

Diagnosis of middle ear disorders using wideband energy



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CLINICAL DIAGNOSIS OF MIDDLE EAR DISORDERS USING WIDEBAND ENERGY REFLECTANCE

A Doctoral Thesis Presented to The Graduate College of Missouri State University In Partial Fulfillment Of the Requirements for the Degree

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Communication Sciences and Disorders

ABSTRACT

Accurate diagnosis of middle ear disorders in adults and children is a challenging task because of the complexity of disorders. Wideband energy reflectance (WBER) technique provides simplicity and accuracy in diagnosing middle ear disorders across wide frequency range. This research is expanding the studies of WBER to investigate the middle ear function in normal and pathological conditions of the middle ear in adults and children. Findings showed that WBER not only can distinguish abnormal from normal middle ear function but also can characterize different middle ear disorders in adults and children. Several specific WBER patterns were established in a variety of middle ear disorders among adults and children that will help in early diagnosis of such pathologies. The ER pattern was including significant higher ER in the children control group than the adult control group at 0.5 kHz and 1 kHz, abnormally high or shallower in otosclerotic ears, abnormally low in ears with TM perforation and abnormally low ER with deep notch in ears with hypermobile TM. In presence of negative middle-ear pressure, elevated ER at ambient pressure is also expected. Results also showed that

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standard tympanometry was less sensitive in diagnosing middle ear disorders when compared to WBER especially in otosclerotic cases. Further studies are still required to validate the clinical use of ER in larger number of individuals with confirmed middle ear disorders.

KEYWORDS: wideband energy reflectance, otosclerosis, otitis media with effusion, eustachian tube dysfunction, tympanometry.

This abstract is approved as to form and content

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Chairperson, Advisory Committee

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By

Alaaeldin Elsayed

A Doctoral Thesis Submitted to the Graduate College Of Missouri State University In Partial Fulfillment of the Requirements For the Degree of Doctorate, Audiology

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DEDICATION

This work is dedicated To My dear parents,

My beloved “ *Enass, Mohamed, and Nada* ”,

Who made all of this possible,

for their endless encouragement and patience.

REVIEW OF THE LITERATURE

Hearing mechanism and the middle ear

Sound transmission. The hearing process includes the transmission of sound energy through the auditory canal to the tympanic membrane (TM). This sound energy results in vibration of the TM with an equal atmospheric

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pressure on both sides of the TM. The mechanical vibrations are, then, transmitted from the TM to the air-filled middle ear space and ossicles (malleus, incus and stapes), which further amplify the sound energy and transmit it, via oval window, to the fluid-filled inner ear. At the inner ear, the mechanical vibration is converted into electric waves and transmitted as nerve signals that are interpreted by the brain as sounds.

Mechanical properties of middle ear. The middle ear is an air-filled cavity that connects the outer ear canal to the labyrinth of the inner ear. This connection is established through the middle ear ossicles-malleus, incus and stapes. The malleus is attached to the TM by its handle; the incus bone lies in the middle between the malleus and the stapes while the footplate of the stapes is attached to the oval window of the inner ear. The middle ear cavity is also connected to the nasopharyngeal cavity through the Eustachian tube (Musiek and Baran, 2007). The Eustachian tube is important in maintaining an equal pressure on both sides of the TM and ventilation of the middle ear cavity. The tube also drain the middle ear into the nasopharynx (Channell, 2008). Figure 1 demonstrates schematic representation of the anatomy of the ear.

When the sound pressure moves the TM the malleus and incus consequently move together as one unit around a pivotal point. In doing so, both bones act as a lever; the lever arm formed by the manubrium of the malleus is slightly longer than that of the incus (about 1: 1.3 ratio). In turn, the rotation of the long process of the incus around its pivotal point leads to the back and forth (piston-like) movement of the stapes footplate in the oval window of the inner ear. The movement of the stapes footplate is directly proportional to <https://assignbuster.com/diagnosis-of-middle-ear-disorders-using-wideband-energy/>

the frequency and amplitude of the sound waves. This route of sound transmission is called the "ossicular route". Acoustic route is another way of transmitting sound waves directly from the TM and the oval window to the cochlea. The direct acoustic stimulation of the oval and round windows, by passing the ossicles (acoustic route), plays a part in sound transmission. In normal ears both routes are functioning but the upper hand is for the ossicular route (Voss, Rosowski, Merchant, and Peake, 2007).

From the above information, it appears that the middle ear plays an important role in the hearing process. The middle ear mainly helps to correct the impedance mismatching between the air-filled middle ear and the fluid-filled cochlea and to transform the acoustic energy at the TM into mechanical energy that will eventually be transferred to the inner ear. The impedance matching function of the middle ear is carried out by three mechanisms: the lever action of the ossicles of the middle ear, the area difference between the TM and the area of the stapes footplate, and the buckling of the curved TM. An outcome of these mechanisms is that the vibration obtained from the large area of the TM is focused to the much smaller oval window of the inner ear (21: 1 area ratio), resulting in a differential pressure between the oval window connected to scala vestibuli and the round window connected to the scala tympani. This pressure differential is critical in maximizing the flow of sound energy and activation of the cochlear structures (Cummings, 2004). Accordingly, middle ear disorders are expected to affect the normal transmission of sound, resulting in conductive hearing loss (discussed below).

An illustration of the anatomical structure of External, Middle and Inner ear.
Modified from “ Medline Plus Medical Encyclopedia: Ear anatomy”.

In addition to correcting the impedance mismatch between the air-filled middle ear and the fluid-filled cochlea, the middle ear also protects the inner ear from loud sound via the acoustic reflex. This mainly occurs as a result of reflex contraction of the two middle ear muscles, the tensor tympani and the stapedius, in response to loud sound leading to increased stiffness of the ossicular chain, and hence diminished sound transmission (Allen, Jeng, and Levitt, 2005). Given that the acoustic reflex mainly decreases the transmission of low frequency sounds thus, it improves speech discrimination in loud, low-frequency noisy environments. Unfortunately, the reflex does not protect the ear against impulsive sounds as gun shots due to prolonged latency in muscle contraction (Lynch, Peake, and Rosowski, 1994).

Pathophysiology of middle ear disorders

To further understand the pathology of middle ear disorders, it is important to consider the middle ear system as a vibrating mechanical system. Such a system is composed of three elements: mass, stiffness, and friction. When the mass and stiffness components are equal, so-called resonant frequency of the middle ear, it is expected that the amplitude of vibration of the middle ear is at maximum. On the other hand, when there is an increase in the mass without change in stiffness or friction the resonant frequency is lowered and the amplitude of vibration is lowered at frequencies above the resonant frequency. In contrast, when there is an increase in the stiffness component of the middle ear the resonant frequency increases and the magnitude of

vibration reduces for frequencies below the resonant frequency (Roeser, Valente, and Hosford-Dunn, 2000).

Middle Ear Disorders are a variable group of pathological conditions that includes, for example, middle ear infection (Otitis Media with Effusion: OME), chronic otitis media with perforation of the TM, Eustachian Tube Dysfunction (ETD), ossicular disruption or dislocation and or/ otosclerosis. Such middle ear disorders may lead to conductive hearing loss due to their effects on mass, stiffness, and/or friction elements of the normal middle ear.

Perforated TM is induced by chronic otitis media or trauma to the ear. As a result, the normal structure and the function of the TM are altered. The degree of hearing loss is directly related to the size of the perforation (Voss et al., 2000) The perforation leads to equalization of pressure on both sides of the membrane which consequently leads to disturbance of the ossicular route and hearing loss (Voss et al., 2000). Normally the inward movement of the stapes is followed by an outward movement at the round window (push and pull mechanism). In the presence of TM perforation, this push and pull mechanism of the ossicles is disturbed and the sound waves energy reaching the oval window is reduced.

Ossicular dislocation usually follows a violent trauma to head or as a consequence of chronic otitis media and/or cholesteatoma. Disarticulation of the incudostapedial joint due to traffic accident was the most common pathology of ossicular disruption(Yetiser s, 2008). With the exception disruption due to chronic otitis media, the dislocation of the ossicles may or may not be accompanied by TM rupture. The injury results in loss of the

impedance matching mechanism of the middle ear and a conductive hearing loss of about 40-60 dB (Merchant, Ravicz, and Rosowski, 1997).

Otosclerosis is a progressive disease of bone resorption and reformation that affects bones derived from the otic capsule. The etiology of the disease is not fully understood. The disease leads to osteodystrophy and fixation of the stapes in the oval window. Among the most accepted etiopathological factors is genetic factors and viral infection. Otosclerosis is characterized clinically by progressive hearing loss, tinnitus and vertigo (Menger and Tange, 2003).

Both conductive and sensory neural hearing loss has been reported in otosclerotic patients (Ramsay and Linthicum, 1994). Otosclerosis may affect the cochlea and other parts of the labyrinth as well (Menger and Tange, 2003). The resulting fixation of the footplate of the stapes leads to increased stiffness of the ossicular chain early in the disease. Increased stiffness of the middle ear affects the transmission of low frequency sounds. At later stages of the disease, the bone starts to grow adding a mass effect. This increase in mass of the middle ear affects the transmission of high frequency sounds as well (Shahnaz and Polka, 1997).

More disorders include inflammatory conditions of the middle ear such as otitis media (OM) and media with effusion (OME), chronic otitis media, and cholesteatoma. OM usually results from upper respiratory infections or allergies that lead to obstruction of the Eustachian tube (Channell, 2008). As a consequence, negative pressure develops in the middle ear resulting in otalgia due to stretching of the TM and mild hearing loss due to the increased stiffness of middle ear transmitting mechanism. If the negative pressure inside the middle ear is not relieved, a transudate accumulates <https://assignbuster.com/diagnosis-of-middle-ear-disorders-using-wideband-energy/>

inside the middle ear. The condition is then called OME. The hearing is further affected by the mass- friction effect. The degree of hearing loss depends on the type and the amount of the transudate. The combination of fluid and pressure in the middle ear was found to reduce TM movement at the umbo by 17 dB over the auditory frequency range (Dai, Wood, and Gan, 2008).

Middle ear function measures

Tuning fork testing. The tuning fork testing is one of the traditionally used qualitative hearing tests. They are used to examine the conductive component of hearing loss (external or middle ear pathology). Several tests have been described including: Rinne, Schwabach, Bing, and Weber tests.

For Rinne test, the vibrating tuning fork is held against the skull, usually on the mastoid process bone behind the ear to cause vibrations through the bones of the skull and inner ear. To cause vibrations in the air next to the ear, the vibrating fork is then held next to, but not touching, the ear. In the test the patient is asked to determine if the sound heard through the bone is louder or that heard through the air. The results of the test are categorized as positive, negative, or equivocal. A negative Rinne test is indicated when the sound is heard louder by bone conduction than by air conduction which suggests a conductive component of the hearing loss. Although Rinne test was found to be highly specific in one study; the same author has suggested that it should be carried out only as a pack up test for pure tone audiometry in audiological evaluation of hearing loss (Browning and Swan, 1988; Thijs and Leffers, 1989). The Schwabach tuning fork test compares patient's bone conduction to the normal examiner. Bing tuning fork tests determines the

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presence or absence of the occlusion effect. Weber tuning fork test determines the type of a unilateral hearing loss. While Rinne test compares air conduction to bone conduction in the same patient.

Although the tuning fork testing is easy and reliable; it is still a subjective test that depends on the response of the patient and the degree of hearing loss. Additional drawbacks are that tuning fork testing is a qualitative and not a quantitative test, and does not diagnose the etiology of the conductive hearing loss.

Pure-tone Audiometry. Pure-tone Audiometry is a behavioral test that measures hearing threshold. The test has been used to diagnose type and degree of hearing loss for more than one hundred years.

During test setting, the patient is subjected to different tones to test the hearing mechanisms via air-conduction and bone conduction. Typically, the normal level of pure tone audiogram air and bone conduction will lie between 0-15 dB HL for children and 0-25 dB HL for adults. According to Northern and Downs (1991), the degree of hearing loss can be classified in adults as (0-25 dB HL) within normal limits, Mild (26-40 dB HL), Moderate (41- 55 dB HL), Moderate-Severe (56-70), Severe (71-90 dB HL) or Profound (91 + dB HL) hearing loss. In children it is classified as normal (0-15 dB HL), Slight (15-25 dB HL), Mild (25-30 dB HL), Moderate (30-50 dB HL), Severe (50-70 dB HL), Profound (70 + dB HL) hearing loss. This classification is applied to PTA of 500, 1000, and 2000 Hz (Roeser et al, 2000).

Different types of hearing loss are interpreted by comparing air conduction thresholds to bone conduction thresholds. When the air conduction threshold <https://assignbuster.com/diagnosis-of-middle-ear-disorders-using-wideband-energy/>

elevated to a maximum around 60-70 dB HL in the presence of normal bone conduction threshold, this type of hearing loss is called conductive hearing loss. In sensorineural hearing loss the pure tone audiogram shows both air and bone conduction thresholds are elevated and with a 10 dB HL or less in between. Mixed hearing loss displays elevation in both air and bone conduction thresholds, but with the bone conduction threshold at better intensities than the air conduction by 10 dB HL or more. In both conductive and mixed hearing loss, the difference in air and bone conduction thresholds is called air-bone gap; and it represents the amount of conductive hearing loss present (Roeser et al, 2000).

The use of pure-tone audiometry provides quantitative information regarding the degree and type of hearing loss. However, it does not diagnose the cause of hearing loss and cannot be used in infants, young children, and difficult-to-test subject. Mannina (1997) reported that the diagnosis of middle ear disorders in school-aged children is less efficient when using pure-tone audiometry alone. To improve the diagnosis of middle ear disorder, Yockel (2001) demonstrated that the addition of tympanometry to audiometry does improve the diagnosis of OME than using audiometry alone.

Assessing Middle ear function is a very important step in early diagnosis and treatment of conductive hearing loss. Since the usually used subjective tests, the tuning-fork and pure tone audiometry, cannot identify the etiology of underlying middle ear disease, other objective measures such as acoustic immittance are needed for differential diagnosis and accurate diagnosis of specific middle ear disorders.

Acoustic Immittance. Several objective measurements of middle ear function have been developed over the last four decades. Various anatomical structures of the middle ear represent complex network system that affects the sound presented to the ear. Not all the sound presented to the middle ear is delivered to the cochlea, but some of the power is absorbed by the bony structure of the middle ear (Zwislocki, 1982). Acoustic Immittance using tympanometry assess the middle ear status by measuring the transmitted sound energy to the middle ear.

Acoustic Immittance provides objective information about the mechanical transfer function in the outer and middle ear. Acoustic Immittance is defined, as the velocity with which an objects moves in proportional to an applied force, while Acoustic Impedance (Z_a) is the opposition offered by middle ear and the TM to the flow of energy. Mathematically acoustic admittance (Y_a) of a system is the reciprocal of impedance. Acoustic Immittance refers collectively to acoustic admittance, acoustic impedance or both (“Tympanometry. ASHA Working Group on Aural Acoustic-Immittance Measurements Committee on Audiologic Evaluation”, 1988). Investigators have found that abnormalities in the middle ear transmission might be reflected in the acoustic condition of the TM (Allen et al, 2005). Acoustic Immittance can be measured to single probe-tone frequency (single frequency tympanometry) or to series of multiple probe frequencies (multifrequency tympanometry).

Single frequency tympanometry. Tympanometry is one of the earliest objective methods used to evaluate middle ear function. Tympanometry measures the acoustic immittance of the middle ear as a function of <https://assignbuster.com/diagnosis-of-middle-ear-disorders-using-wideband-energy/>

changing the air pressure in the ear canal. A single probe tone tympanometry is the conventional measure of middle ear function in response to low frequency probe tone, 226 Hz, under varying static air pressure. Evaluation of the acoustic immittance of normal and different middle ear disorders was done by Otto Metz, 1946, and confirmed later by Feldman, 1963 (Katz, 2009)

In 1970, James Jerger began to incorporate immittance measurement into the routine audiological evaluation. Jerger classified tympanograms as type A, B, or C depending on the shape of the tympanogram (with or without peak) and location of the peak when present. Type A is the normal tympanogram with the peak at or near the atmospheric pressure (+25 to -100 daPa). Type A is further divided into subtypes Ad and As for high and low peaked type A tympanograms respectively (Feldman, 1976). Type B tympanogram has no peak and relates to middle ear effusion, infection with normal ear canal volume, or due to large TM perforation with large ear canal volume. Type C is a negatively shifted tympanogram that reflects Eustachian tube dysfunction, a precursor of serous OM, mostly evolved from type B (Katz, 2009).

Since 1970, single frequency Tympanometry is the conventional clinical middle ear measure because it is a non-invasive, objective, and cheap indicator of many middle ear pathologies in children and adults.

Unfortunately, low frequency probe tone tympanometry has high false negatives in infants younger than seven months (Holte, Margolis, and Cavanaugh, 1991). This is explained by the movement of the infant's ear

canal wall with pressure changes in the external ear canal due to immaturity
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of the bony part of the external auditory canal. In addition, tympanometry was found to be relatively insensitive to many lesions that affect the ossicular chain of the middle ear (Lilly, 1984). Furthermore, Keefe and Levi (1996) reported false positive tympanometry results compared to energy reflectance, a recent middle ear function measure. They found normal middle ear energy reflectance at higher frequencies in infants with flat low probe tone tympanometry.

Multifrequency tympanometry. Multifrequency Tympanometry (MFT), which was first introduced by Colletti in 1976, measures middle ear impedance using multiple frequency probe tones ranging from 226-Hz to 500 Hz and up to 2000 Hz (Colletti, 1976). Similar to previous discussion about the three elements of the mechanical system of the middle ear, admittance of the middle ear has three components: stiffness (compliant susceptance), mass susceptance and conductance (resistance).

A tympanometric pattern was developed by Vanhuyse and colleagues in 1975 that helped in interpreting the underlying middle ear pathology using MFT. The Vanhuyse tympanometric pattern is based on the assumption of the shapes and locations of reactance (X) and resistance (R) tympanograms. Using a conversion equation the model can predict the shapes of susceptance (B) and conductance (G) tympanograms. Vanhuyse et al proposed four normal patterns: 1B1G, 3B1G, 3B3G, and 5B3G as shown in Figure 2. 1B1G pattern is the normal tympanogram with a one susceptance (B) and one conductance (G) peak. It occurs when reactance (X) is negative and its absolute value is greater than resistance (R) at all pressure used (the ear stiffness is controlled). As the probe frequency increases the curve

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becomes more complex and notched. 3B1G model has three peaks of susceptance (B) and one conductance (G) peak. It represents negative reactance (X) with an absolute value greater than resistance (R) at low pressure and smaller than resistance (R) at high pressure. The third model (3B3G) appears when the ear is mass-controlled. In 3B3G model the reactance is positive and less than resistance ($X < R$) at low pressure and negative at high pressure. 5B3G pattern occurs when the reactance is positive and greater than resistance ($X > R$) at low pressure and becoming negative at high pressure (Margolis, Saly, and Keefe, 1999). Figure 2.

A graphic presentation of the model presented by Vanhuysse, Creten and Van Camp (1975). The resistance (R), negative resistance (-R) and the reactance (X) tympanograms are shown in the upper left corner of each panel. Negative R is shown to compare the magnitude of the reactance X. The corresponding admittance (Y), (lower left corner), susceptance (B), (upper right corner) and conductance (G), (lower right corner) are also shown in each panel. Four patterns are presented and classified according to the number of extrema in the susceptance B and conductance G tympanograms. The pattern (1B1G) in panel one shows both susceptance and conductance have single extrema and reactance is negative. The pattern (3B1G) in panel two shows conductance G is single peaked with three extrema in susceptance B, reactance X is still negative but its absolute value is greater than resistance at high pressure. The pattern (3B3G) in panel three shows three extrema in susceptance B, conductance G, and admittance Y tympanograms, reactance Y is positive but less than resistance R. The pattern (5B3G) in panel four shows five extrema in susceptance B tympanogram and three extrema in

conductance G , and admittance Y tympanograms, reactance X is positive and greater than resistance R at low pressure.

Because of the use of measuring middle ear function to several probe tone frequency, MFT is considered superior to single frequency tympanometry in detecting high impedance pathological conditions of the middle ear such as middle ear effusion, otosclerosis, and cholesteatoma. Such pathological conditions were not detected by conventional tympanometry (Colletti, 1976, Keefe and Levi, 1996, Shahnaz et al 2009). Several studies have shown that MFT has higher sensitivity and specificity in detecting middle ear pathologies such as TM mass or adhesions (Margolis, Schachern, and Fulton, 1998). Also, MFT is more sensitive than single frequency tympanometry in identifying normal and abnormal middle ear condition in neonates (Shahnaz, Miranda, and Polka, 2008). However, MFT is of limited clinical use for several reasons: long testing time, limited frequency range, and unreliable data above 1000 Hz (Allen et al, 2005). The use of wideband energy reflectance is shown to address the above limitations of MFT.

Wideband energy reflectance. The wideband energy reflectance (WB ER) is a new technique that has been introduced recently to evaluate middle ear dysfunction (Keefe, Ling, and Bulen, 1992). Simply the idea of WB ER is that incident sound to the ear is transmitted through the ear canal and TM, some of this sound energy is absorbed through the middle ear and cochlea and part of it is reflected back (Figure 3). The energy reflectance (ER) is defined as the square magnitude of pressure reflectance $|R(f)|^2$, which represents the ratio of the sound energy reflected from the TM to the incident sound energy at frequency (f). ER ratio ranges from one to zero (1. 0 = all incident

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sound energy is reflected, and 0.0 = all sound energy is absorbed) (Allen et al, 2005). ER is an indicator of the middle ear power to transfer sound (Feeney, Grant, and Marryott, 2003).

Energy reflectance (ER) measures middle ear function over a wide band of frequencies (0.2- 8 kHz). ER is the ratio of the reflected energy (red arrow) to the incident energy (yellow arrow). When all incident sound energy is reflected back ER ratio equals one. When all incident sound energy is absorbed ER equals zero. Red arrow represents reflected sound energy; yellow arrow represents incident sound energy; green arrow represent absorbed sound energy. Modified from " Medline Plus Medical Encyclopedia: Ear anatomy".

WB ER measures middle ear function using a chirp stimulus at 65 dB SPL over a wide frequency range, typically 0.2 to 8 kHz and at fixed ambient pressure (Feeney et al, 2003). Normative data has shown that most incident acoustic power is reflected back to the ear canal (ER ratio close to 1) at frequency range below 1 kHz or above 10 kHz that also show poor hearing threshold or at frequencies below 1 kHz and above 4 kHz (less efficient middle ear function) (Keefe, Bulen, Arehart, and Burns, 1993). More specifically, 50% of the acoustic power is transmitted to the middle ear between 1-5 kHz frequency range, indicating that the most effective middle ear transfer function (ER is at its lowest values, closer to one) occurs around 1-5 kHz (Allen et al, 2005; Keefe et al, 1993; Schairer, Ellison, Fitzpatrick, and Keefe, 2007).

WBER has been used in measuring normal middle ear function and middle ear disorders using ambient pressure (Allen et al, 2005; Feeney et al, 2003; Shahnaz et al., 2009). In other studies the researchers used pressure to measure the acoustic stapedial reflex (Feeney and Sanford, 2005; Schairer et al, 2007). Development of the middle ear in infants was also investigated using WBER (Keefe and Abdala, 2007; Keefe et al, 1993; Keefe and Levi, 1996).

Wideband energy reflectance in neonatal screening

Keefe et al. (1993) and Keefe and Levi (1996) reported that the acoustic response properties of the external and middle ear varies significantly over the first 2 years of life. These changes, mostly physical changes, are responsible for the mass-dominant infant's middle ear system with lower resonant frequency. The main components of this mass-dominant effect is the pars flaccida of the TM, ossicles, and perilymph in the cochlea (Van Camp, Margolis, Wilson, Creten, and Shanks, 1986). The mesenchyme in infant's middle ear may add to the mass effect (Meyer, Jardine, and Deverson, 1997). This is completely in contrast to adult's middle ear, which is a stiffness-dominant system at low frequency (Holte et al, 1991; Keefe and Levi, 1996). The TM, tendons and ligaments, the space between the mastoid and the middle ear cavity, and the viscosity of the perilymph and the mucous lining of the middle ear cavity constitute the stiffness component of the middle ear (Van Camp, Margolis, Wilson, Creten, and Shanks, 1986).

Recently, Shahnaz (2008) have compared MFT and WBER findings between normal adults and normal-hearing neonates in the neonatal intensive care units (NICU), who passed the neonatal hearing screening test. The

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researcher found maximum absorption of the incident energy at narrower range of frequencies (1.2 – 2.7 kHz) in normal babies compared to adults (2.8 – 4.8 kHz) (Shahnaz, 2008; Shahnaz et al, 2008). This preliminary normative data from 49 neonatal ears reflects the potential diagnostic benefits of the WBER test in detecting middle ear effusion in neonates.

Wideband energy reflectance in otosclerosis

Although the main definitive diagnosis of Otosclerosis is during surgery, an accurate preoperative audiological diagnosis is very important indication for surgery. Still, pure-tone audiometry has its own limitations that prevent accurate diagnosis of otosclerosis. Also, standard 226 Hz tympanometry is usually within normal type A tympanogram in most otosclerotic patients (Jerger, Anthony, Jerger, and Mauldin, 1974). While multiple frequency tympanometry may be helpful in diagnosing otosclerosis, it adds little information to the diagnosis (Probst, 2007). On the other hand, the WBER responses in three ears of otosclerosis fell outside the 5th to 95th percentile of the normative data and presented a distinctive pattern for the disease (Feeney et al, 2003); which suggests that WBER is a sensitive middle ear measure. In a recent study WBER was found to be helpful in distinguishing 28 otosclerotic ears from normal and/or other causes of conductive hearing loss. A significantly higher ER was found in otosclerotic ears at frequency range of 0.4- 1 kHz as compared to normal ears. In the same study WBER was found to be more sensitive in diagnosing otosclerosis than the conventional 226 Hz tympanometry and the MFT (Shahnaz et al., 2009).

Wideband energy reflectance in other middle ear pathology

Hunter and colleagues (2008) found higher sensitivity of WBER in detecting otitis media in infants and children with cleft palate (Hunter, Bagger-Sjoberg, and Lundberg, 2008). Feeney and colleagues in 2003 studied WBER at ambient pressure in 13 ears with different middle ear disorders and comparative normal. Different middle ear disorders were involved in this study included: four ears with OME, one ear with ossicular discontinuity, two ears with otosclerosis, two ears with hypermobile TM, two ears with perforated TM, and one participant with bilateral sensorineural hearing loss. The results suggested a distinctive WBE