# OAEs in Clinical Audiology Today: Best Practices for Identification and Diagnosis of Auditory Dysfunction

- OAEs add value to audiologic assessment
- Update on generation of OAEs
- Clinical application of OAEs by audiologists
  - Under-utilization
  - Limitations in technique and analysis
- Evidence-based clinical applications in pediatric populations
- Evidence-based clinical applications in adults

## We Really Need Best Practices for Clinical Measurement of OAEs: OAEs are a Value Added Test

- Value added tests (VATs)
  - The procedure adds value to the description of auditory status for the patient … information that's
    - ✓ Not available from other procedures,
    - ✓ Obtained quicker than with another procedure
    - ✓ Useful in managing the patient
- OAEs are an example of a VAT
- Some traditional procedures do *not* invariably add value
  - SRT
  - Bone conduction pure tone audiometry
  - Word recognition in quiet at 40 dB SL

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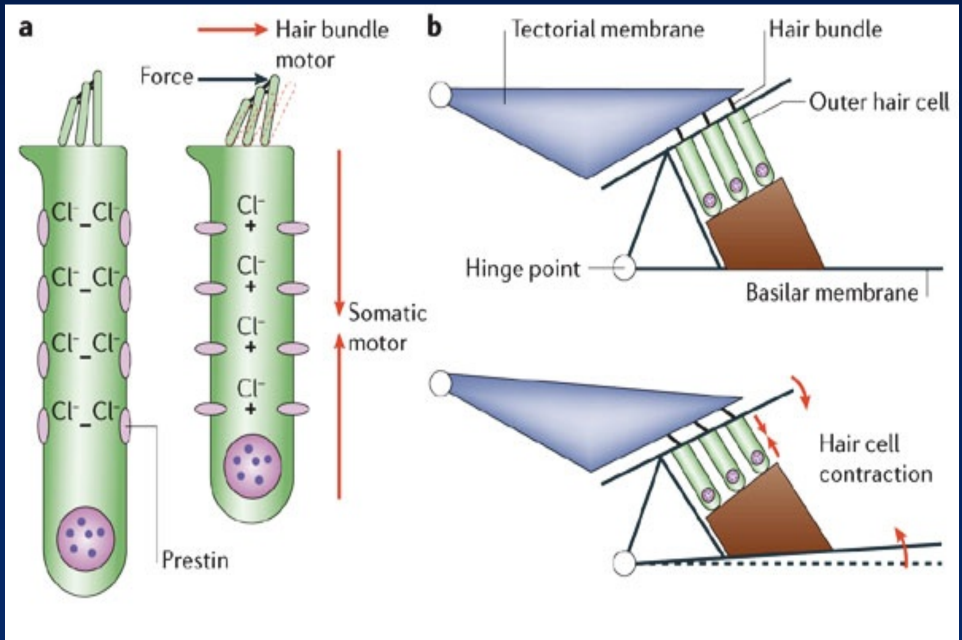
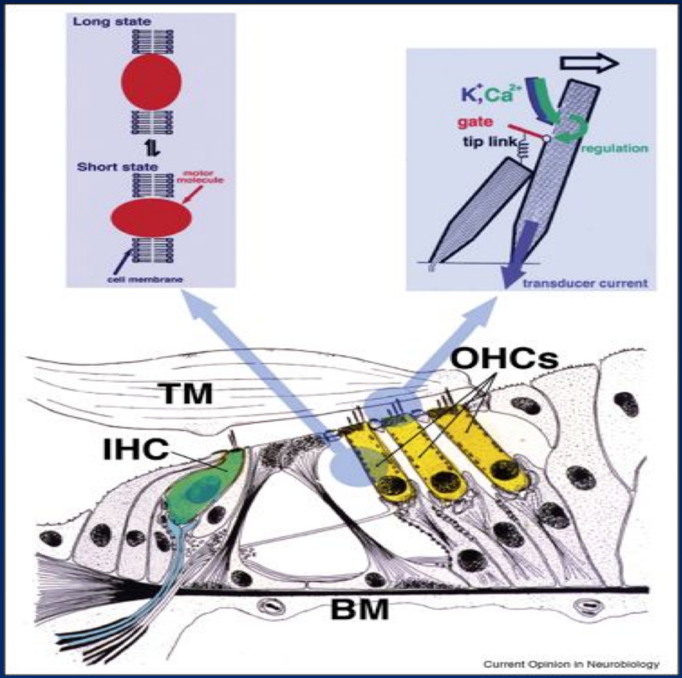
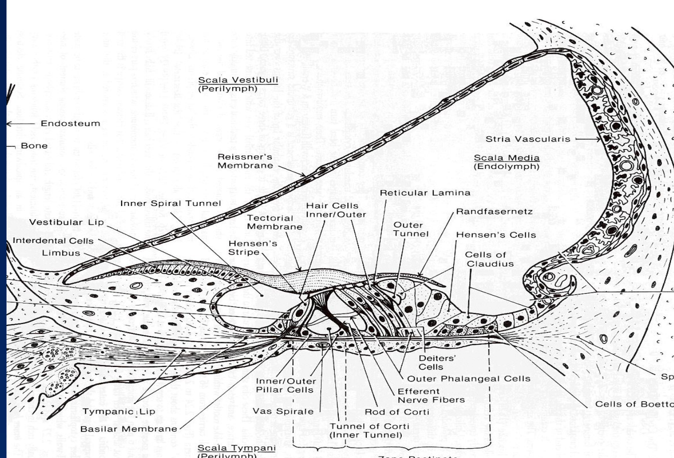
# OAEs, OHCs and Cochlear Mechanics



# Cochlear Origins of OAEs



# Anatomy and Physiology of OAEs: Inner Ear and Outer Hair Cells




s is a diagrammatic sketch showing the cytologic structures of the cochlear duct. Courtesy of H. Davis, Central Insti-
n University, St. Louis, Missouri. (Davis, 1962).

**OAEs are related to OHC motility**

**DPOAEs (e.g., $f_2 > f_1 >$ fdp) with CF apical to the stimulus have two sources**

**Initial DPOAE energy generated in region of overlap between $f_1$ and $f_2$**

**Some energy propagates outward to external ear**

**Some energy propagates inward toward apex of cochlea. It generates activity in region of the CF (2f1-f2) and produces a second DP**

## Otoacoustic Emissions:
## Principles, Procedures, and Protocols
### Sumitrajit Dhar, Ph.D., James Hall III, Ph.D.

**Plural Publishing**
**(www.pluralpublishing.com)**
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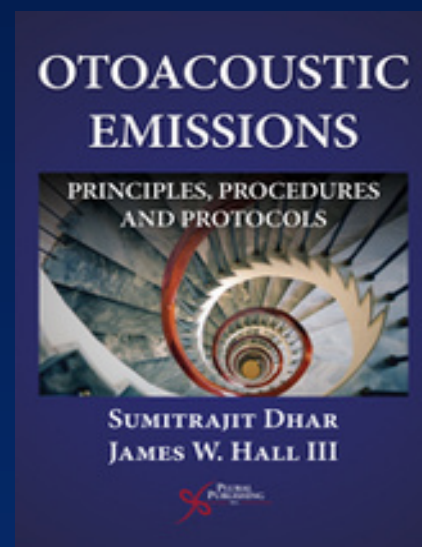
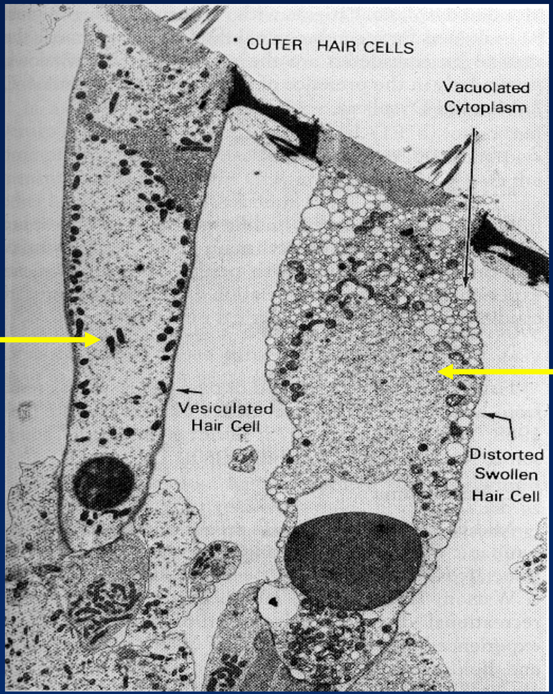


# OAEs in Early Detection of Outer Hair Cell Dysfunction

Normal OHC (OAEs)




Abnormal OHC (OAEs)

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## Otoacoustic Emissions are Under-Utilized in Clinical Audiology: Formal Best Practice OAE Guidelines Do Not Exist

| Procedure | % performing procedure |
|---|---|
| Pure tone audiometry: air conduction | 100% |
| Pure tone audiometry: bone conduction | 100% |
| Word recognition | 95% |
| Speech reception threshold | 91% |
| UCL (LDL) for speech | 83% |
| Tympanometry | 45% |
| UCL (LDL) for tones | 45% |
| Acoustic reflexes | 20% |
| Otoacoustic emissions (OAEs) | 4% |

*Source: The Hearing Journal, December, 2002*

## CLINICAL APPLICATION OF OTOACOUSTIC EMISSIONS (OAE): General advantages

- Highly sensitive to cochlear (outer hair cell function)
- Site specific (to outer hair cells)
- Do not require behavioral cooperation or response
- Ear specific
- Highly frequency specific
- Do not require sound-treated environment
- Can be quick (< 30 seconds)
- Portable (handheld devices)
- Relatively inexpensive

## CLINICAL APPLICATION OF OTOACOUSTIC EMISSIONS (OAE): Possible disadvantages

- Susceptible to effects of noise
- Affected greatly by middle ear status
- Provide cochlear information only about outer hair cells
- May be abnormal or not detected with normal audiogram
- Are not detectable with hearing loss > 40 dB HL
- Cannot be used to estimate degree of hearing loss
- Not a measure of neural or CNS auditory function
- Not a test of hearing

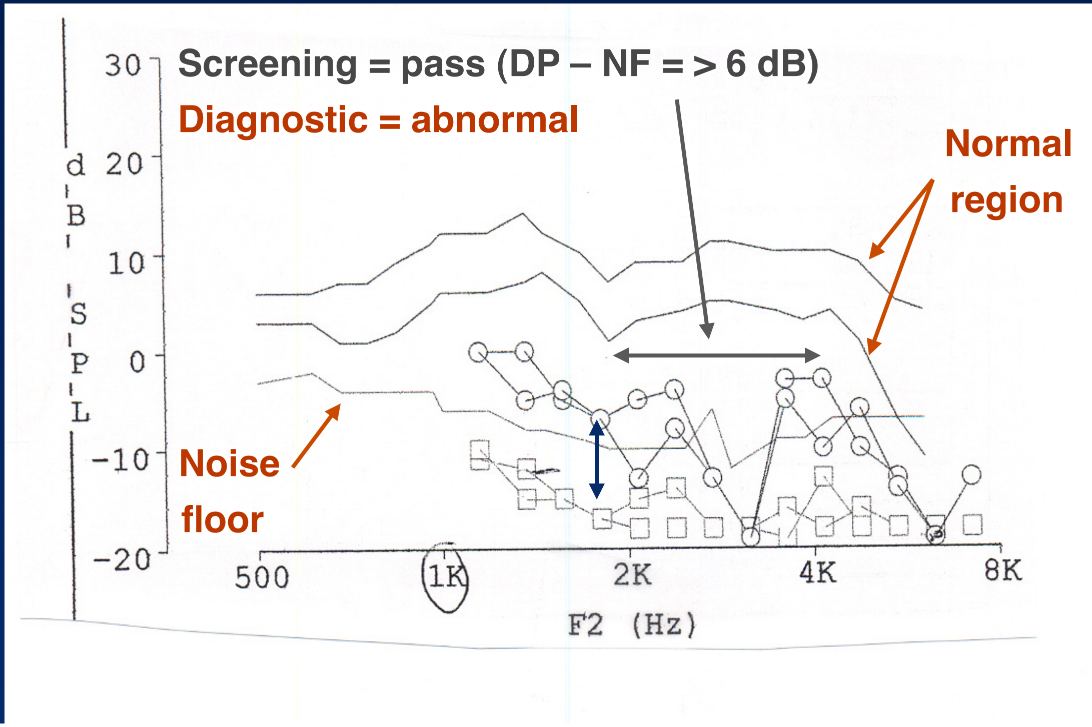
## Otoacoustic Emissions in Audiology Today: Limitations in use of OAEs by clinical audiologists

- Over reliance on screening protocols, e.g.,
  - Recording within a limited frequency region
  - Simple “pass” versus “fail” outcome
- Questionable techniques for measurement and analysis, e.g.,
  - Single trial or run (remember … “If your OAEs do not repeat, your test is not complete!”
  - Failure to achieve lowest possible noise levels (< 95%ile for adult normal subjects)
  - Analysis limited to “present” or “absent”
- Not applied in a variety of patient populations
  - Only used as a screening technique for newborn infants
  - Not applied routinely in the initial diagnostic audiologic assessment of most patients (children and adult)
- False assumption
  - OAEs will provide the same information that is available from the audiogram … “I know the patient has a sensorineural hearing loss … why should I perform OAEs? …

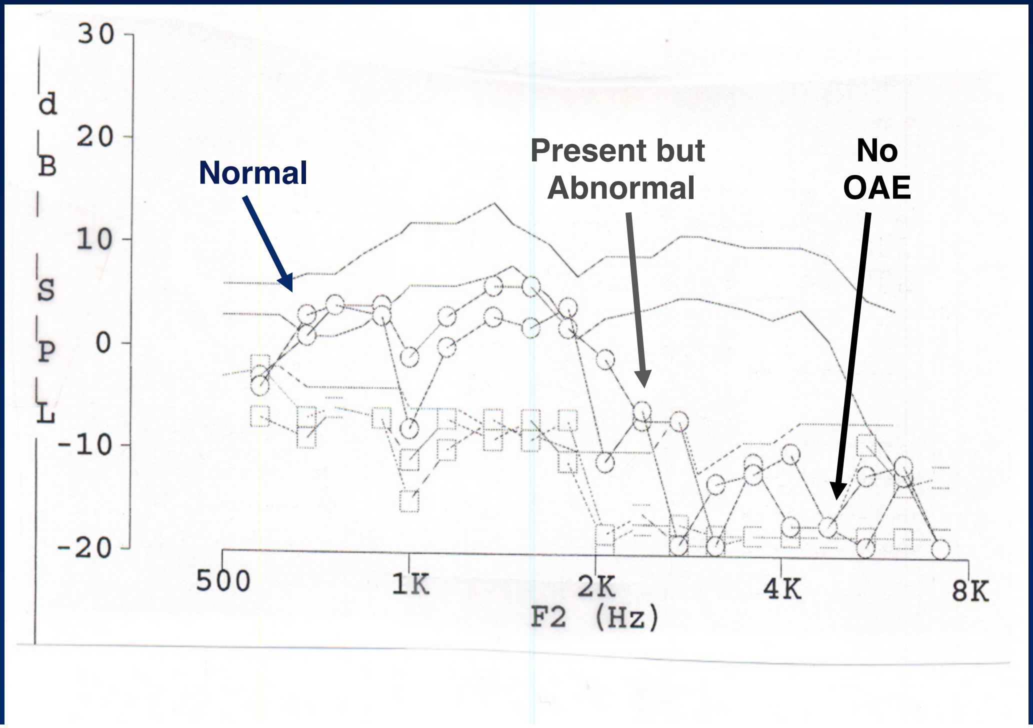
# OAEs:
# Essentials of Analysis and Interpretation

- Verify that noise floor is low
  - below upper limit for a normal population
- Verify the presence of OAEs for each frequency
  - amplitude ≥ 6 dB above noise floor
- Interpret amplitudes for each frequency RE: normal region
  - OAEs within normal limits = “normal”
  - OAEs present but below normal limits = “abnormal”
  - OAEs < 6 dB above noise floor (OAE – NF = < 6 dB) = “absent”

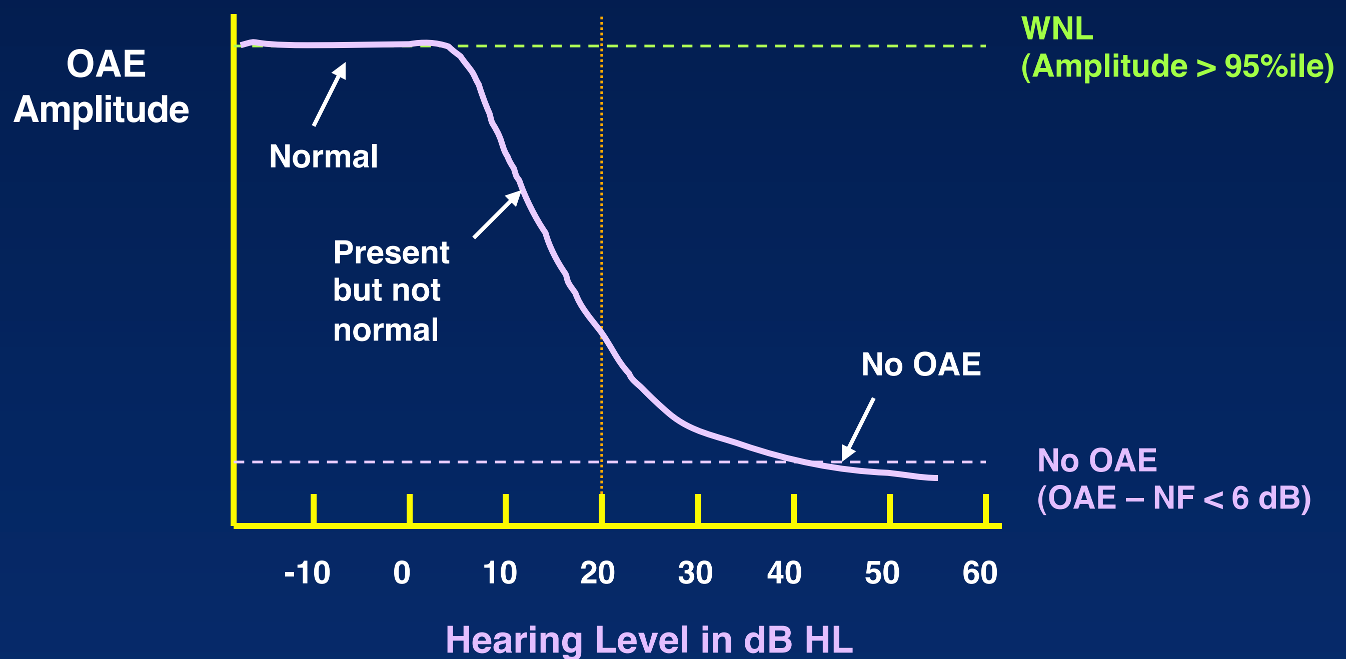
# Diagnostic Application of OAEs: Findings for multiple frequencies vs. normal region



# Analysis of DPOAE Amplitude: Diagnostic Applications



## Relation Between OAE Amplitude and Hearing Loss
## DPOAE 65/55 dB SPL      TEOAE 80 dB SPL



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## Selected Clinical Applications of OAEs in Pediatric Populations

- Pediatric Applications
  - Newborn hearing screening
  - Diagnosis of auditory dysfunction in infants and young children (including identification of auditory neuropathy spectrum disorder)
  - Monitoring ototoxicity*
  - Pre-school/school screenings*
  - Identification of pseudohypacusis*

** Evidence-based but under-utilized clinical application*

## OTOTOXICITY: Categories of drugs

- Aminoglycoside antibiotics
  - gentamicin
  - tobramycin
- Other antibiotics (e.g., vancomycin)
- Antineoplastic (chemotherapeutic) drugs
- Diuretics, including loop diuretics (e.g., lasix)
- Salicylates (aspirin)
- Quinine drugs (e.g., Larium)
- Environmental chemicals (e.g., solvents)

## OTOTOXICITY:
## Rationale for Monitoring with DPOAEs (*not* TEOAEs)

- Highly sensitive to cochlear (outer hair cell) dysfunction
- Most ototoxic drugs first damage outer hair cells
  - aminoglycosides (e.g., gentamicin)
  - loop diuretics (lasix or furosemide)
  - cisplatin
- Objective (can be performed on sick patients)
- Brief test time (one or two minutes)
- High degree of frequency detail (selectivity)
- High frequency limit up to 10,000 Hz (DPOAEs only … TEOAE limit is about 5000 Hz)
- Earlier detection of cochlear auditory dysfunction compared to audiogram

# OTOTOXICITY:
# Recent Published Research (1)

- Knight et al. Early changes in auditory function as a result of platinum chemotherapy: use of extended high-frequency audiometry and evoked distortion product otoacoustic emissions. *J Clinical Oncology 25*, 2007.
  - "Pilot data suggest that EHF thresholds and DPOAEs show ototoxic changes before hearing loss is detected by conventional audiometry."
- Jacob et al. Auditory monitoring in ototoxicity. *Rev Brasilian Otorhinnolaryngol 72, 2006*
  - "For the early detection of auditory lesions induced by ototoxic pharmaceutical drugs, high-frequency audiometry and evoked otoacoustic emissions both allow early identification of hearing disorders before changes are seen in conventional pure-tone audiometry."

# OTOTOXICITY:
## Selected Literature by Drug

- Vancomycin
  - Ruggieri-Marone & Schochat (2007)
  - Newborn infants
  - DPOAE
- Cisplatin & Carboplatin
  - Zorowka et al (1993); Dhooge et al (2006)
  - Children with brain tumors
  - TEOAE & DPOAE

# OTOTOXICITY:
# Selected Literature by Drug

- Gentamicin
  - Stavroulaki et al (2002)
    - ✓ Cystic fibrosis
    - ✓ DPOAE and TEOAE
- Tobramycin
  - Mulheran & Degg (1997); Martins et al (2010)
    - ✓ Cystic fibrosis
    - ✓ DPOAE
- Amakacin
  - Ruggieri-Marone & Schochat (2007)
  - Newborn infants
  - DPOAE

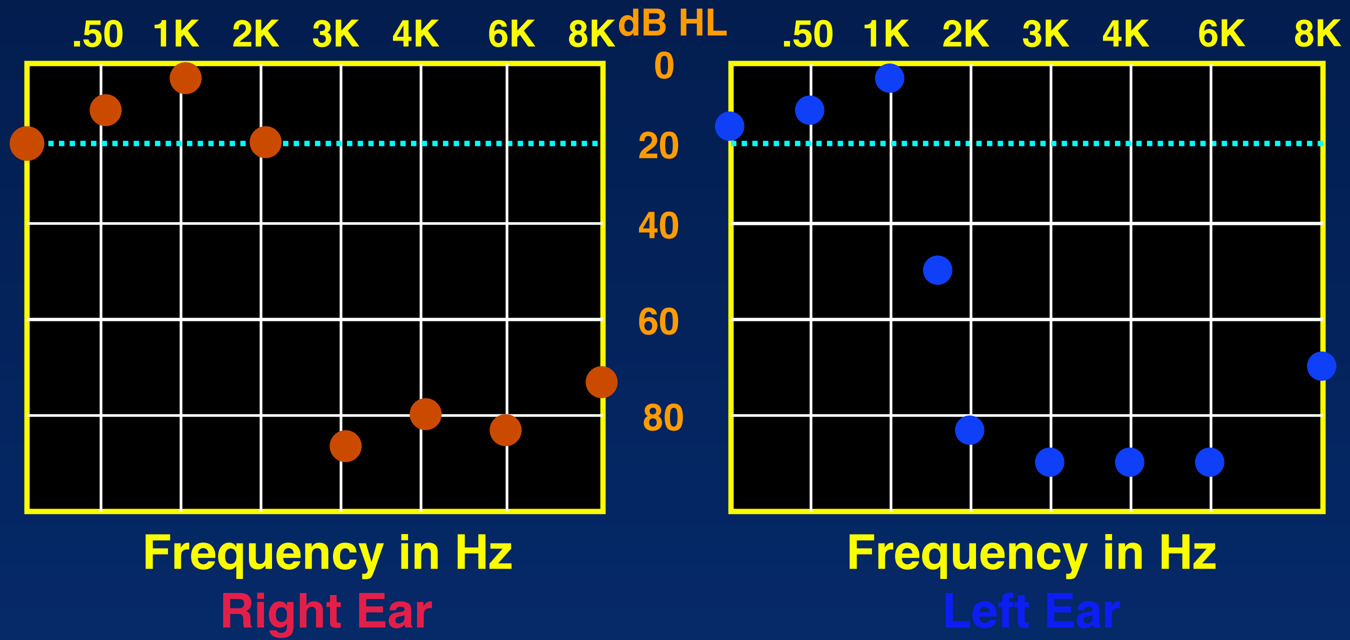
# OTOTOXICITY:
# Recent Published Research (2)

- Lisowska et al. Otoacoustic emissions measurements in children during the chemotherapy because of the acute lymphoblastic leukemia. *Otolaryngology Poland 60*, 2006.
  - "Our results indicate that:
    - ✓ a) DPOAE is a more sensitive technique for the assess of chemotherapy-induced ototoxicity than conventional audiometry,
    - ✓ b) with DPOAE monitoring very subtle hearing changes can be detected,
    - ✓ c) DPOAE amplitude was significantly decreased at all frequencies studied in 50% children with leukemia"

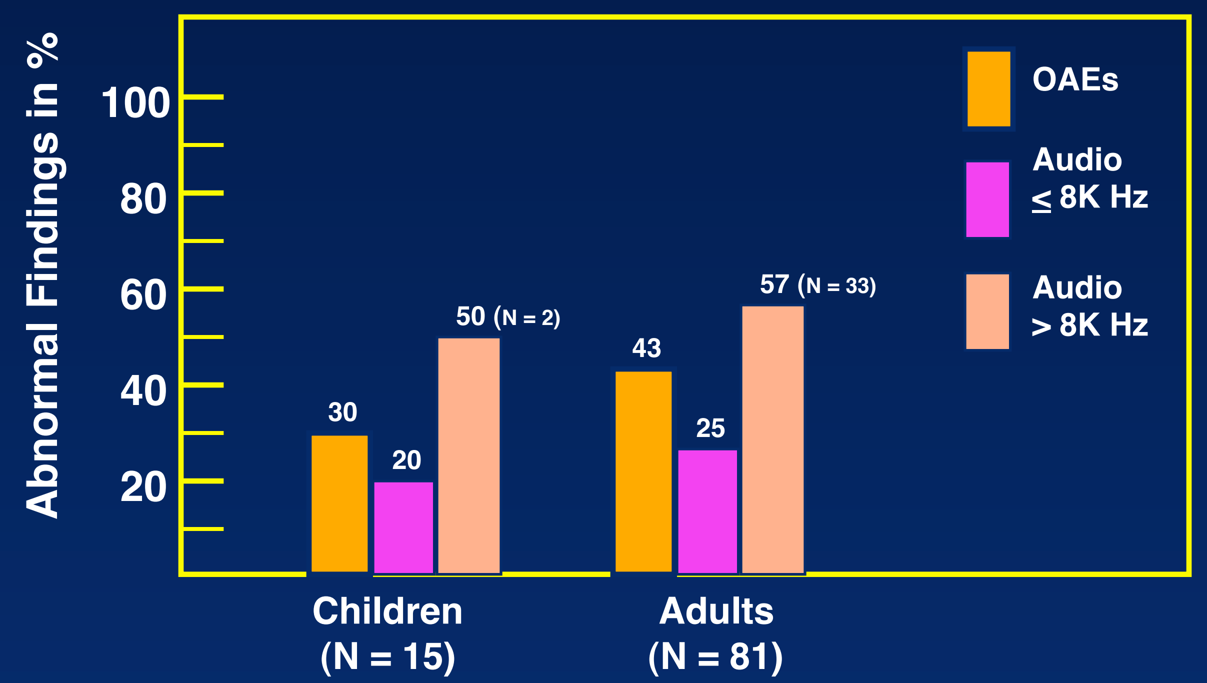
# OTOTOXICITY:
# Recent Published Research (3)

- Dhooge et al (Belgium). Distortion product otoacoustic emissions: an objective technique for the screening of hearing loss in children treated with platin derivatives. Int J Audiology 45, 2006.
  - "Because of the several advantages of DPOAEs (noninvasive, objective, rapid, easy to use, sensitive) this method should be added in the audiological follow-up in infants and toddlers."
- Biro et al (Hungary). Characteristics and risk factors of cisplatin-induced ototoxicity in testicular cancer patients detected by distortion product otoacoustic emission. *Oncology 70, 2006.*
  - "DPOAE is a fast, noninvasive and reliable method in detecting late ototoxicity in testicular cancer patients."

# Case Report 2: Adult with Cystic Fibrosis Treated with Tobramycin



# Hearing Findings in Patients with Cystic Fibrosis: University of Florida



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- Pediatric Applications
  - Newborn hearing screening
  - Diagnosis of auditory dysfunction in infants and young children (including identification of auditory neuropathy spectrum disorder)
  - Monitoring ototoxicity*
  - Pre-school/school screenings*
  - Identification of pseudohypacusis*

** Evidence-based but under-utilized clinical application*

# Selected Literature:
# Pre-School and School Age Hearing Screening with OAEs

- Lyons et al (2004)
  - N = 1003
  - Age: 4-8 years
  - DPOAE
  - 90% hit rate (for 20 dB HL hearing loss)
- Sideris & Glattke (2006)
  - N = 200
  - Age: 2-6 years
  - TEOAE
  - 21% refer rate
- Berg et al (2006)
  - N = 4003
  - Age: 2-9 years
  - DPOAE
  - 13.6%

## Selected Literature:
## Pre-School and School Age Hearing Screening with OAEs

- Dille et al (2007)
  - N = 33
  - Age: 0.5-4 years
  - TEOAE & DPOAE
  - Failure rates > 40%
- Hunter et al (2007)
  - N = 421
  - Age: 0-2 years
  - DPOAE
  - 30% (high rate of otitis media)
- Psillis et al (2007)
  - N = 76
  - Age: 1-5 years
  - DPOAE

# Selected Literature:
# Pre-School and School Age Hearing Screening with OAEs

- Eiserman et al (2008)
  - N = 4591
  - Age: $\leq$ 3 years
  - DPOAE
  - Refer rate 18%
- Georgalas et al (2008)
  - N = 196
  - Age: 6-12 years
  - TEOAE
  - Refer rate 32%
- Hild et al (2008)
  - N = 512
  - Age: 10-69 years
  - DPOAE
  - Refer rate 24%
- Yin et al (2009)
  - N = 744
  - Age: 2-6 years
  - TEOAE
  - Refer rate 5.5%

## Selected Literature:
## Pre-School and School Age Hearing Screening with OAEs

- Screening auditory function in first grade children (≥ 6 years old)
  - Lyons A, Kei J & Driscoll C. DPOAEs in children at school entry: A comparison with pure-tone screening and tympanometry results. *JAAA 15: 2004* (Univ. of Queensland, Brisbane, Australia)
    - ✓ N = 1003 children
    - ✓ "When the results of a test protocol which incorporates both DPOAEs and tympanometry were used in comparison with the gold standard of pure tone screening plus tympanometry, test performance was enhanced. The use of a protocol that includes both DPOAEs and tympanometry holds promise as a useful tool in hearing screening of schoolchildren, including difficult-to-test children" (p. 702).

## Selected Literature:
## Pre-School and School Age Hearing Screening with OAEs

- General Conclusions
  - Goal of hearing screening is to identify sensory hearing loss > 20 dB HL (Gold standard is pure tone hearing screening)
  - OAE screening in pre-school and school-age children is:
    - ✓ Feasible by non-audiology personnel
    - ✓ Relatively quick and efficient
  - Test performance (Pass, Refer, Sensitivity, Specificity) varies for:
    - ✓ TEOAE versus DPOAE
    - ✓ Test protocols
    - ✓ Criteria for Pass versus Refer

## Screening for APD in Kindergarten Children: Pure Tone Hearing Screening

## Screening for APD in Kindergarten Children: Distortion Product Otoacoustic Emissions

# Screening for Auditory Processing Disorders in Kindergarten Children: Refer Criteria

| Screening Procedure | Pass Criteria |
|---|---|
| Pure tone audiometry | Response at 20 dB HL for 500 Hz, 1000 Hz, 2000 Hz, 3000 Hz, and 4000 Hz |
| Tympanometry | Type A (peak pressure with range of + 50 to - 150 daPa) |
| Otoacoustic emissions | DP – NF difference > 6 dB at 2K, 4K and 8K) |

# Screening for Auditory Processing Disorders in Kindergarten Children (N = 322)

| Screening Procedure | Pass | Fail* |
|---|---|---|
| Pure tone audiometry | 83% | 17% |
| Tympanometry | 89% | 11% |
| Otoacoustic emissions | 87.5% | 12.5% |
| Combined peripheral screening procedures | 65% | 35% |

** Unilateral or bilateral, and at any frequency for pure tone and DPOAE measures*

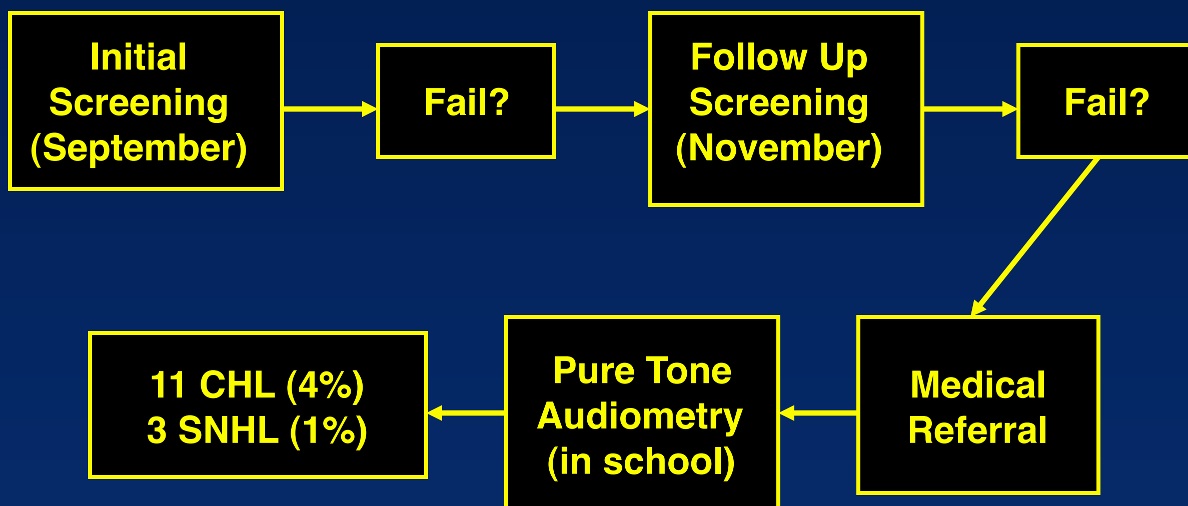
## Kindergarten Student Hearing Screening: Pure Tone versus Tymp/DPOAE Findings (N = 303)*

| | Pure Tone Findings | |
|---|---|---|
| Tymp/DPOAE Findings | Pass | Fail |
| Pass | 62% | 11%** |
| Fail | 16% | 11% |

** Screening outcome for both ears. Relation highly significant.*

*** Includes CNT outcomes and failures at 500 Hz only. No children in this group had peripheral hearing loss.*

# Follow Up of Hearing Screening Failures: Kindergarten Children (N = 268)



# Hearing Screening in the Head Start Population: Equipment

# Hearing Screening in the Head Start Population: Typical Venue

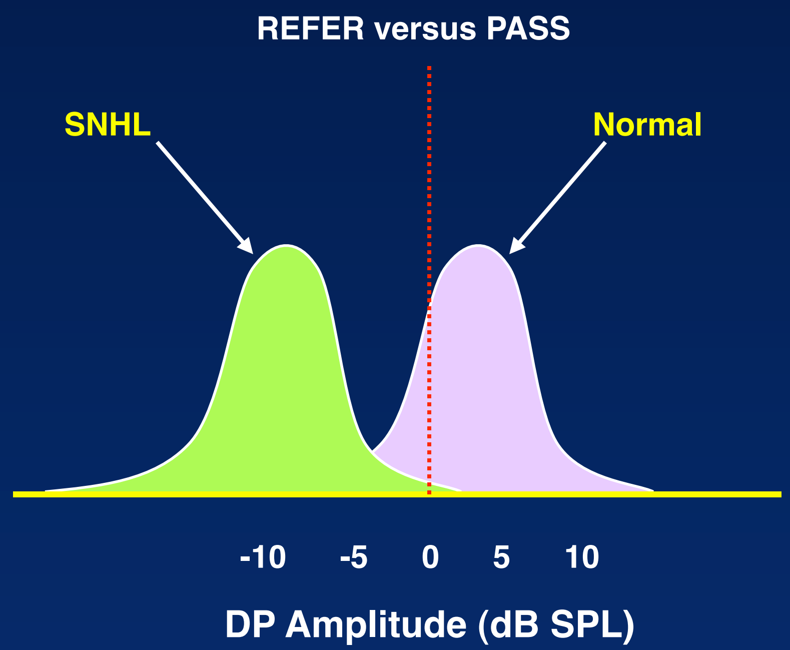
# Hearing Screening in the Head Start Population: Otoscopy

# Hearing Screening in the Head Start Population: Tympanometry

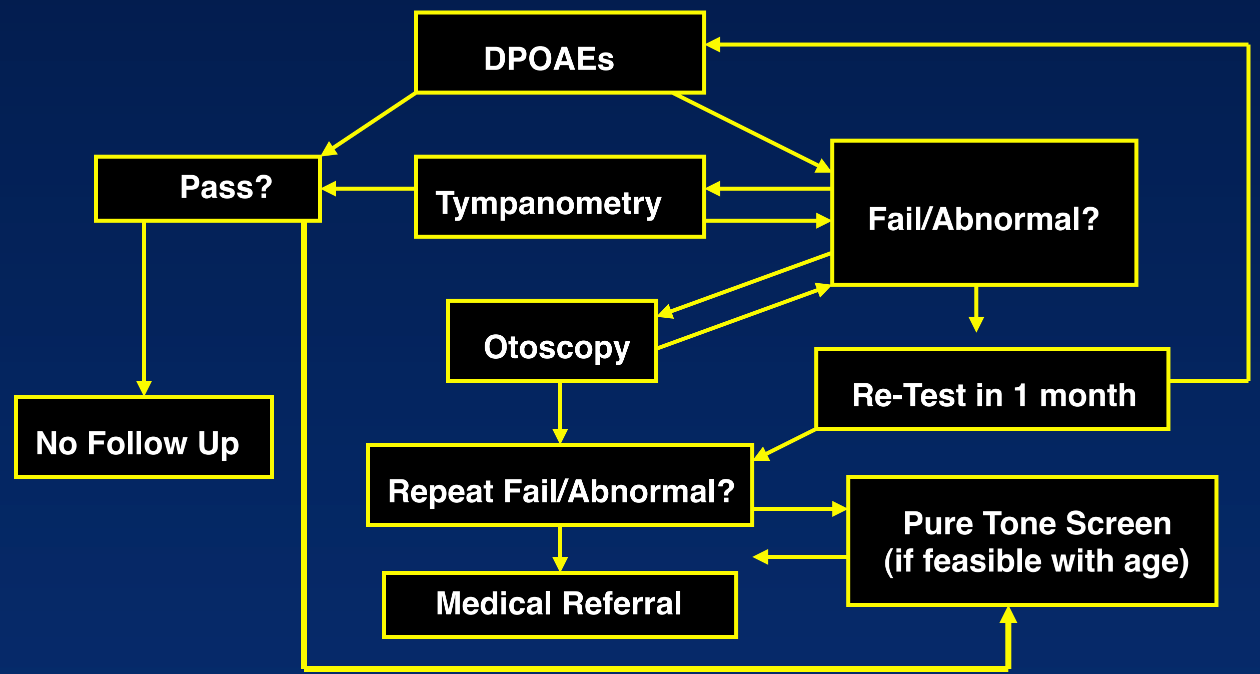
# Hearing Screening in the Head Start Population: Distortion Product OAEs ($\geq$ 2000 Hz)

## OAE Screening in Pre-School and School Age Children: Criterion for PASS versus REFER

*(Data from Gorga, Stover & Neely, 1996)*



## Hearing Screening with Tympanometry and OAEs Versus Pure Tones in the Head Start Population



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- **Pediatric Applications**
  - **Newborn hearing screening**
  - **Diagnosis of auditory dysfunction in infants and young children (including identification of auditory neuropathy spectrum disorder)**
  - **Monitoring ototoxicity***
  - **Pre-school/school screenings***
  - **Identification of pseudohypacusis***

**** Evidence-based but under-utilized clinical application***

# Selected Literature: Detection and Diagnosis of Pediatric Pseudohypacusis with OAEs

- Balatsouras et al (2003)
  - At risk children include those with emotional trauma
  - Tendency to more common in adolescent girls
  - OAE findings contribute to increased cooperation and valid behavioral thresholds
- Saravanappa et al (2005)
  - OAEs contribute to quicker, easier, and more confident diagnosis
  - Patient and parent awareness of OAE findings results in "improvement" in hearing and disappearance of condition
- Holenweg & Kompis (2010)
  - Without evaluation with OAEs, one-out-of-five children with pseudohypacusis were fit with hearing aids
- Morita et al (2010)
  - Late or misdiagnosis of pseudohypacusis can lead to:
    - ✓ Increase cost of health care
    - ✓ Litigation
    - ✓ Inappropriate medical (e.g., steroid) treatment
- Ioannis et al (2009)
  - "Otoacoustic emissions were used in all children who participated in this study and in some cases their role as 'lie detector' produced a striking and immediate result."

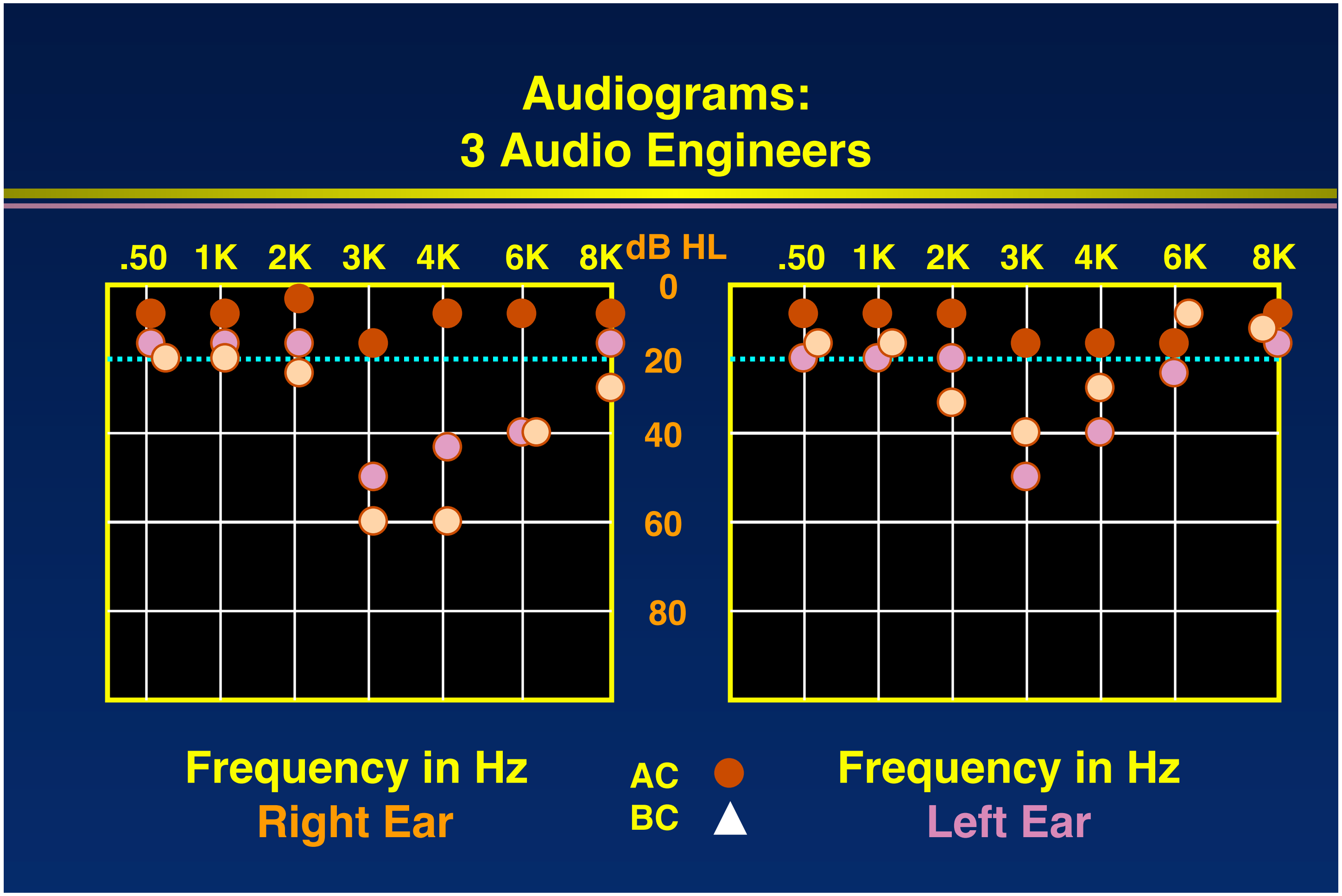
# Clinical Applications of OAEs in Pediatric and Adult Populations

- **Adult Applications**
  - Diagnosis of cochlear versus retrocochlear auditory dysfunction
  - Identification of pseudohypacusis (malingering)
  - Monitoring ototoxicity
  - Hearing screening*
    - ✓ industrial settings
    - ✓ Military personnel
  - Diagnosis of auditory dysfunction in noise/music exposure *
  - Diagnosis and management of tinnitus & hyperacusis *

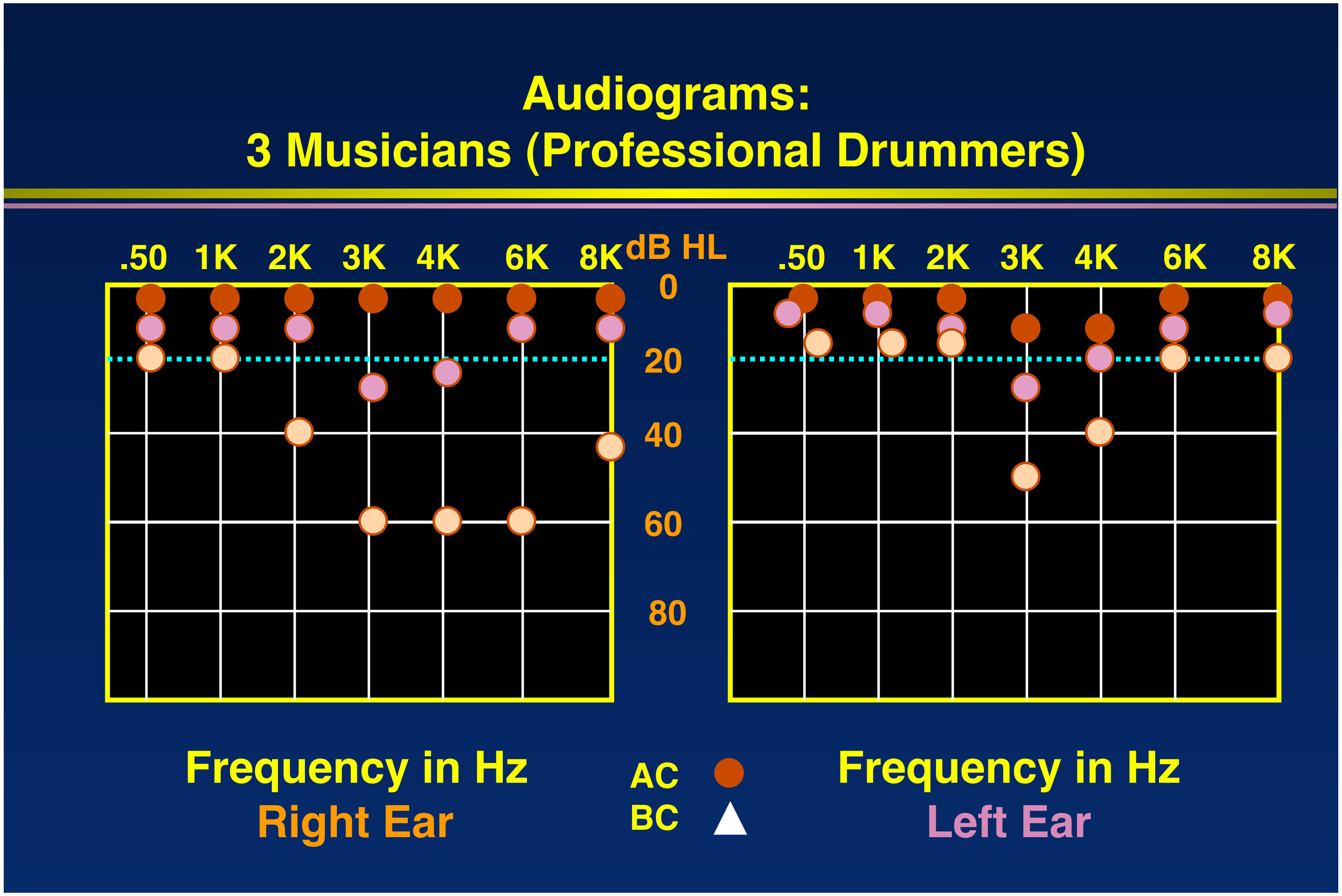
** Evidence-based but under-utilized clinical application*

## New Evidence for Five Clinical Applications of OAES in Adults: Recent Research on Noise Induced Auditory Dysfunction

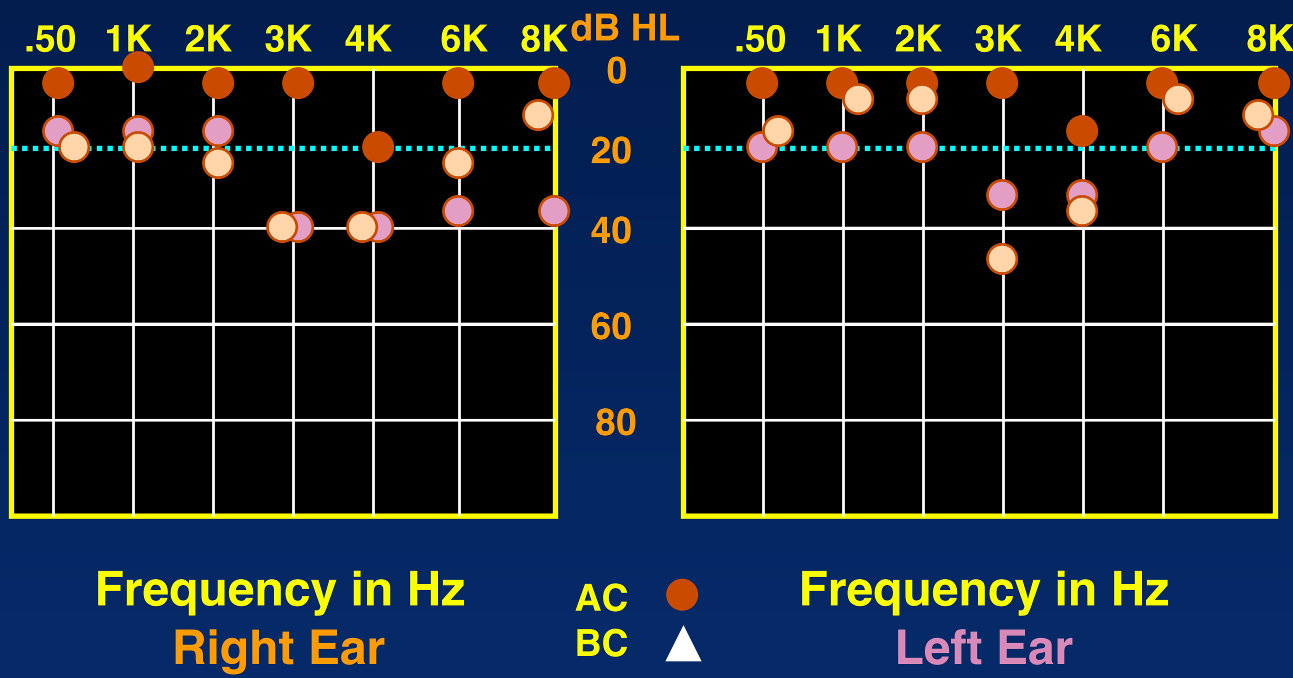
- Redhead JT. Otoacoustic emissions and recreational hearing loss. *Medical J Australia 169*, 1998.
- Veuillet et al. Otoacoustic emissions and medial olivocochlear suppression during auditory recovery from acoustic trauma in humans. *Acta Otolaryngologica 121*, 2001
  - spontaneous OAEs may increase following noise exposure
- Lapsley et al. A longitudinal study of changes in evoked otoacoustic emissions and pure tone thresholds as measured in a hearing conservation program. *Int J Audiology 43*, 2004
- Lapsley et al. Low-level otoacoustic emissions may predict susceptibility to noise-induced hearing loss. *JASA 120*, 2006
  - OAEs predict noise induced hearing loss for Navy personnel on air craft carriers
- Olszewski et al. Hearing threshold shift measured by otoacoustic emissions after shooting noise exposure in soldiers using hearing protectors. *Otolarngology Head & Neck Surgery 136*, 2007.



Audiograms:
3 Audio Engineers
.50
1K
2K
3K
4K
6K
8K
dB HL
0
20
40
60
80
Frequency in Hz
Right Ear
AC
BC
Frequency in Hz
Left Ear

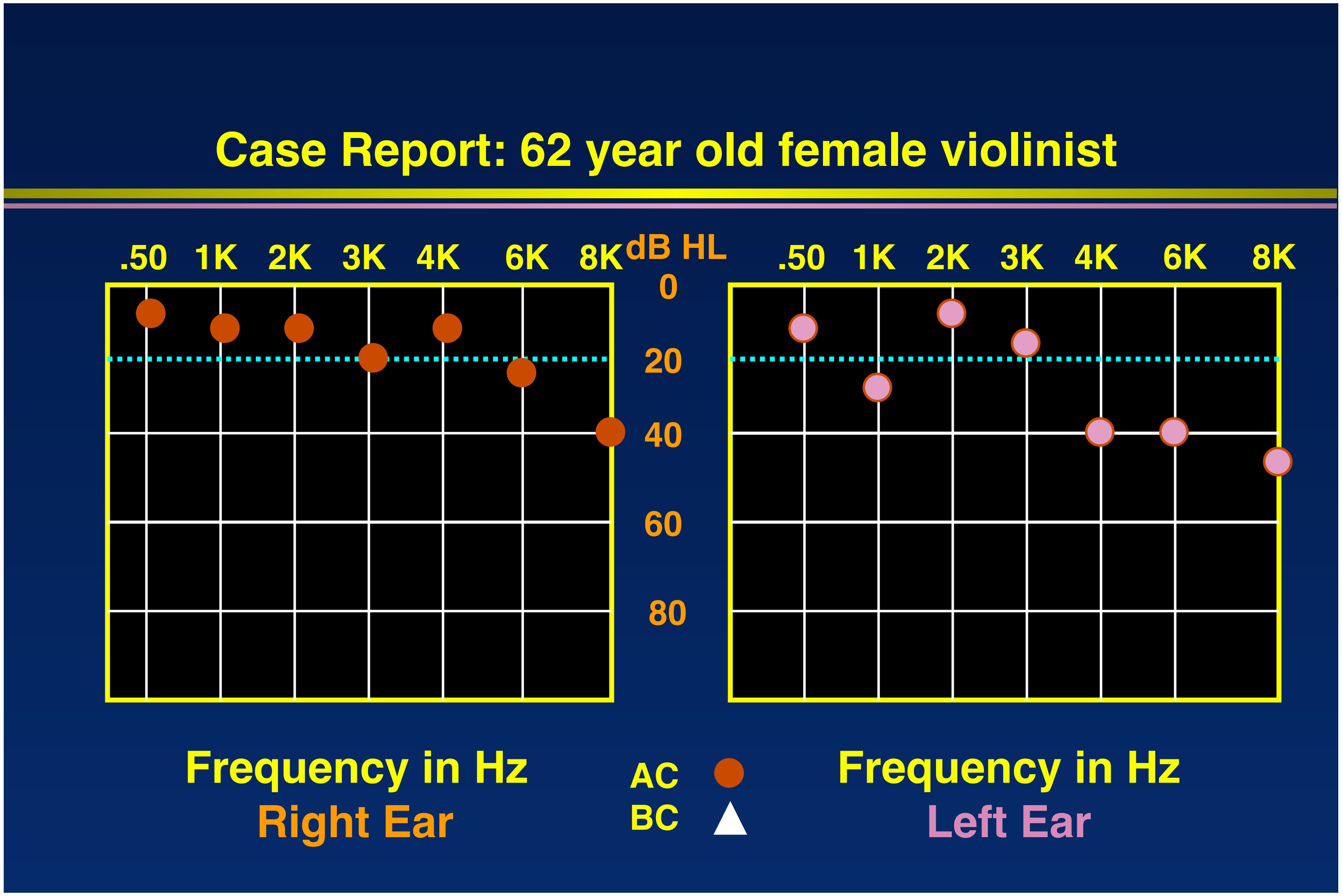

Audiograms:
3 Musicians (Professional Drummers)
.50 1K 2K 3K 4K 6K 8K
dB HL
0
20
40
60
80
.50 1K 2K 3K 4K 6K 8K
Frequency in Hz
Right Ear
AC
BC
Frequency in Hz
Left Ear

# Audiograms:
# 3 Musicians (Professional Guitarists)



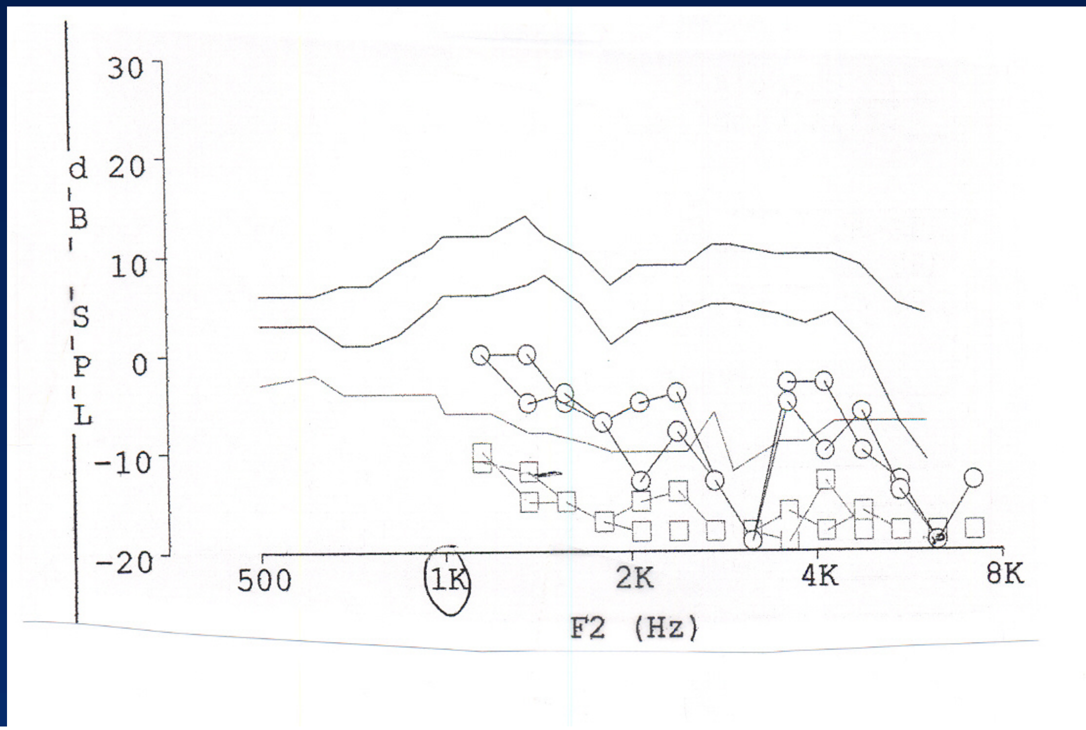
# CASE REPORT: Music exposure

- 62 year old female
- Professional violinist and violin teacher
- Bothersome tinnitus bilaterally, left > right ear
- Hyperacusis (LDLs = 70 to 80 dB HL)
- Sound level measurements when playing violin
  - Right ear = 81- 86 dBA SPL
  - Left ear = 91 - 97 dBA SPL (peak > 100 dB SPL)

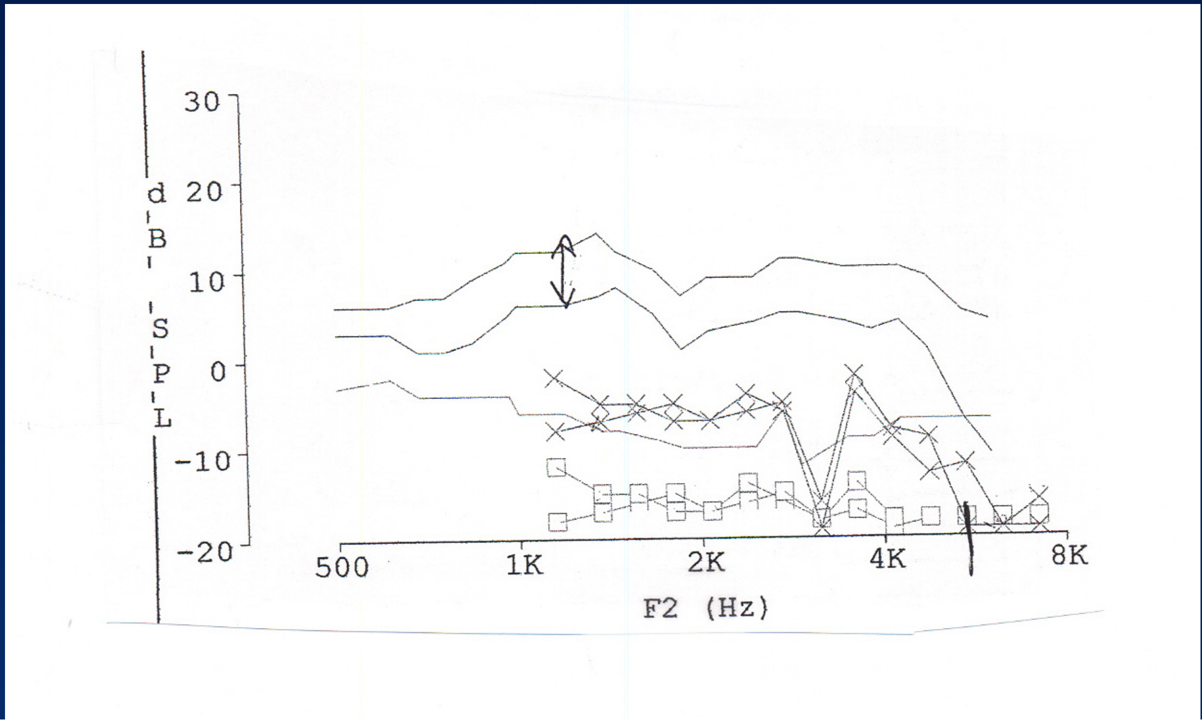


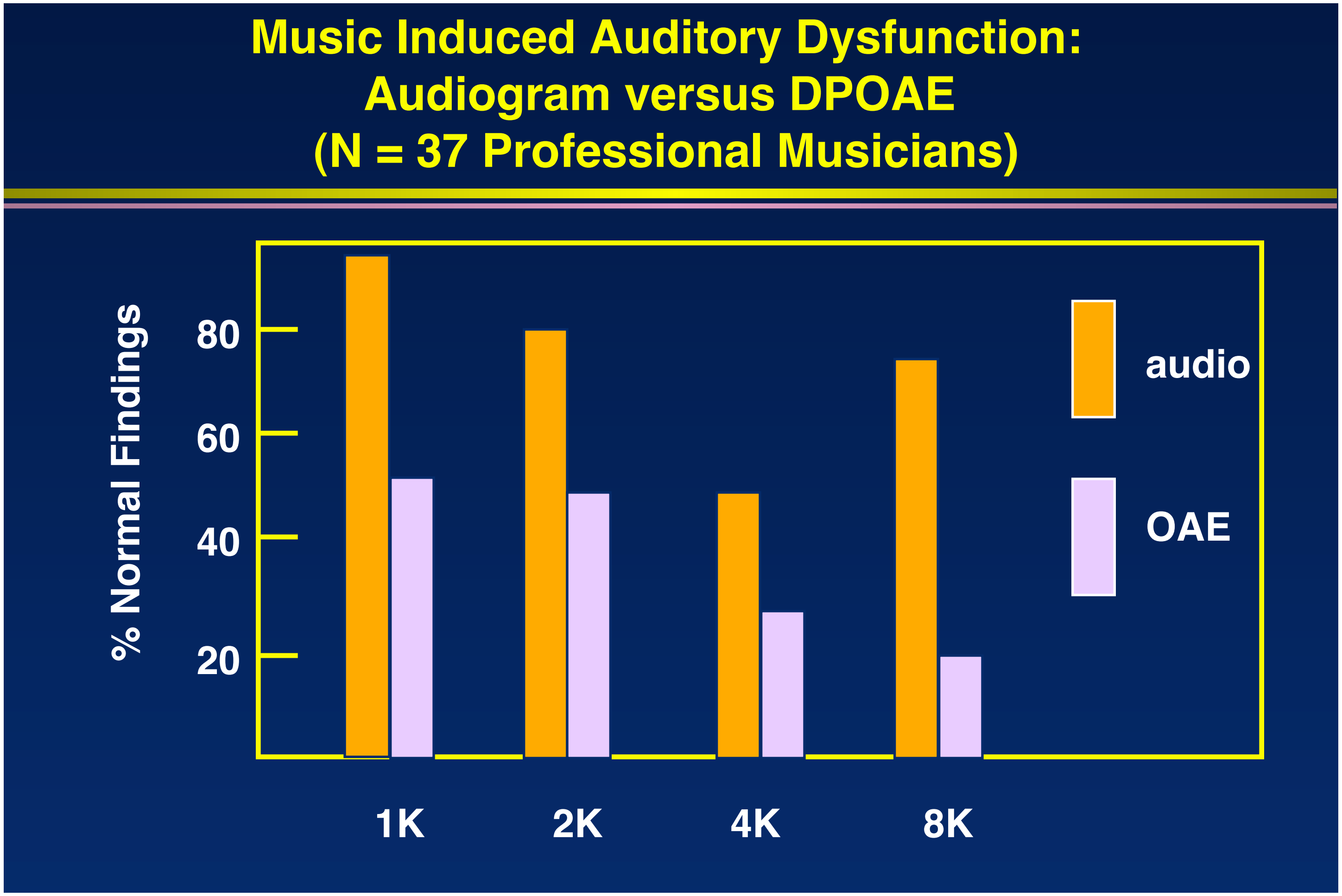
Case Report: 62 year old female violinist
.50
1K
2K
3K
4K
6K
8K
dB HL
0
20
40
60
80
.50
1K
2K
3K
4K
6K
8K
Frequency in Hz
Right Ear
AC
BC
Frequency in Hz
Left Ear

## Music Induced Hearing Loss and OAEs:
## *62 year old violinist and violin teacher (right ear)*



# Music Induced Hearing Loss and OAEs:
## *62 year old violinist and violin teacher (left ear)*




Music Induced Auditory Dysfunction:
Audiogram versus DPOAE
(N = 37 Professional Musicians)
% Normal Findings
80
60
40
20
1K
2K
4K
8K
audio
OAE

## Preventing Music Induced Hearing Loss: Etymotic Research (ER) Musician's Earplugs (ER-9, ER-15, ER-25 dB)

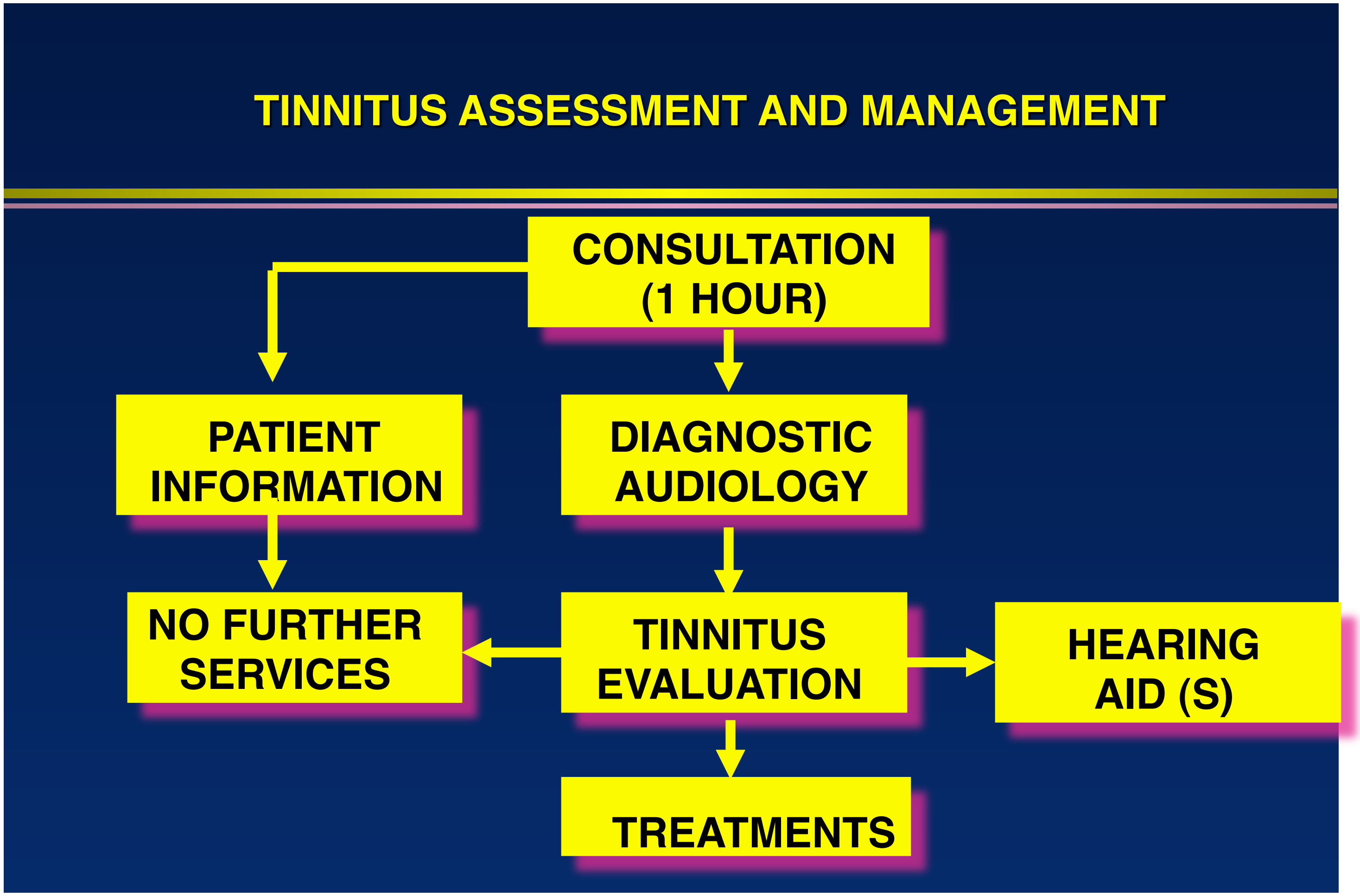
## Preventing Music Induced Hearing Loss: Ear-Level Monitors

## Conclusion: OAEs Can Play an Important Role in Hearing Conservation

- Rationale for OAEs
  - Highly sensitive to cochlear deficits
  - Objectively and quickly administered
  - Easily administered by non-audiology personnel
- Possible protocol
  - Baseline audiologic assessment with OAEs
  - Monitor auditory status with OAEs
  - Pure tone audiometry only with change in OAEs
- New research (Universities of Michigan and Florida)
  - Early detection of cochlear dysfunction with OAEs (including iPod users)
  - Immediate preventive treatment with micronutrients
    - ✓ magnesium
    - ✓ vitamins

## BASIC SCIENCE OF TINNITUS:
## Mechanisms within the auditory system

- Origin in cochlea
  - hair cell damage
  - imbalance between OHC and IHC function
- Eighth cranial nerve
  - increased or changed resting potential
- Influence of middle ear disorder in perception of existing tinnitus
- Auditory brainstem, thalamus, and cortex
  - perception of sound in primary auditory cortex
  - inappropriate subcortical neural circuitry
- Non-traditional auditory regions
  - limbic system
  - autonomic nervous system
- Efferent auditory system
  - reduced activity


TINNITUS ASSESSMENT AND MANAGEMENT
CONSULTATION (1 HOUR)
PATIENT INFORMATION
DIAGNOSTIC AUDIOLOGY
NO FURTHER SERVICES
TINNITUS EVALUATION
HEARING AID (S)
TREATMENTS

# An Ounce of Prevention is Worth a Pound of Cure

*by James W. Hall III, Ph.D.*

Tinnitus is a symptom, not a disease. It's important to always remember this simple fact. When someone begins noticing an unusual sound in his or her ears, whether it's a ringing, buzzing, roaring, cricket sound, or any other sound or combination of sounds, the first logical step is to discover the underlying disorder related to the tinnitus. The exact type of tinnitus sound that a person hears is not important diagnostically. Almost all tinnitus is associated with a disorder in the auditory system – that is, somewhere within the ear or the nerves that carry signals from the inner ear to the hearing parts of the brain. By analyzing information from the patient (what health professionals call "taking a history") in combination with the results of diagnostic tests, a physician and an audiologist can usually rule out the diseases that include tinnitus as a symptom.

The majority of people with tinnitus do not have an active disease or pathology but, rather, damage or dysfunction within the inner ear that is related to exposure to high levels of sound and/or to the aging process. Nonetheless, until disease or pathology is ruled out with a thorough diagnostic assessment, it is irresponsible to simply offer to a person with tinnitus reassurance that "it's nothing to be concerned about...most people hear sounds like that."

*Knowledge is Power.*
*—Francis Bacon*

Persistent or almost constant tinnitus is very different from the temporary ringing-type tinnitus - called spontaneous transient tinnitus - that most people notice from time to time. Spontaneous transient tinnitus typically occurs abruptly, often when a person is in a quiet setting. The ringing sound lasts only seconds, then fades away. Hearing might be muffled during this brief time period. The precise scientific explanation for spontaneous transient tinnitus is not known, but there is general agreement that it is a normal auditory experience and not a reason for concern about health or hearing.

There is evidence, dating back more than 50 years, that tinnitus can be viewed as a normal auditory experience. In 1953, an otologist (a medical doctor specializing in the ear) and an audiologist conducted a very clever study (Heller and Bergman, 1953). Eighty people were enrolled as subjects in the study. Morris Heller, M.D., verified by medical history and a physical examination that the subjects had no ear disease, while Moe Bergman, Ph.D., performed an audiogram (a simple test of hearing tones) to confirm that the subjects had normal hearing sensitivity. One by one, the subjects were placed in a specialized sound-treated room. Upon emerging from the room, these normal-hearing subjects were asked if they heard anything. The vast majority (75 out of the 80, or 94%) reported that they heard some type of sound in the room. The three sounds described most often by the subjects were "humming," "buzzing," and "ringing," although a diverse collection of 23 other sounds were also noted (e.g., whistling, squeaking, and a thumping pulsation). Because of this study, we've learned that almost everyone will hear sounds...that is, tinnitus...in a very quiet setting.

It's reasonable to assume that most people who are reading an article in *Tinnitus Today* already hear their tinnitus. Therefore, you might think it's too late to prevent a problem that already exists. But there is a type of prevention that is important to focus on - the prevention of deteriorating quality of life sometimes brought about by persistent tinnitus.

## Hearing Protection – The First Line of Defense

The old adage coined by Ben Franklin, "An ounce of prevention is worth a pound of cure," certainly applies in any discussion of the best treatment strategy for tinnitus. The most common single cause of hearing loss and tinnitus in adults is exposure to excessive sound levels. As a rule, sound levels that you have to shout over to be heard can cause inner ear damage. The source or type of sound – for example, rock or classic music, gunfire, machinery noise, factory noise, or fireworks – does not determine the risk for hearing loss. The two most important factors that determine the risk for hearing loss are the intensity (or loudness) of the sound and the length of time that a person is exposed to the sound. There is also a genetic factor in the susceptibility to noise-induced hearing loss. That is, some people are more likely to sustain damage to the tiny and delicate hair cells in the inner ear than others. Two people may be exposed to the same levels of noise for the same duration of time, for example, two factory workers or two musicians in an orchestra or a rock band. Despite the similarity in sound exposure, one person will develop a significant and permanent hearing loss, while the other person's hearing will remain normal.

Other risk factors are associated with the onset of tinnitus, among them middle ear problems (pressure imbalances behind the eardrum due to Eustachian tube dysfunction), sinus disease, temporomandibular joint (TMJ) disorders, high levels of personal stress, and some drugs used to treat health problems unrelated to tinnitus. In my clinical experience, a person will often first notice tinnitus when *two or more* of these risk factors occur during the same period of time. Prompt medical or, as appropriate, non-medical attention to each of these disorders can help prevent persistent tinnitus.

## Professional Care – the Second Line of Defense

You may already have bothersome tinnitus. But you can prevent further deterioration in the quality of your life. In fact, you can almost always return to the quality of life you enjoyed in the past – before it was negatively affected by tinnitus. Knowledge is an essential ingredient in the process of restoring quality of life and of recovering from the debilitating effects of tinnitus. For a person with tinnitus, knowledge is truly power. What does a person with tinnitus need to know?

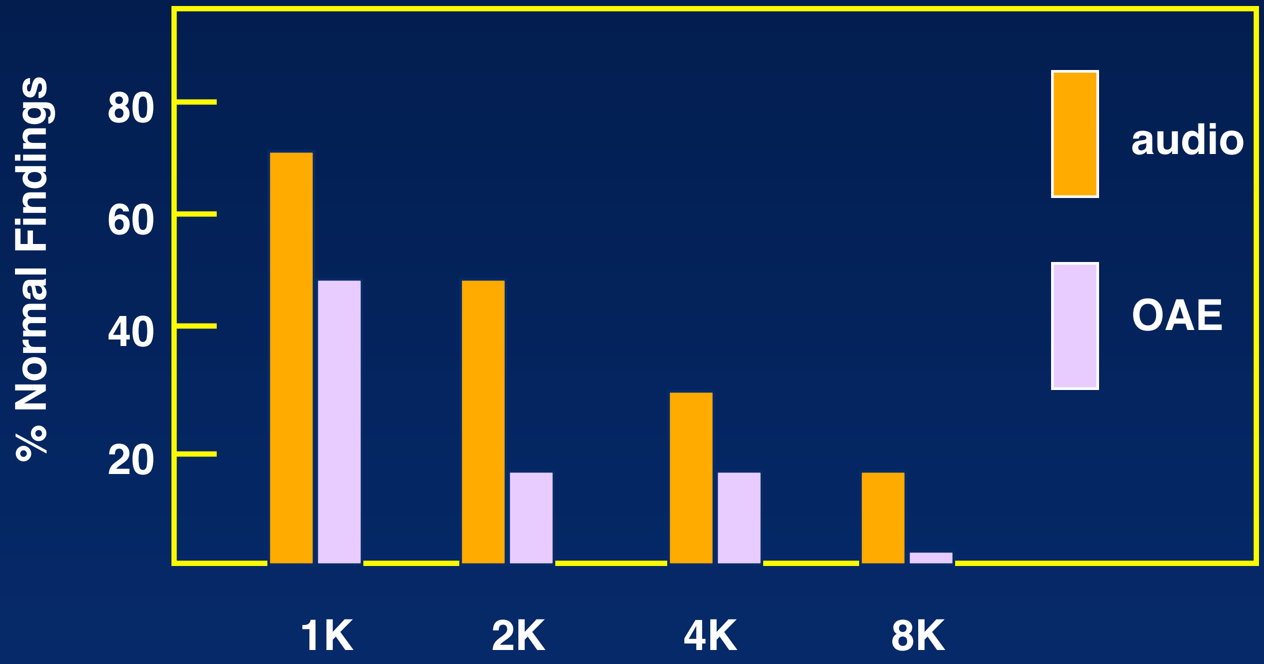
*Sometimes, the silence can be like thunder.*
*— Bob Dylan*

*(continued on page 16)*

## OAEs in Tinnitus Assessment and Management

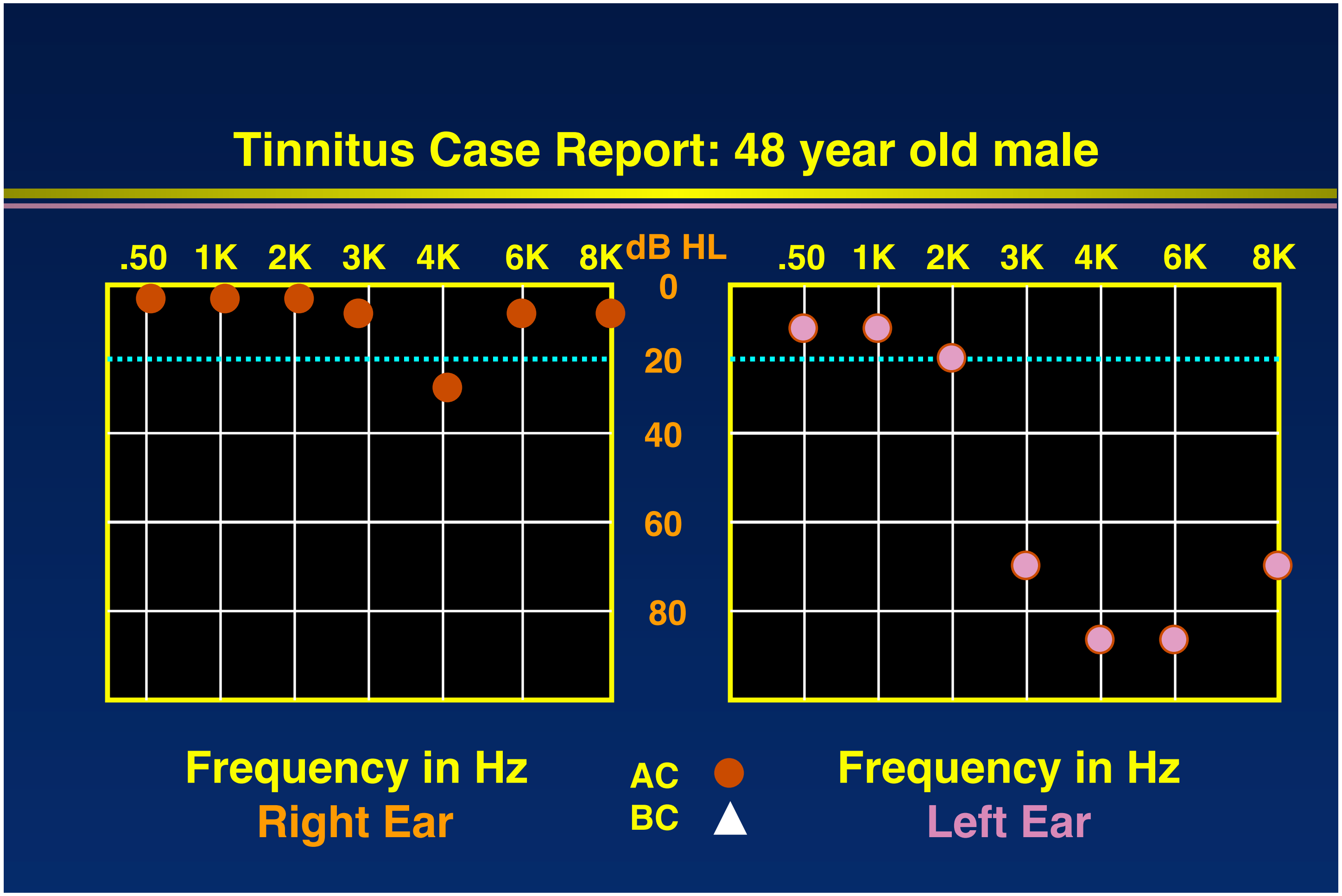
- **DIAGNOSTIC AUDIOLOGY**
  - Immittance measurement (no ARs if hyperA)
  - Pure tone audiometry (inter-octaves > 2000 Hz)
  - High frequency audiometry if 250 - 8K Hz WNL
  - Word recognition scores (at MCL)
  - DPOAE for 500 to 10,000 Hz w/ 6 freqs/octave
  - Neuro-diagnostic ABR as indicated

# TINNITUS ASSESSMENT AND MANAGEMENT:
## Audiogram versus DPOAE



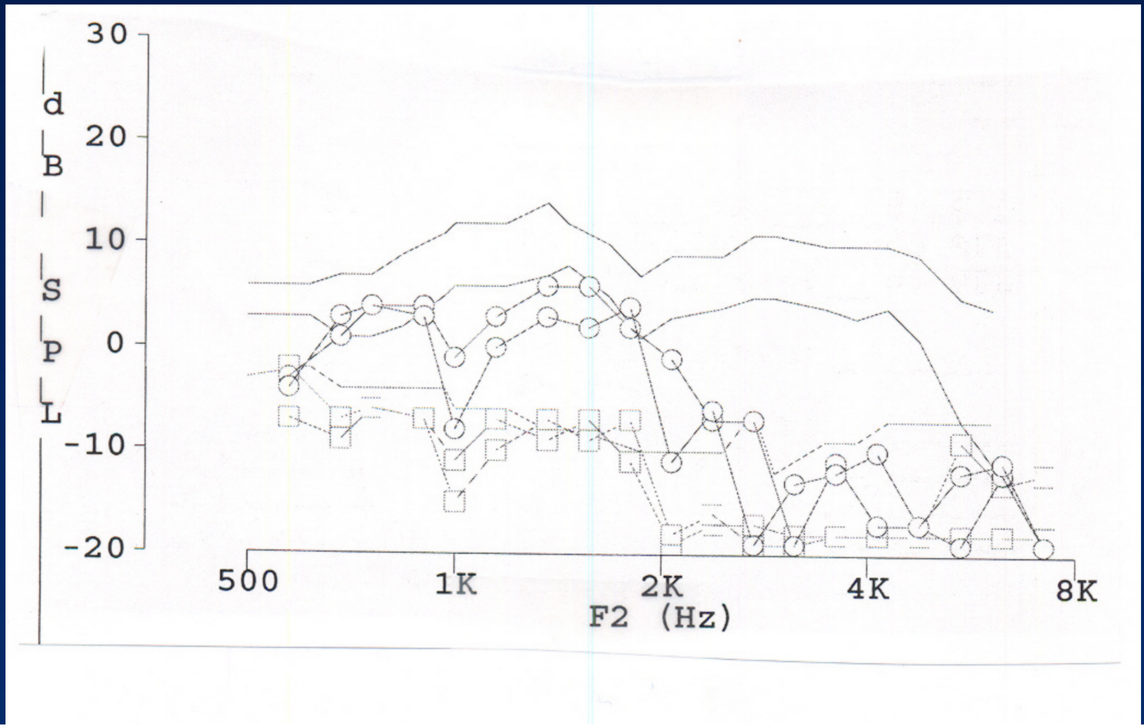
## TINNITUS CASE REPORT: 48 year old male

- Right handed
- History of noise exposure (shooting rifle)
- Bothersome tinnitus
  - Tinnitus Handicap Inventory = 48
  - Tinnitus severity = 5 on 0 to 10 scale
  - Tinnitus impacts quality of life
    - ✓ can’t concentrate
    - ✓ difficulty falling asleep

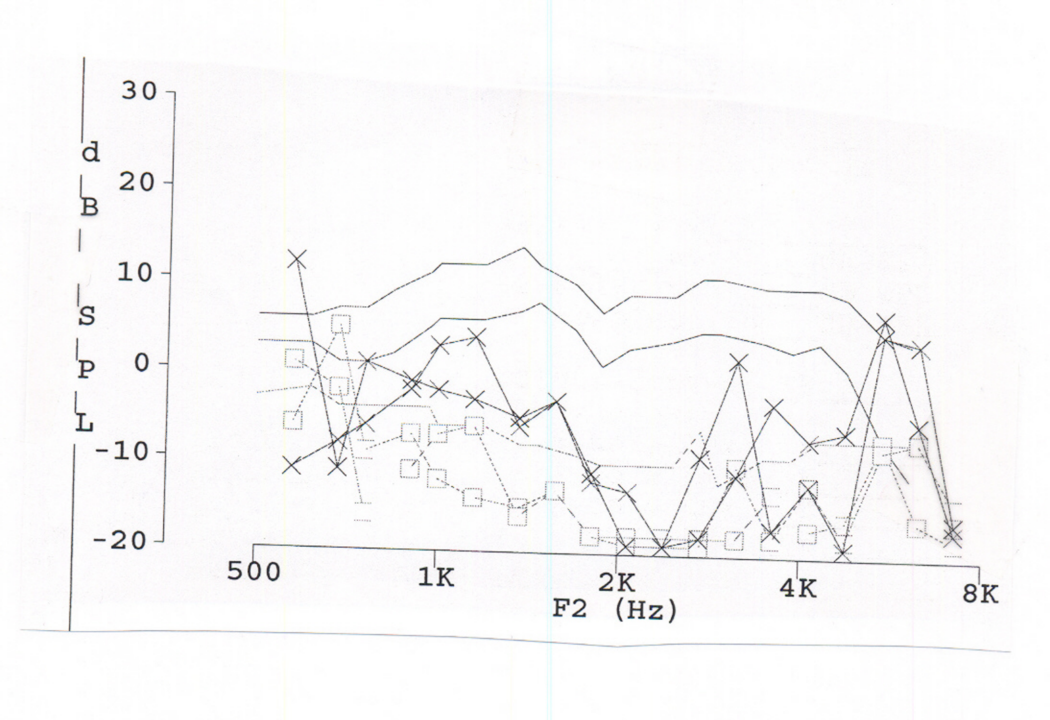


Tinnitus Case Report: 48 year old male
.50
1K
2K
3K
4K
6K
8K
dB HL
0
20
40
60
80
.50
1K
2K
3K
4K
6K
8K
Frequency in Hz
Right Ear
AC
BC
Frequency in Hz
Left Ear

## TINNITUS CASE REPORT (48 year old male): Right Ear DPOAEs



# TINNITUS CASE REPORT (48 year old male):
# Left Ear DPOAEs



# OTOACOUSTIC EMISSIONS: Research Directions

- Instrumentation
  - Combination devices for measurement of transient and distortion product OAEs
  - Combination devices for recording OAEs with:
    - ✓ Immittance measures (tympanometry & acoustic reflexes)
    - ✓ Auditory brainstem response
  - High frequency (> 8000 Hz) distortion product OAEs
  - Ipsilateral and contralateral suppression of OAEs
    - ✓ Statistical analysis of findings without versus with suppression noise presented bilaterally
- Basic science
  - Mechanisms of outer hair cell physiology and biomechanics
  - Relation of OAEs to SIDS