Wideband Immittance for Diagnosis of Hearing Loss

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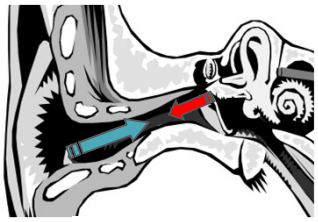
Topics to be Covered

- Wideband Reflectance Principles
- Wideband Absorbance Principles
- Terminology
- Instrumentation
- Research Background
- Clinical Applications

Roots of Wideband Immittance Measures

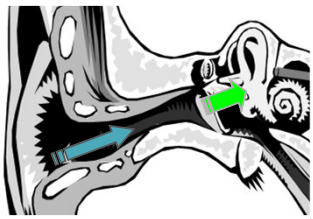
- Wideband immittance research systems developed by Allen (1986) and Keefe, Bulen, Arehart, & Burns (1993).
- Application in clinical assessment of the middle ear has occurred in the past 2 decades.
- Frequency ranges can be accurately tested up to 8 kHz due to improved calibration and reflectance technique (Keefe et al., 1993).

Wideband Reflectance Principle



$$\text{Energy Reflectance} = \frac{\text{Reflected Power}}{\text{Incident Power}}$$

Wideband Absorbance Principle



$$\text{Absorbance} = \frac{\text{Absorbed Power}}{\text{Incident Power}}$$

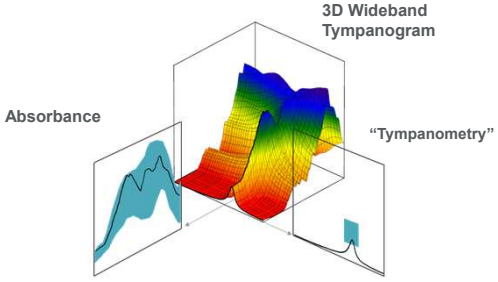
Wideband Absorbance is Sensitive to Many Disorders

- Middle ear effusion
- Ossicular disarticulation
- Eardrum perforation
- Ossicular fixation
- Eardrum atrophy
- Tympanosclerosis
- Conductive hearing loss
- Structural ossicular abnormalities
- Superior canal dehisence
- Increased intracranial pressure

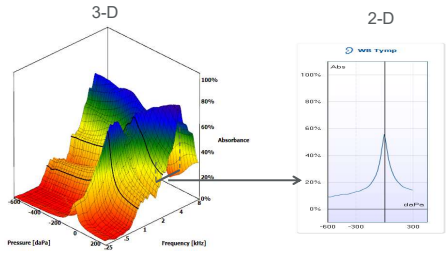
Interacoustics Titan Wideband Immittance

- Pressurized Measures
- Uses newly developed probe
- Acoustic Reflexes
- Pressurized TEOAE and DPOAE
- ABR with CE-Chirp

Titan Suite

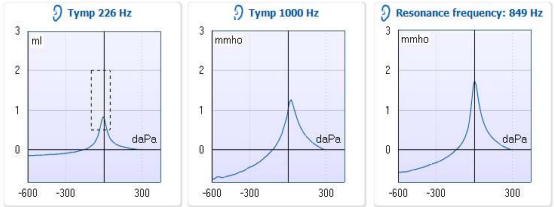


The Wideband Tympanogram



Wideband Tympanometry

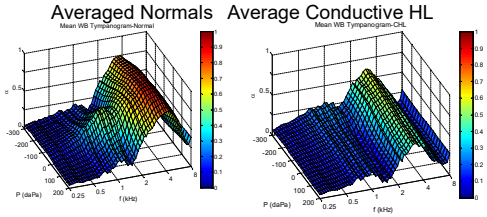
2-D Tympanogram "Slices"



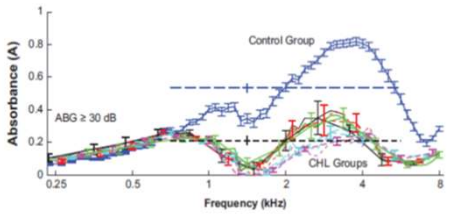
Wideband Tympanometry Research

Keefe & Simmons experimental system (2003)

Averaged Normals Average Conductive HL

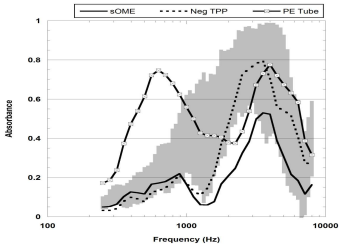


Wideband Absorbance for Detection of Conductive Hearing Loss
Keefe et al., 2012

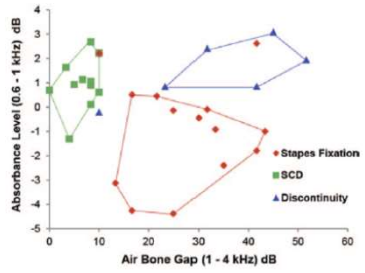


Obtained on Interacoustics Experimental Wideband system

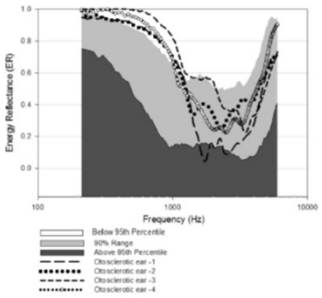
Effects of OME, middle ear pressure and PE tube
Sanford et al., 2014



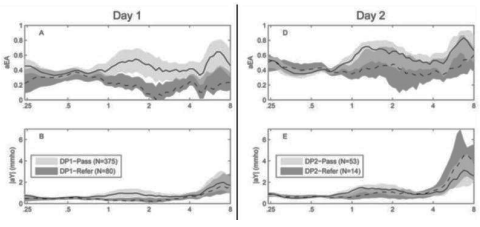
Relation Between Pathology, ABG and Absorbance
Nakajima et al., 2013



Effects of Otosclerosis (Shahnaz & Bork, 2006)

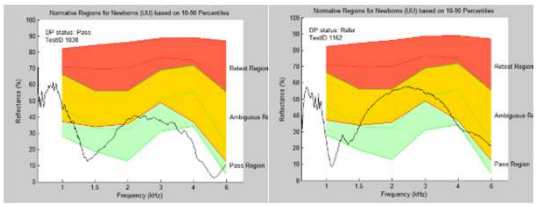


Wideband absorbance versus admittance in newborns with abnormal DPOAE



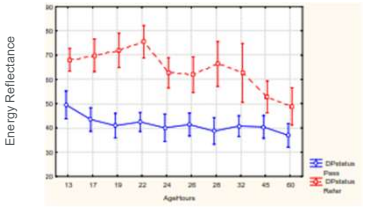
Sanford et al. (2009), Ear and Hearing

Wideband Reflectance Normal and Abnormal Regions for Newborns



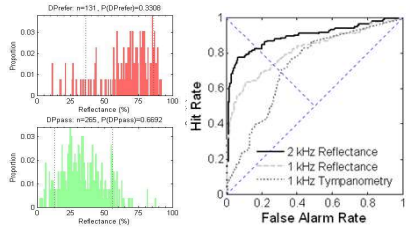
Hunter et al., 2010, Ear and Hearing

Wideband reflectance improves with age for Refer Ears



Hunter et al., 2010, Ear and Hearing

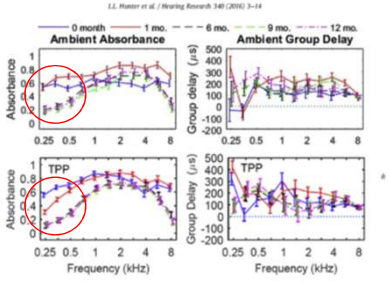
Test performance for wideband reflectance compared to 1 kHz tympanometry



Hunter et al., 2010, Ear and Hearing

Pass = 352 Refer = 141

Development of Ambient Absorbance in Normal and NICU Infants



Wideband Absorbance in Down Syndrome

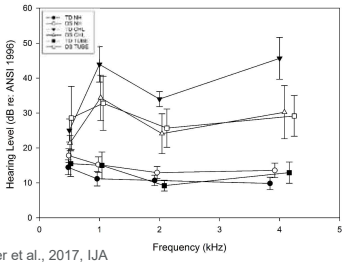
34 children with DS (mean age 6.4 yrs, 63 ears):
- 16 normal hearing (6.55 yrs)
- 28 CHL (4.94 yrs)
- 18 tubes (8.45 yrs)

49 TD children (mean age 5.1 yrs, 98 ears):
- 48 normal hearing (7.35 yrs)
- 19 CHL (1.34 yrs)
- 30 tubes (3.60 yrs)

Ears with SNHL (2) and MHL (2) were excluded

•Hunter et al., 2017, IJA

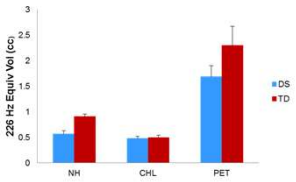
Hearing Thresholds in Down Syndrome and Typical Children



Hunter et al., 2017, IJA

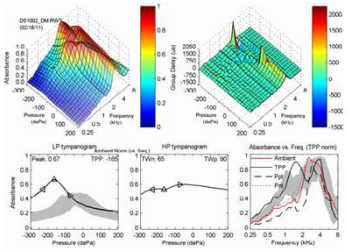
Standard Tympanometry

- 226-Hz tympanometry showed normal results in 3/14 ears of TD children who had CHL, and was unable to be obtained in 6/30 ears of TD children with tubes (inability to maintain seal), while WAI was completed in all ears with tubes.



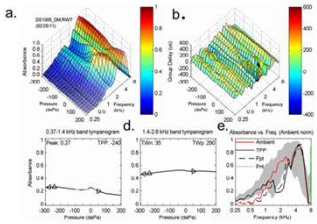
Hunter et al., 2017, IJA

Right ear of a 64 month-old male with Down syndrome and normal hearing (10-15 dB HL across frequencies) and normal DPOAE.



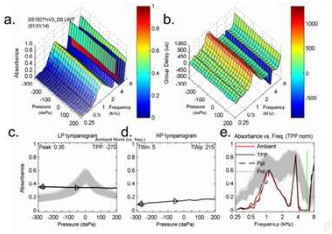
Hunter et al., 2017, IJA

Left ear of a 35 month-old female with DS, who was diagnosed with OME and had elevated air conduction hearing levels.

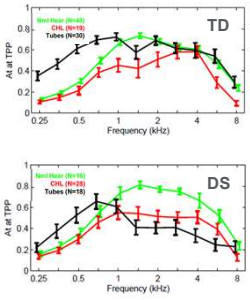


Hunter et al., 2017, IJA

Patient with DS and patent PE tube



Hunter et al., 2017, IJA



- Absorbance across frequencies for diagnosis groups
- Measured at tymp peak pressure (TPP)
- Absorbance higher in tubes for low Hz
- Absorbance lower in CHL for mid-Hz
- Correlates to behavioral hearing levels in both groups

Hunter et al., 2017, IJA

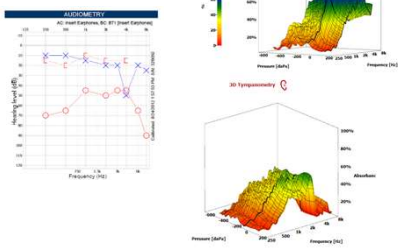
Summary – Down Syndrome

- Normal hearing children with DS have similar absorbance across a wide range of frequencies as shown by WAI, compared to TD children.
- This finding validates WAI as a clinical tool in children with DS.

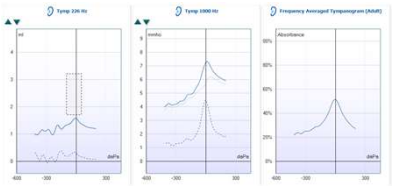
Case Examples

Adult Case

Courtesy of Navid Shahnaz, Ph.D.

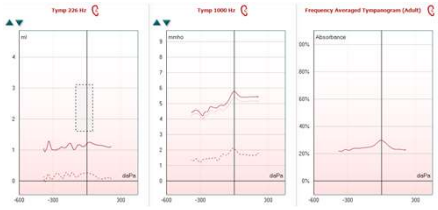


Adult Case: Otosclerosis Left Ear



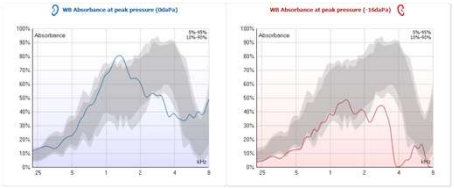
Courtesy of Navid Shahnaz, Ph.D.

Adult Case: Otosclerosis Right Ear



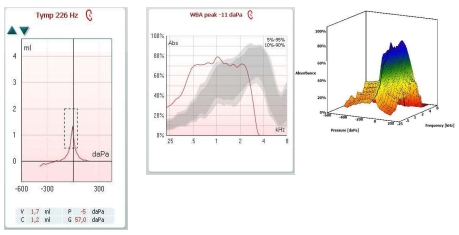
Courtesy of Navid Shahnaz, Ph.D.

Adult Case: Otosclerosis



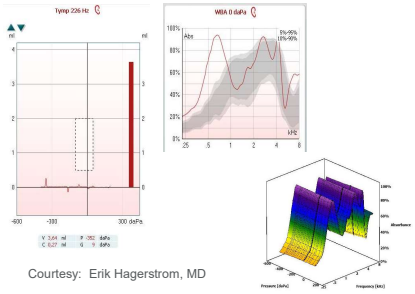
Courtesy of Navid Shahnaz, Ph.D.

Adult Case: Disarticulation



Courtesy: Erik Hagerstrom, MD

Adult Case: Perforation + Disarticulation



Courtesy: Erik Hagerstrom, MD

Wideband Test Combinations Diagnostic Interpretation

Diagnosis	WB Tymp	WB Reflex	OAE	Audio/ABR
Normal	Normal	Normal	Normal	Normal
Conductive	Abnormal	Elevated Threshold or Absent	Absent	Elevated air threshold, normal bone
Cochlear	Normal	Normal, elevated or absent depending on degree of loss	Absent	Elevated air, sensitivity loss
Neural	Normal	Abnormal or absent	Normal	Absent or markedly abnormal

Take Home Messages

- It's time to move beyond the ABCs of immittance
- Wideband tympanometry uses a familiar of probe and measurement system
- The stimulus and recording is wideband
- Signal averaging and normative data are powerful techniques
- Test-retest reliability is high
- Clinical studies show better test performance than single frequency tympanometry

Ear and Hearing Supplement

Acoustic Immittance Measures

Basics and Advanced Practice

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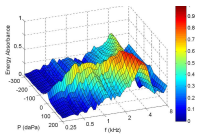

Questions?