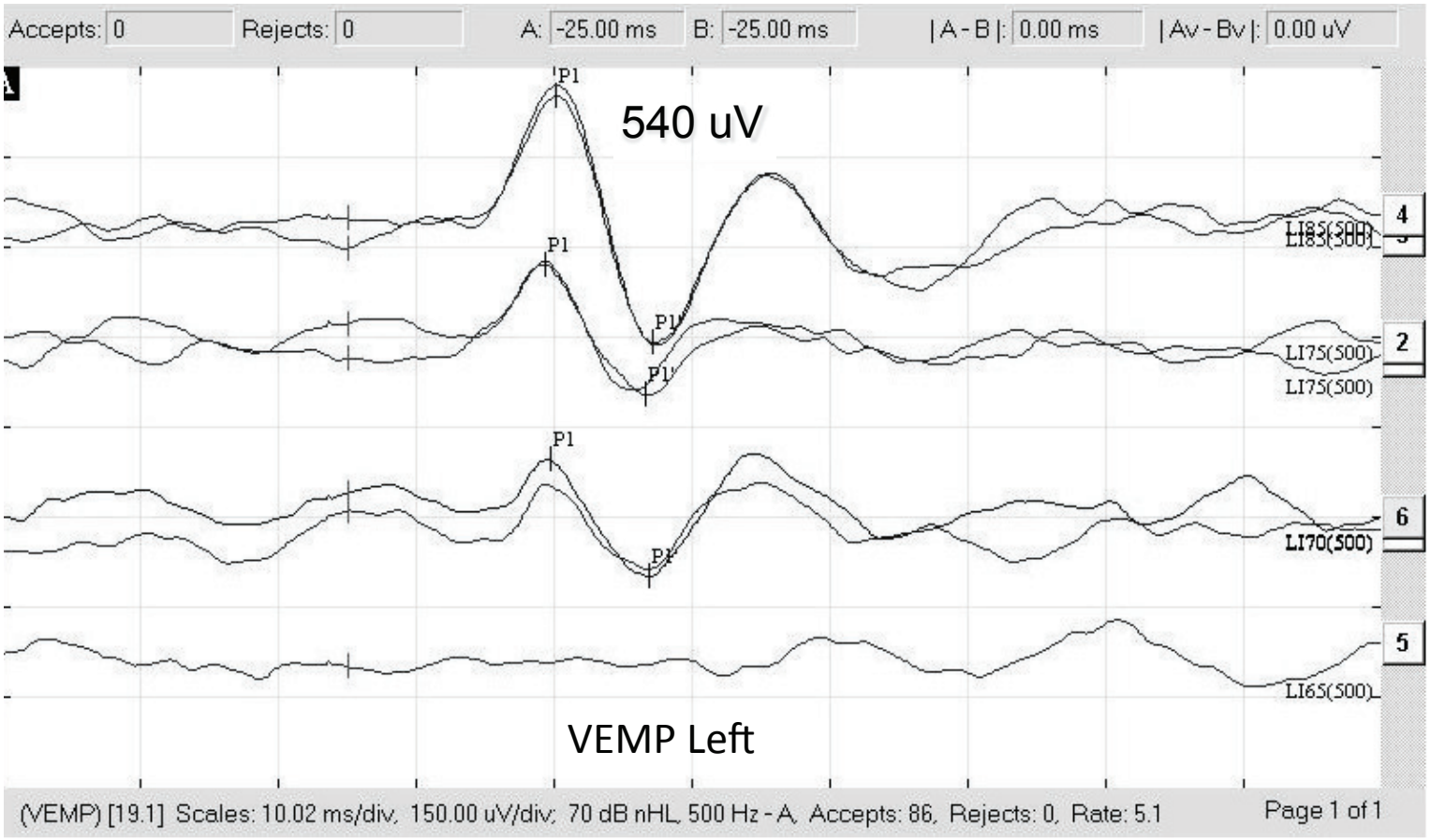
SCD Threshold ~65 dB nHL

85 dB nHL

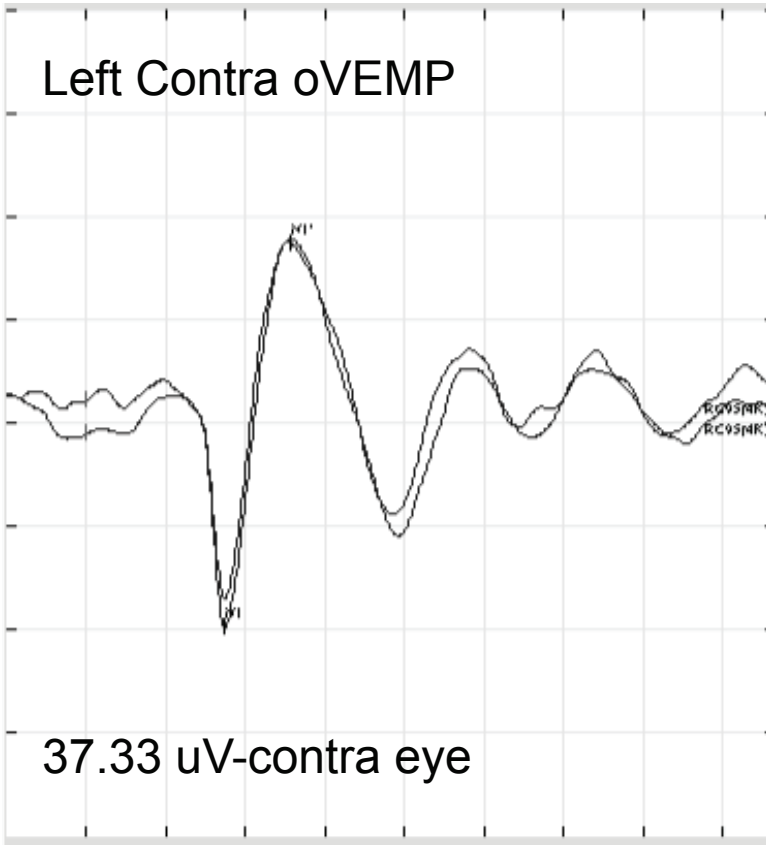
75 dB nHL

70 dB nHL

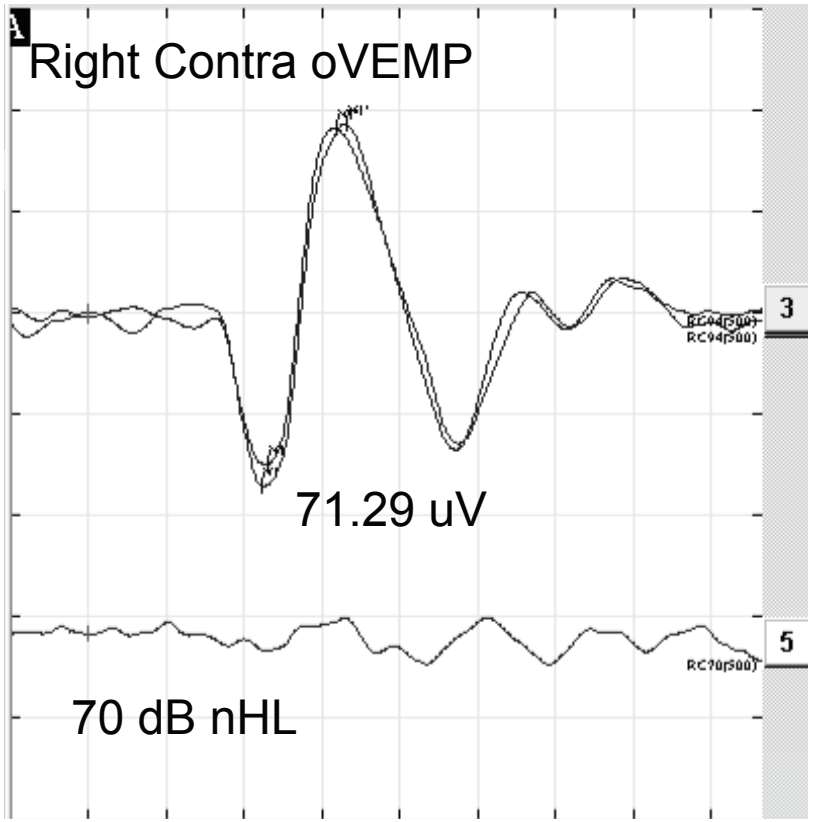
65 dB nHL



oVEMP, 500 Hz, 95dBnHL



4.98 ms/div, 10 uV/div (contra)

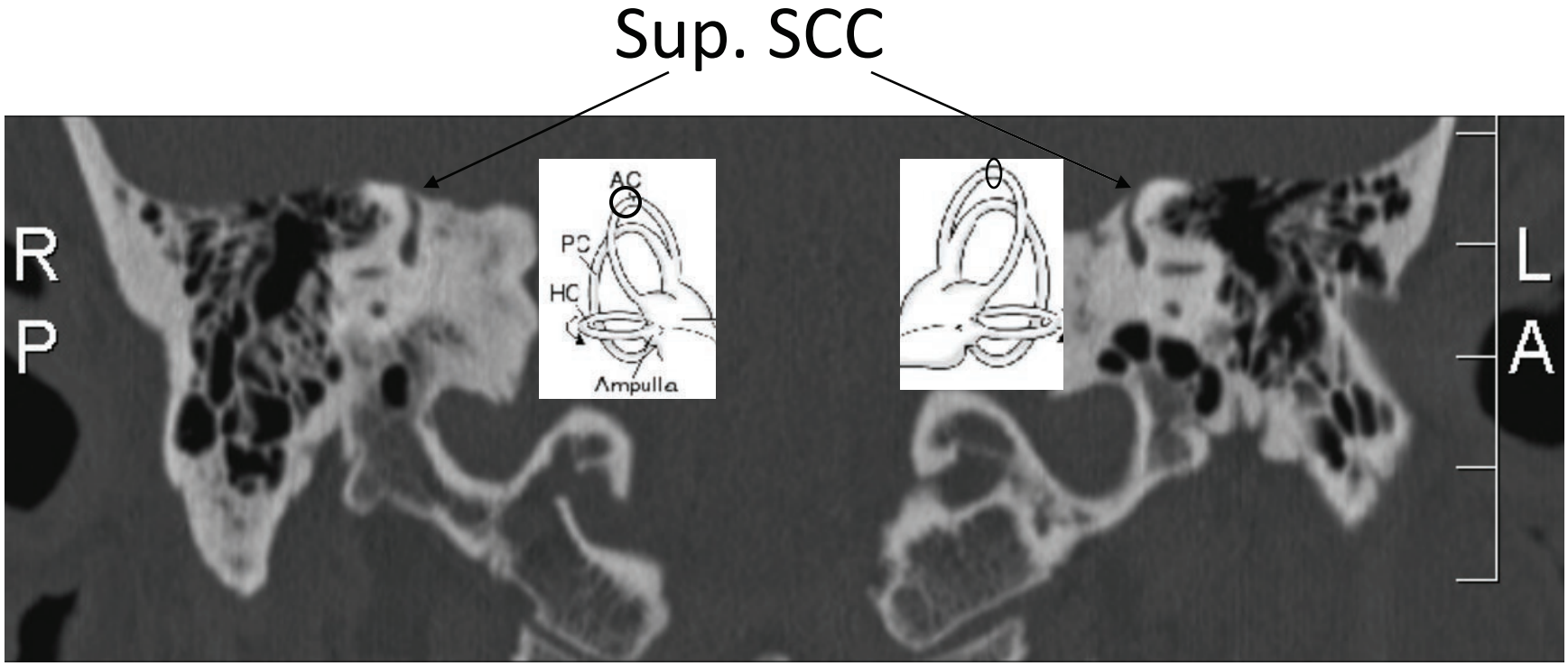


4.98 ms/div, 20 uV/div

6.69 uV

Patient Humming

Coronal Sections



.97 mm^2

.8 mm^2

CT Scan

- “There is no obvious bony roof over the bilateral superior semicircular canals.”
- Impression: Findings consistent with bilateral superior semicircular canal dehiscence, more prominent on the right.

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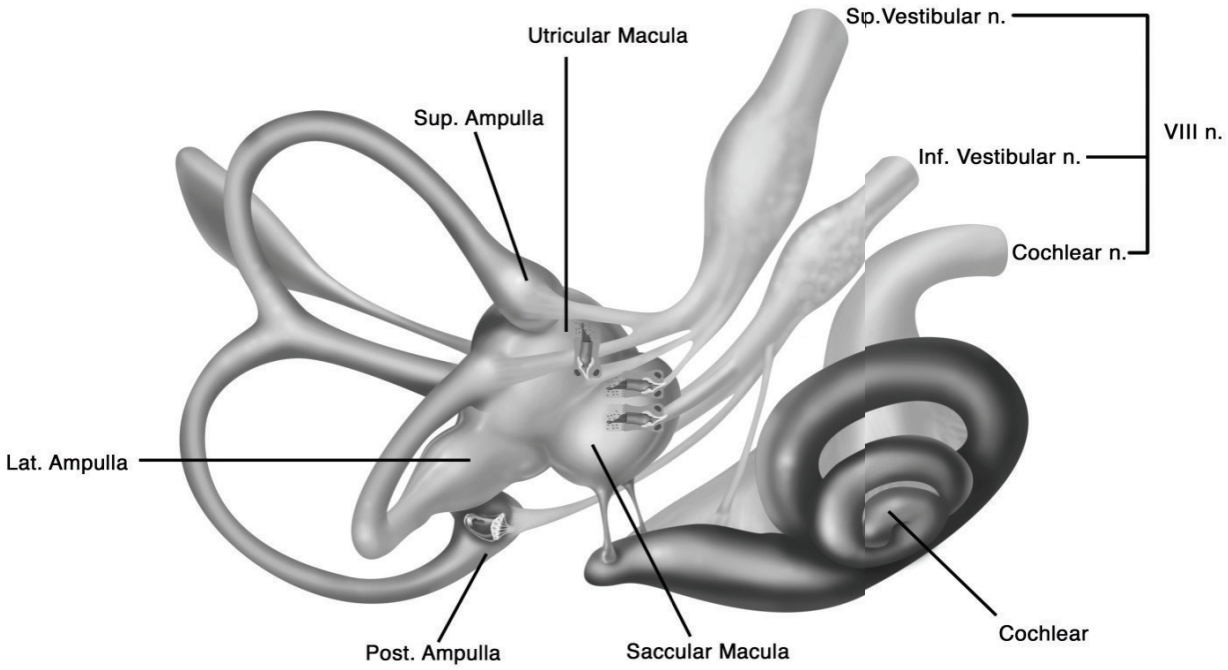
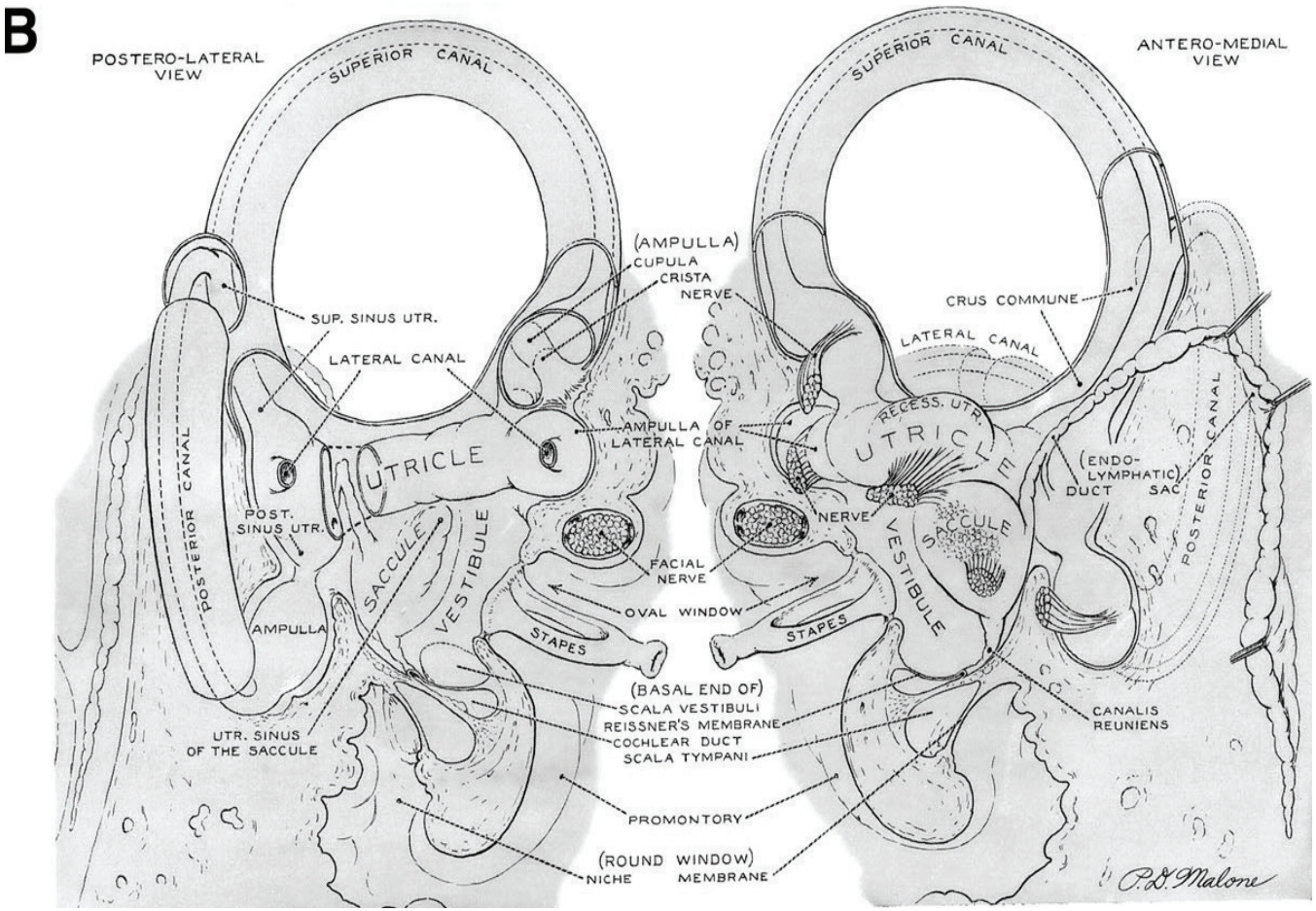
- Trauma/Blast - Noise induced hearing loss

Peripheral Vestibular System



Peripheral Vestibular System



Van de Water, 2012

Background

- A growing body of evidence suggests that noise can result in impairment of the vestibular system.
- also adversely affects portions of the peripheral vestibular system (Juntunen et al, 1987; Manabe et al, 1995; Golz et al, 2001; Kumar et al, 2010).
- These consequences, much like those incurred by the auditory system, can be either permanent or temporary. Research suggests that the saccule and inferior vestibular nerve seem to be the structures most damage from noise (Golz et al, 2001; Hsu

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History

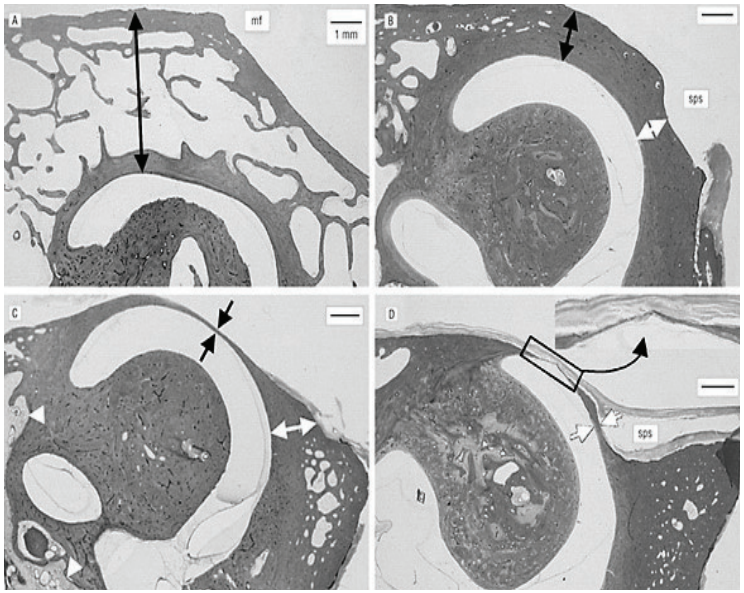
- 1998: Minor describes SCDS
  - 8 patients with sound +/- pressure induced vertigo
  - Eye movements align with superior canal
  - Common history of fistula repair or stapedectomy
  - Mobile “third window” theory

Definition

- Rare inner ear disorder
- Abnormal thinning of the bone over the superior semicircular canal
- Results in mobile third window
  - Auditory symptoms
  - Vestibular symptoms

Epidemiology

- 0.5% incidence complete dehiscence
- 1.4% incidence bony thickness <0.1 mm
- Average thickness over canal .96 mm
- Median age ≈ 40
- Women = Men
- Right > Left

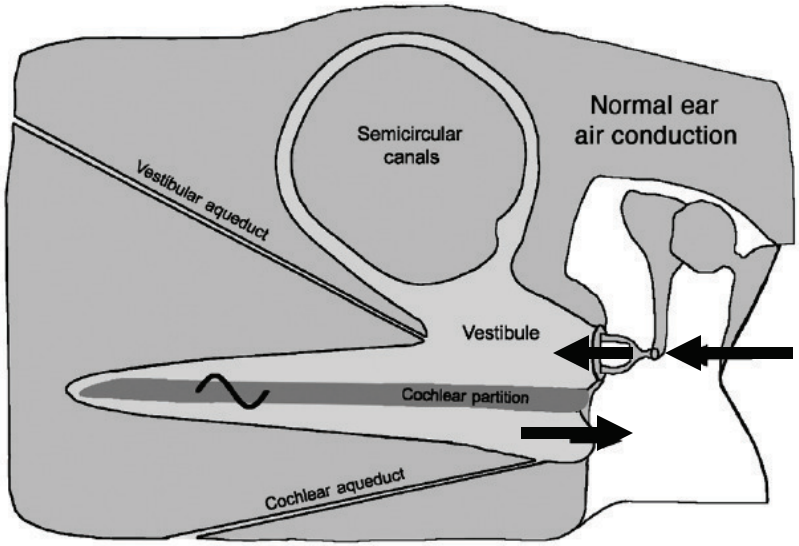


Carey, J. P. et al. Arch Otolaryngol Head Neck Surg 2000;126:137-147.

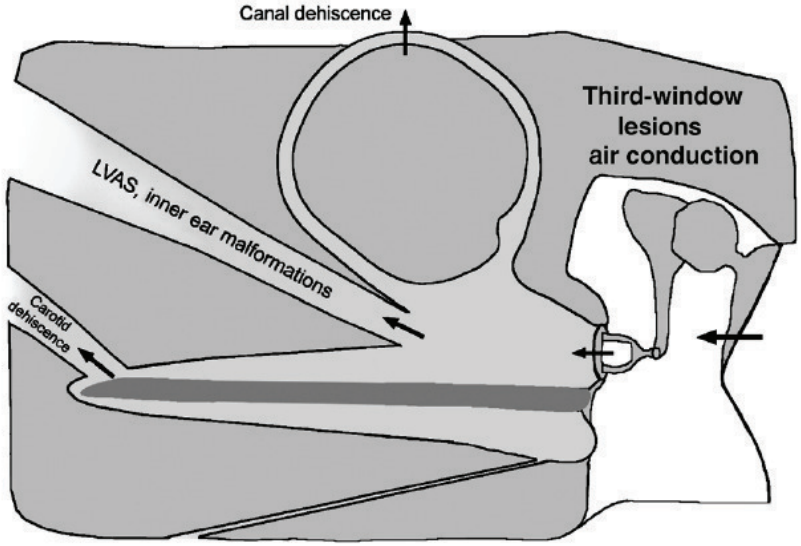
Pathophysiology

- When the bony capsule overlying a semicircular canal is disrupted, one of the major protective mechanisms that prevent sound energy from stimulating the canal is lost.
- Tullio (1929) demonstrated this in his seminal experiments with sound as a stimulus for the labyrinth in pigeons after he fenestrated their semicircular canals.

Pathophysiology

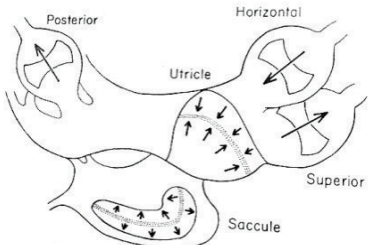


Normal



Dehiscence

RICHARD R. GACEK



Otology & Neurotology
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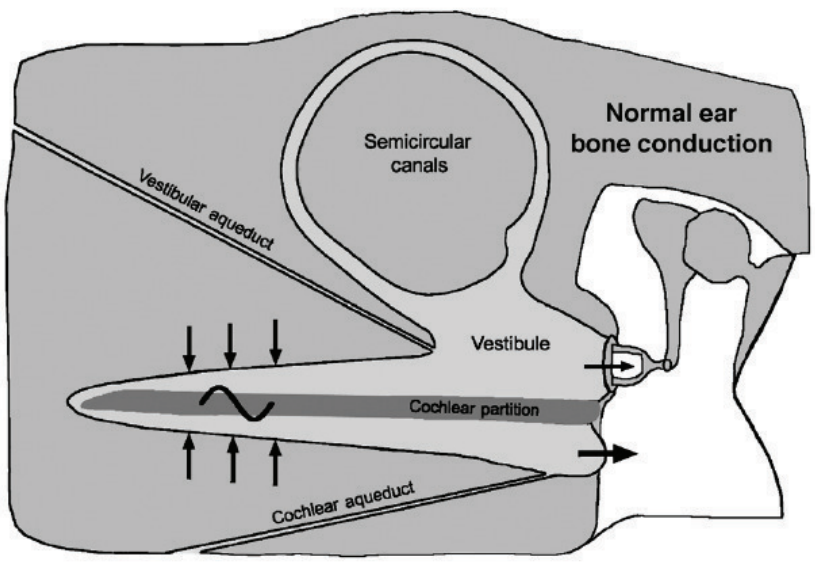
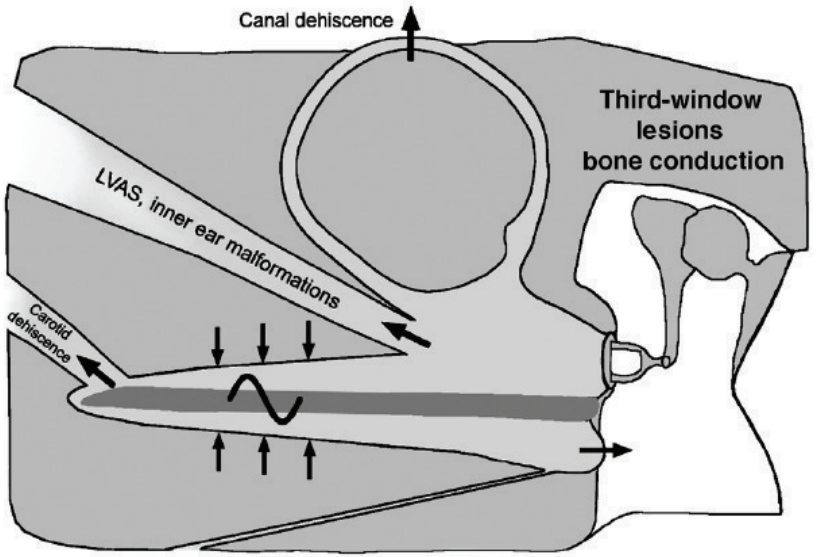
Bone Conduction





Normal **Dehiscence**

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Pathophysiology

superior canal afferents

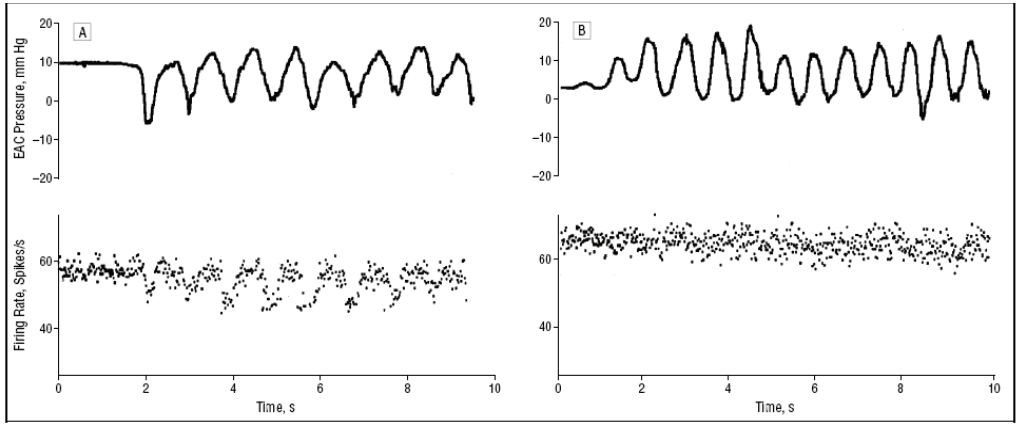
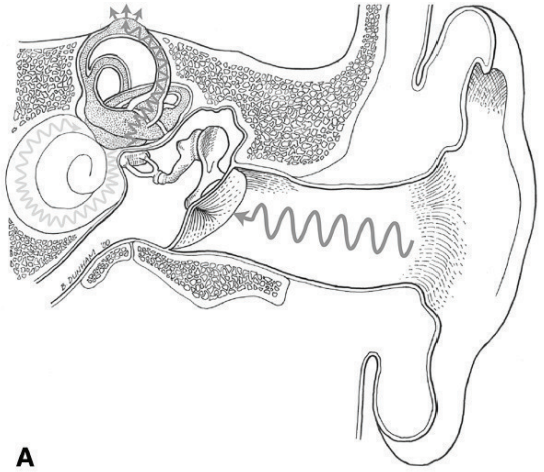
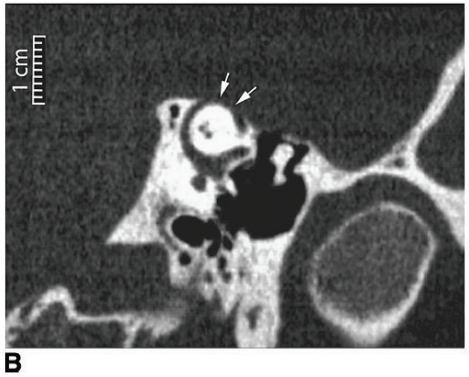


Figure 4. A superior canal afferent responding to sinusoidal external auditory canal (EAC) pressure while the superior canal fenestra is open (A) or sealed with muscle and a rigid layer of cyanoacrylate (B).



ARCH OTOLARYNGOL HEAD NECK SURG/ VOL 127, NOV 2001

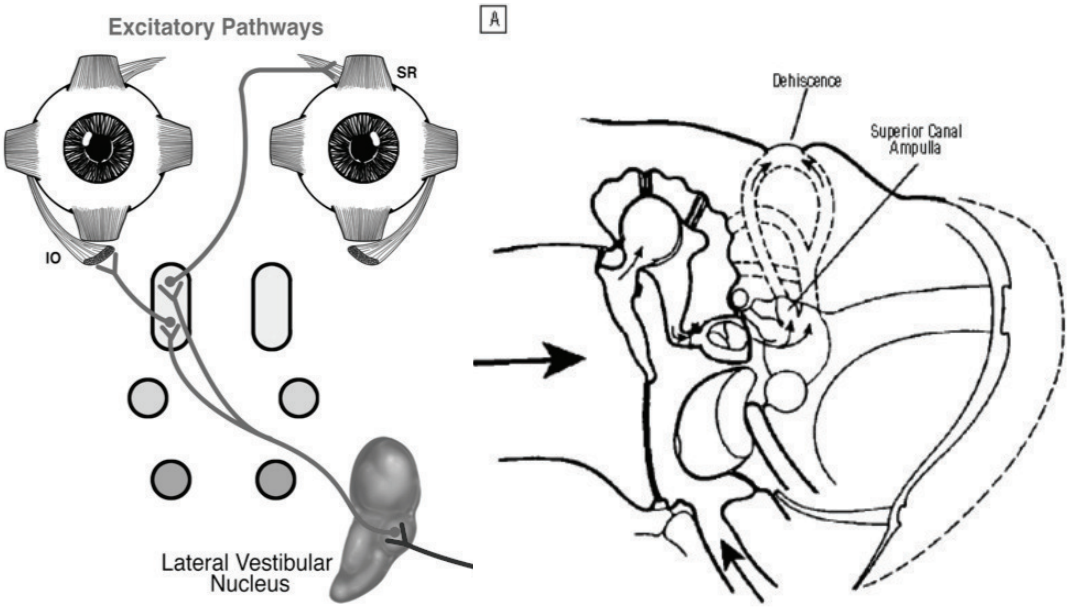


Pathophysiology

- Vestibular signs: 95%
  - Sound-evoked eye movement: 82%
  - Valsalva induced eye movements: 75%
  - Tragal pressure induced eye movement: 45%
  - Sound induced head movement: 20%

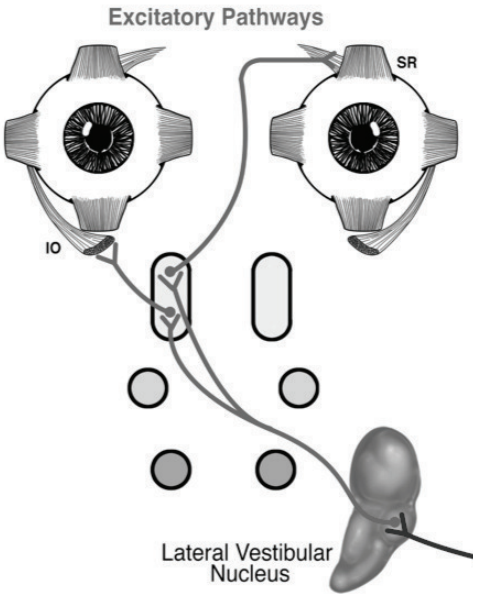
Pathophysiology
(Excitation)

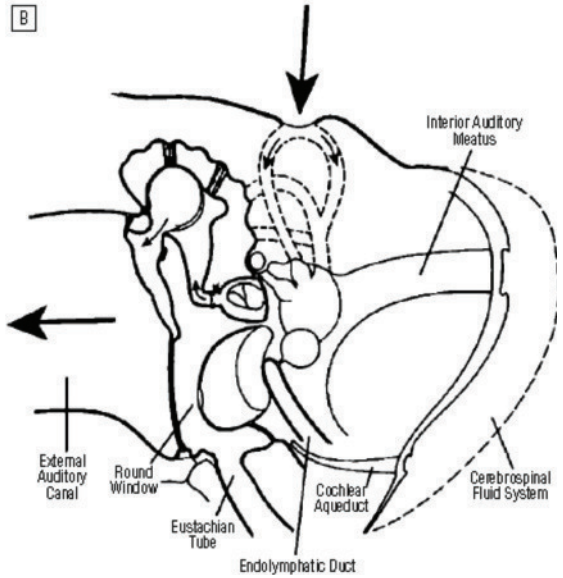
-
-
  open-pinched nostrils)
- Positive Pressure
- Eyes deviate up and toward the nose

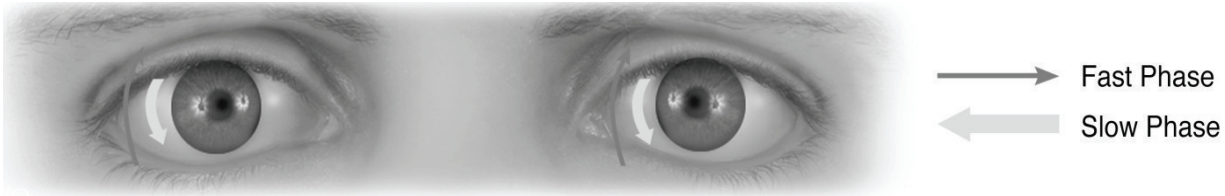


Pathophysiology
(Inhibition)

- (glottis closed)
- Eye movements will be down and away from nose







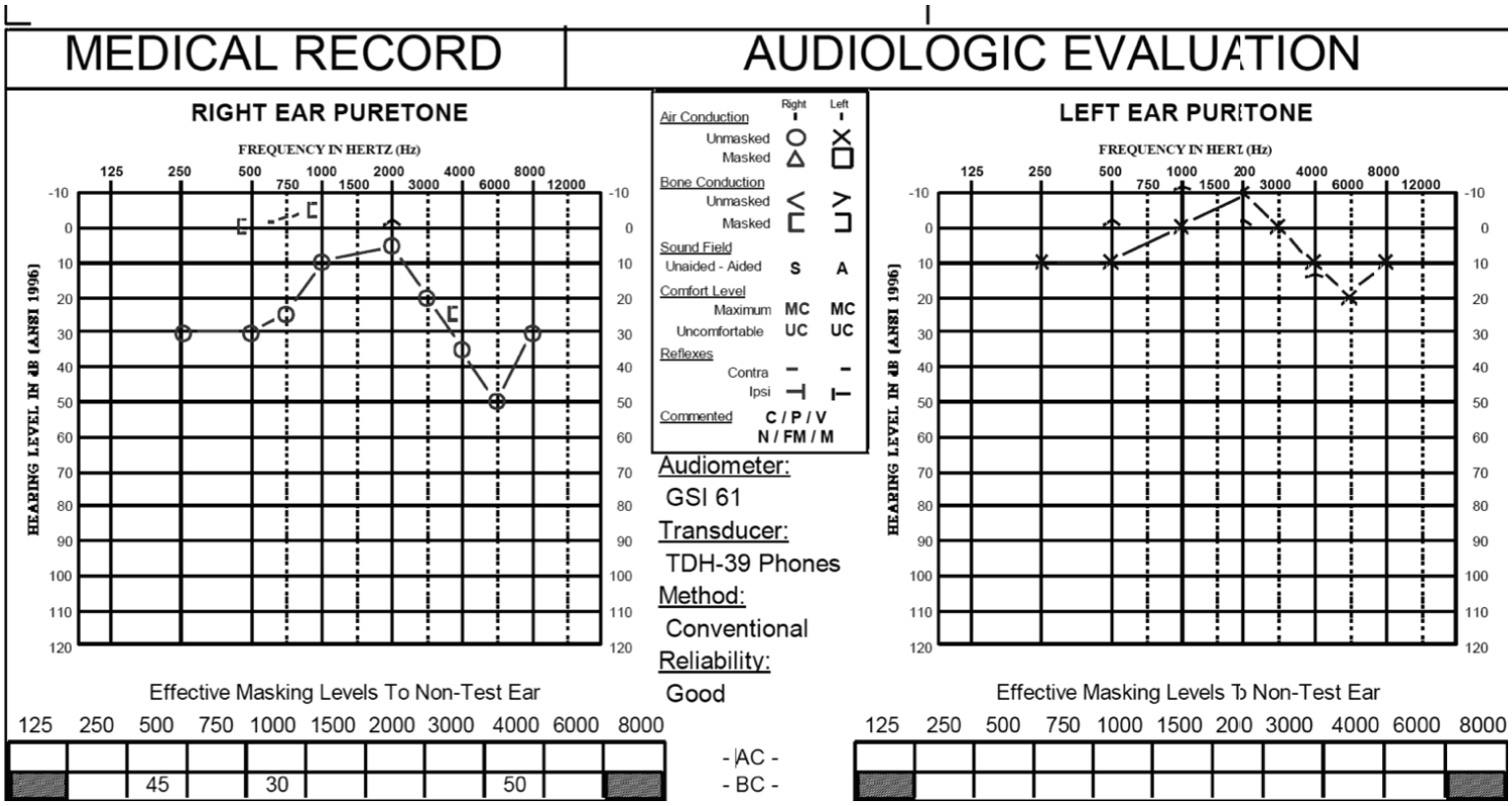
Work-up for SCDS

- History
  - Symptoms
- Examination
- Hearing Test
  - Behavioral and Electrophysiological
- Vestibular Function Testing
- Imaging
- EcochG
- Wideband Reflectance

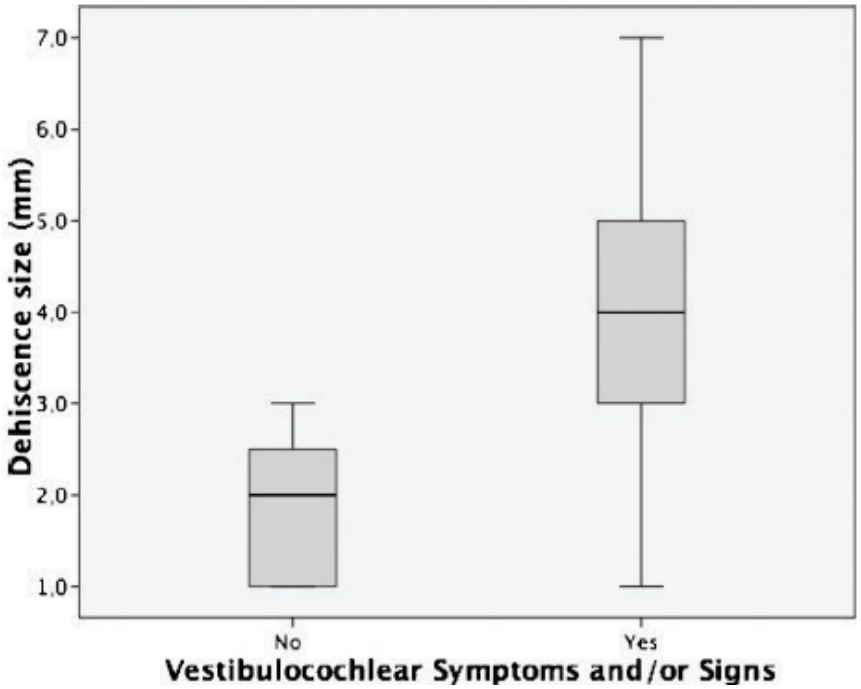
Audiometric and Vestibular Findings

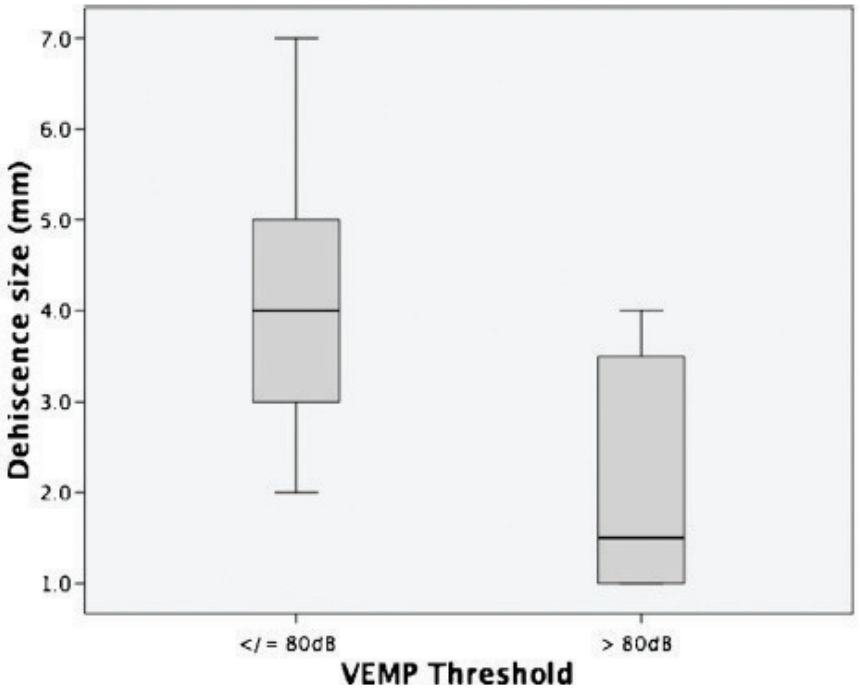
- Pseudo-conductive HL
- Normal immittance
  - Tympanograms
  - Acoustic reflexes
- Sensitivity to bone conducted sound
- VEMPs demonstrate higher amplitudes and lower thresholds

Audiometric Findings in SCD (Conductive)



>Dehiscence = >Symptoms



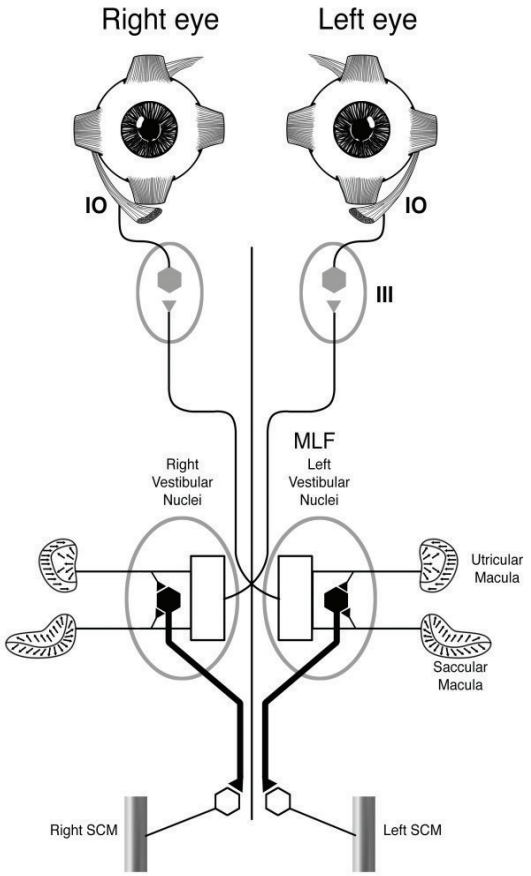


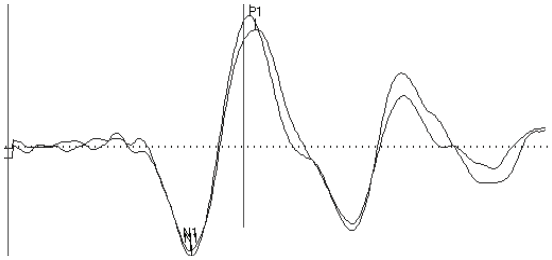
Pfammatter, Otol Neurotol, 2010

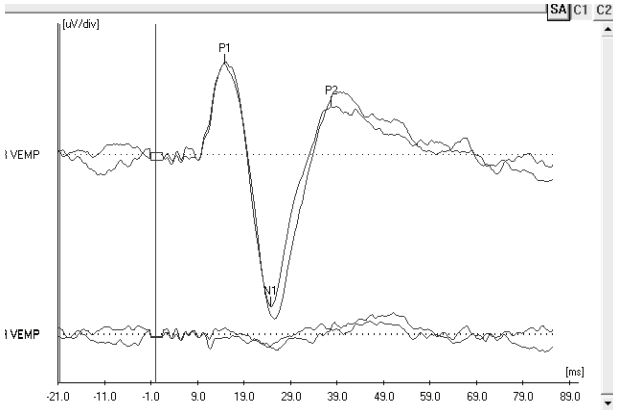
SCD Factor

- When I cough I get dizzy
- I get dizzy when I sneeze
- Loud sounds make me dizzy
- I get dizzy when I have a bowel movement
- Loud sounds make my vision blurry
- I get dizzy when I strain to lift something
- I get dizzy spells where I also feel like I have a lump in my throat
- I become dizzy when I am in large crowds

VEMP Pathways







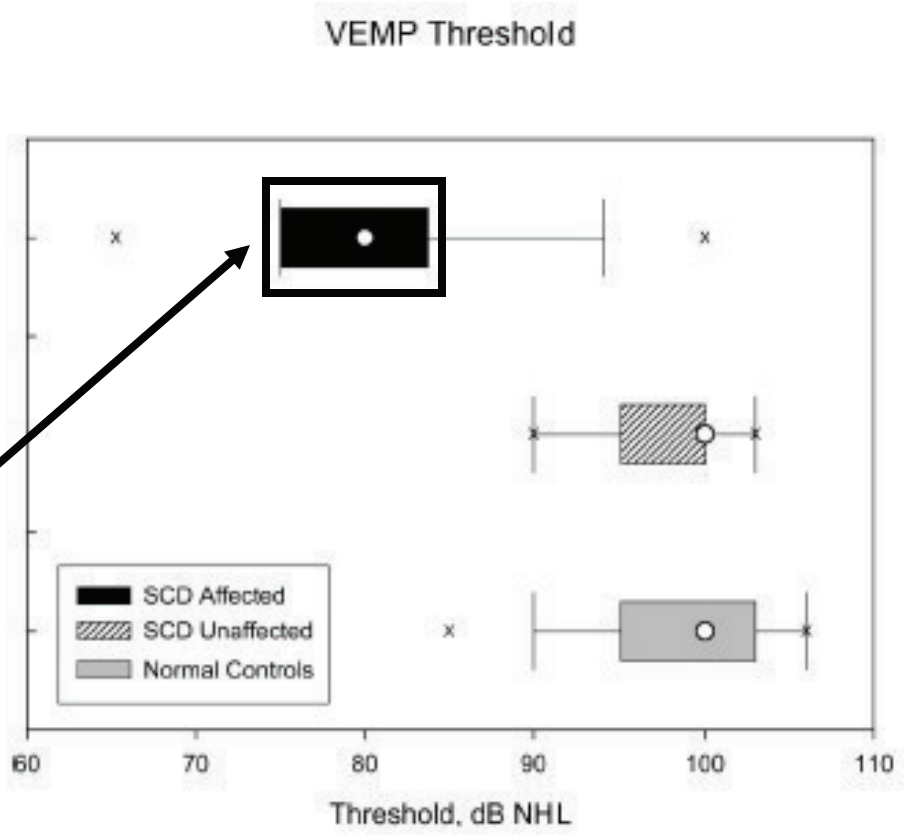
oVEMP and cVEMP

cVEMP

- Recumbent patient is asked to raise their head from the table- (bilateral testing)

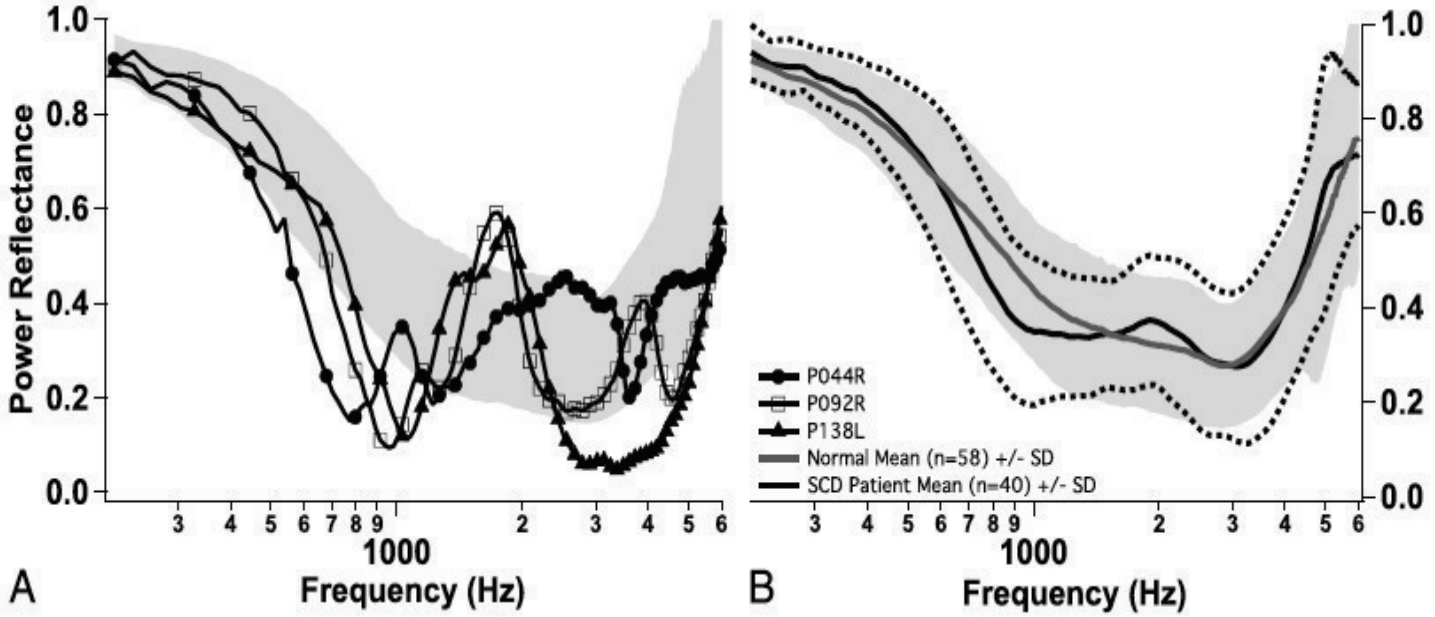
Clinical Applications of VEMP
Hypersensitivity Disorders

- Patients show large VEMP's at reduced thresholds and abnormally large VEMP
- VEMP threshold differences 72 dB +/- affected side vs 96 dB +/-4 dB on the unaffected side.



From: Minor (2005)

WBT – 1Khz



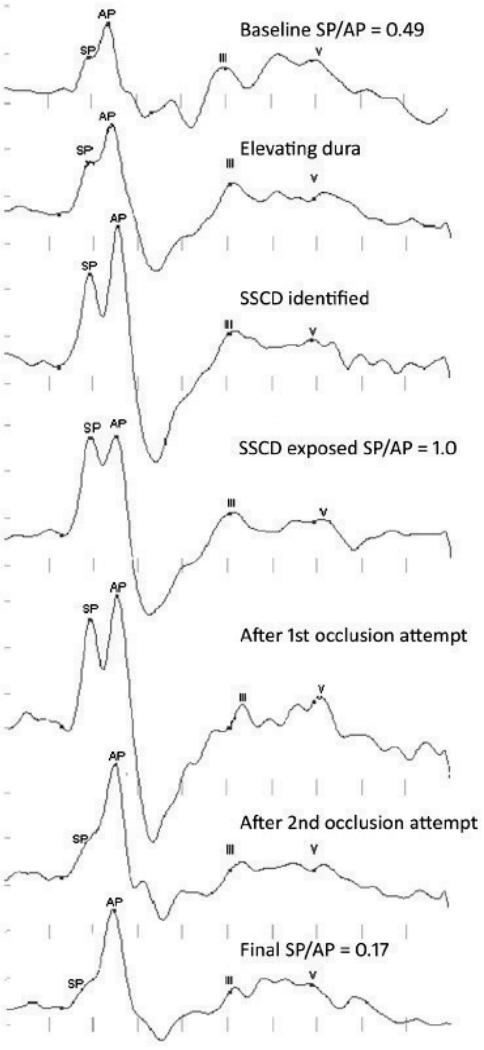
Merchant et al., Otology & Neurotology, 2014

ECochG

- ECochG
  - Summation Potential / Action Potential ratio (SP/AP) Increased: >0.4
  - Sensitivity 89%,
  - Specificity 70%

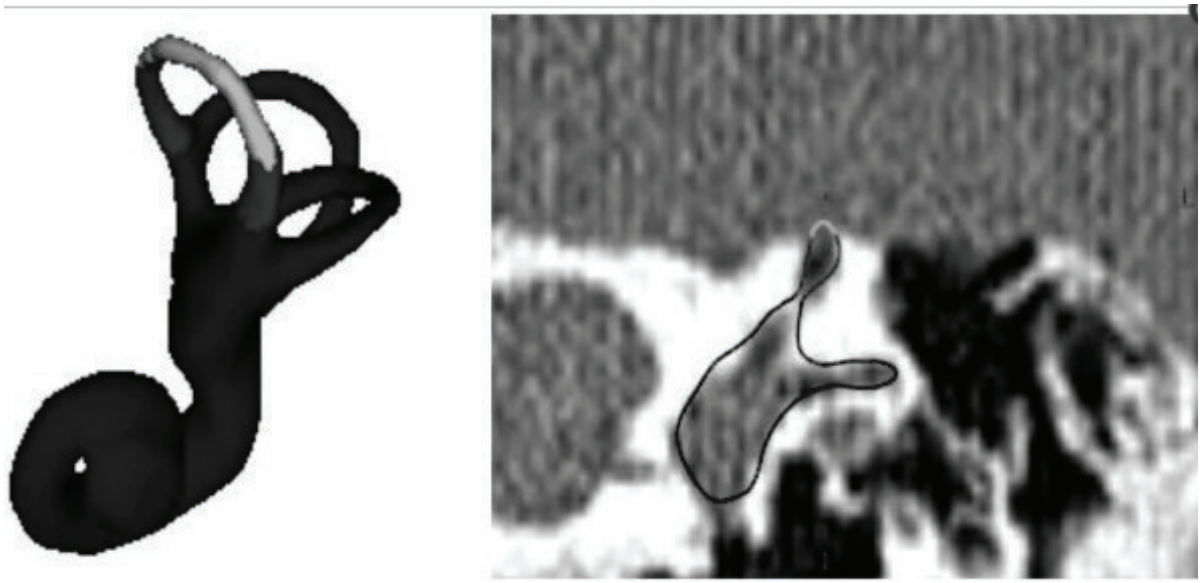
- Good for OR

Art et al., *Otol Neurotol*, 2011

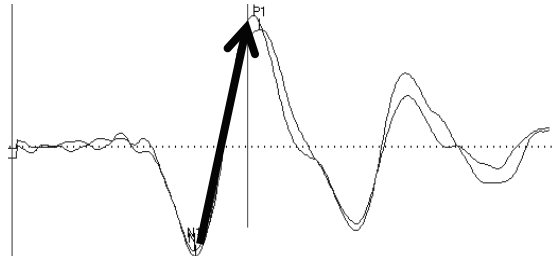


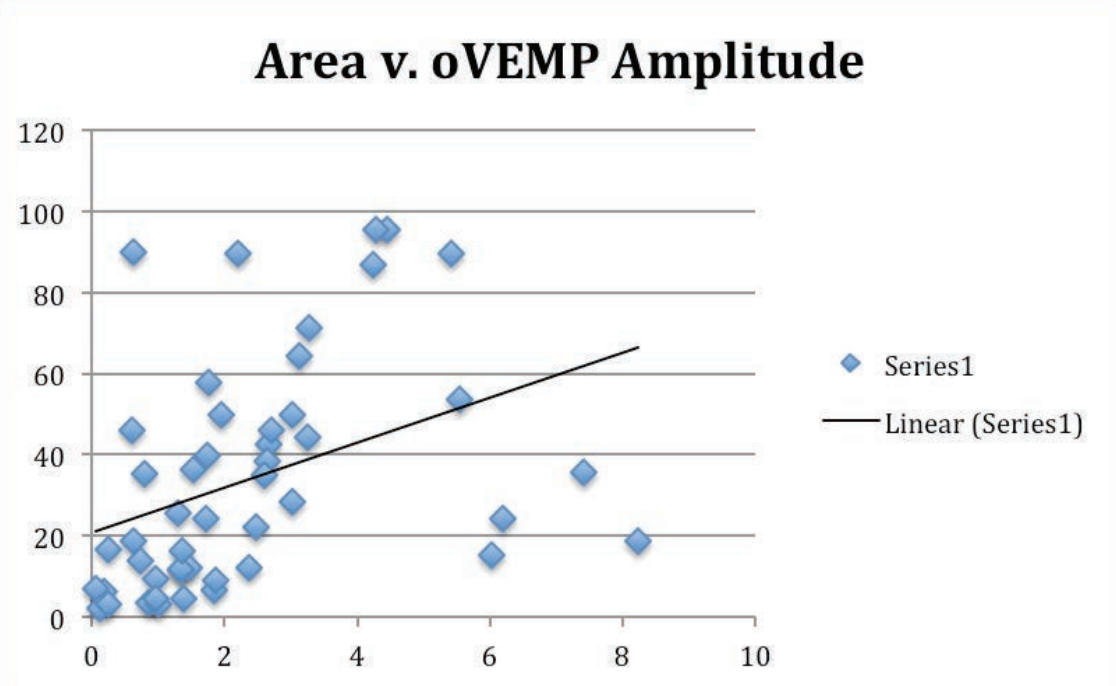
Correlation of Superior Canal Dehiscence Surface Area With Vestibular Evoked Myogenic Potentials, Audiometric Thresholds, and Dizziness Handicap.

Hunter JB[1], O'Connell BP, Wang J, Chakravorti S, Makowiec K, Carlson ML, Dawant B, McCaslin DL, Noble JH, Wanna GB.



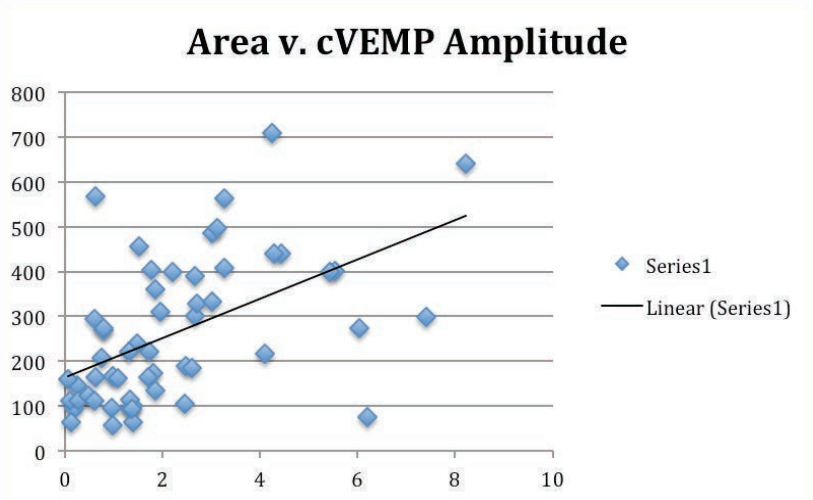
Area vs. oVEMP P-P Amplitude



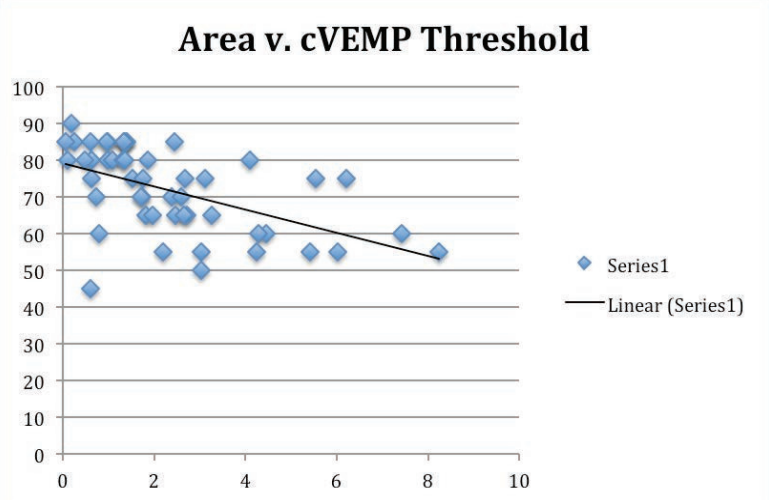


(r = 0.56, p < 0.0001)

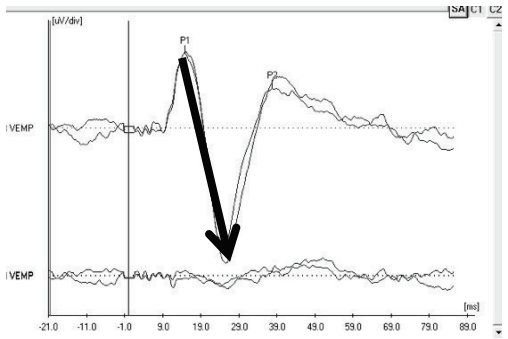
Area vs. cVEMP Amplitude and Threshold



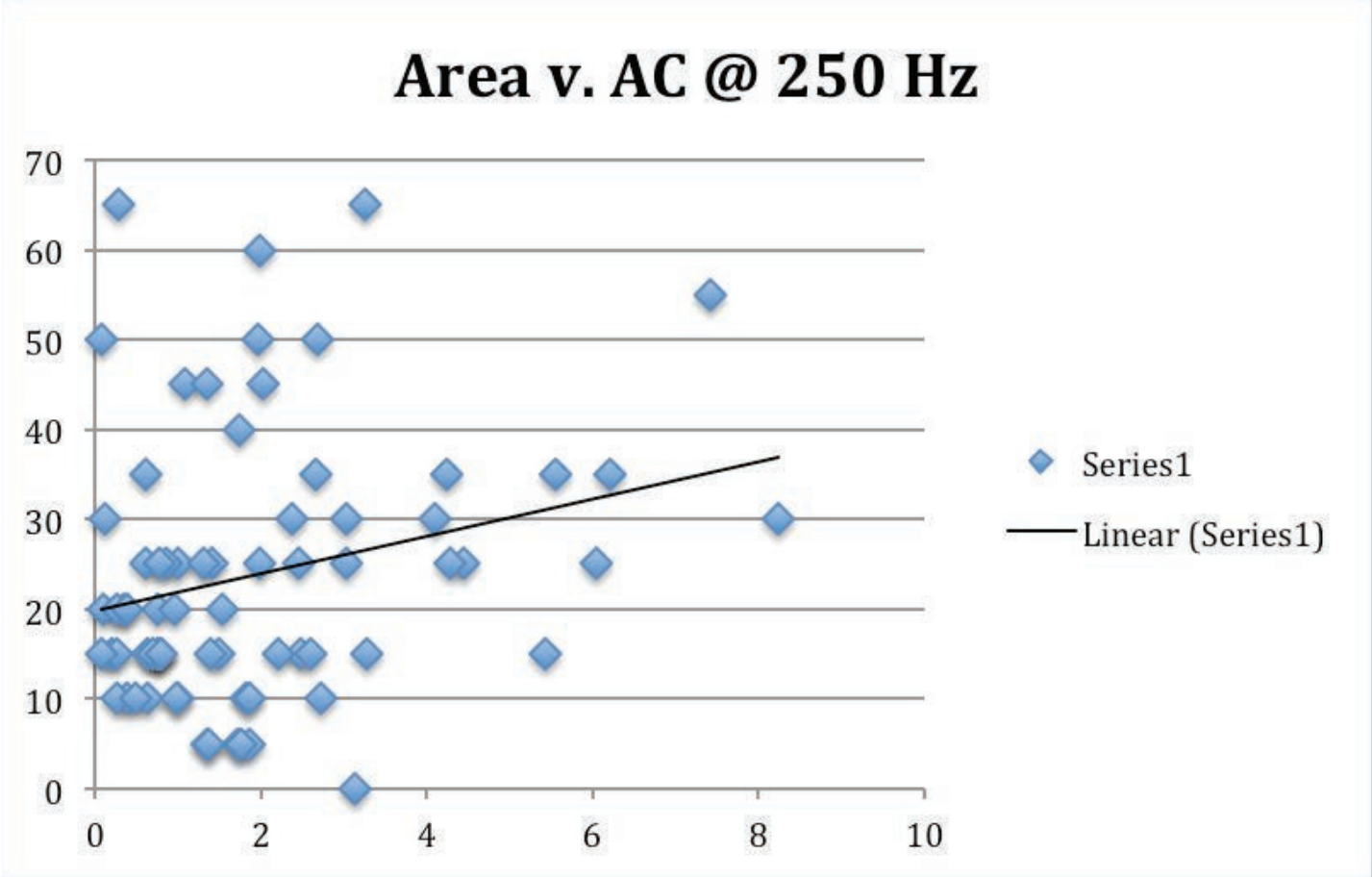
(r = 0.49, p < 0.0001)



(r = -0.63, p < 0.0001



Area vs. Hearing Thresholds



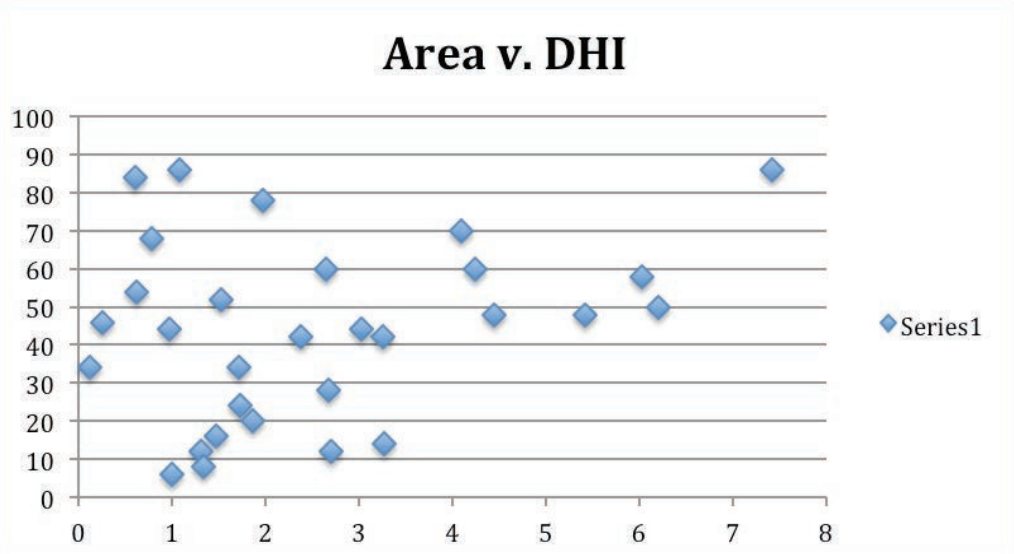
(r = 0.30, p = 0.013)

Area vs. Dizziness Handicap

DIZZINESS HANDICAP INVENTORY (DHI)

Instructions: The purpose of this test is to identify difficulties that you may be experiencing because of your dizziness or unsteadiness. Please answer "yes," "sometimes," or "no" to each question. Answer each question as it pertains to your dizziness problems only.

	Yes (4)	Sometimes (2)	No (0)
P1. Does looking up increase your problem?			
E2. Because of your problem do you feel frustrated?			
F3. Because of your problem do you restrict your travel for business or recreation?			
P4. Does walking down the aisle of a supermarket increase your problem?			
F5. Because of your problem you have difficulty getting into or out of bed?			
F6. Does your problem significantly restrict your participation in social activities such as going out to dinner, going to the movies, dancing, or to parties?			
F7. Because of your problem do you have difficulty reading?			
P8. Does performing more ambitious activities like sports, dancing, household chores, such as sweeping or putting dishes away, increase your problem?			
E9. Because of your problem are you afraid to leave your home without having someone accompany you?			
E10. Because of your problem have you been embarrassed in front of others?			
P11. Do quick movements of your head increase your problem?			
F12. Because of your problem do you avoid heights?			



Role of the Audiologist

- The a more in-depth examination of whether a patient has SCD should be established based on:
  - Case history
  - Audiometry
  - Bedside tests
  - VEMP responses
  - Questionnaires

Transforming Superior Canal Dehiscence to Chronic Subjective Dizziness: From SCD to CSD (McCaslin et al., 2010).

Outline

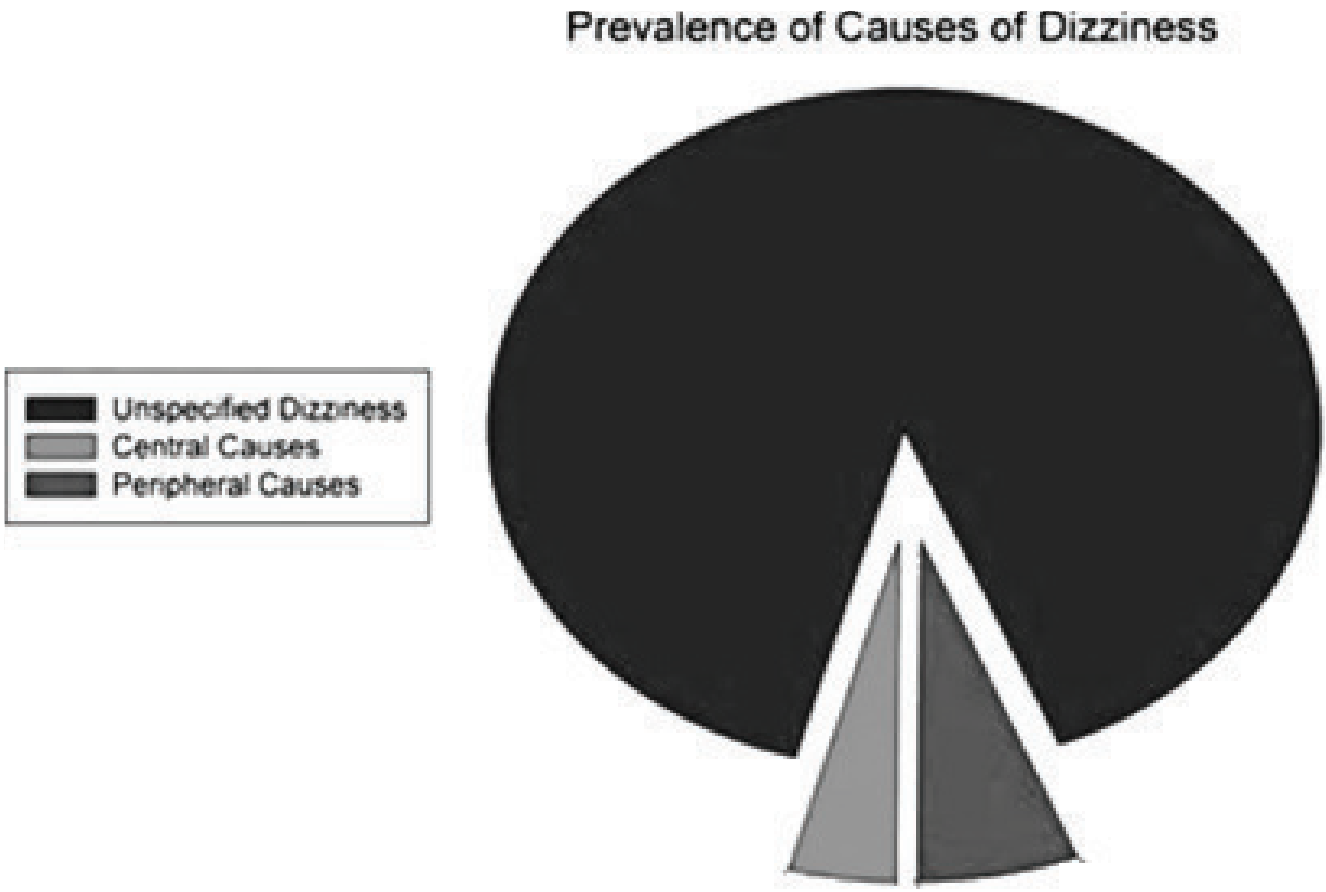
- Case
- Review of Anatomy and Physiology
- Superior Canal Dehiscence
- Pediatrics
- Noise induced hearing loss
- Meniere's Disease

Prevalence

- 1.03% (5,793) of patients 0-18 yoa present with primary complaint related to balance
- 0.45% of patients 0-18 yoa diagnosed with a balance disorder (O'Reilly et al 2010)
  - 4 year retrospective review of a pediatric health system records for ICD9 codes related to balance disorders: 561,151 inpatient and outpatient encounters were reviewed
  - 2,546 pediatric patients diagnosed with a balance disorder

O'Reilly et al., Otology Neurotology, 2010

What they found . . .



But…

- Vestibular impairment is the single most common associated feature of SNHL (Cushing, 2015)
- Studies have suggested that up to 85% of children with SNHL have some degree of vestibular impairment (Arnvig, 1955, Cushing et al., 2008, O'Reilly et al., 2011).
- So, 0.45% is likely an underestimation of prevalence in our clinical populations