A Guide *to* Otoacoustic Emissions (OAEs) *for* Physicians

Steven D. Smith, Au.D.

Director of Audiology, Director of Physicians Hearing & Balance Center
Drs. Kitchens, Chapman, & Anderson, PA, Montgomery, Alabama

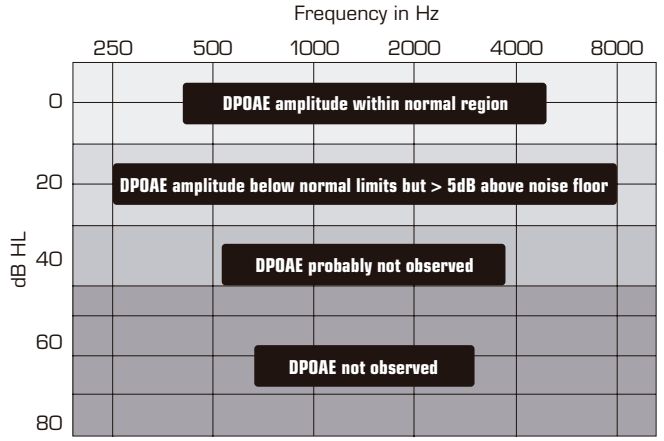
Introduction

In 1978, Dr. David Kemp first showed that the cochlea (inner ear hearing organ) was capable of producing, as well as receiving, sounds. These sounds produced by the cochlea are now known as “evoked otoacoustic emissions.”

Since 1978, a tremendous amount of energy has gone into investigating otoacoustic emissions (OAEs). There are numerous research articles published on OAEs and related clinical topics. In 1995 a variety of FDA-approved otoacoustic emission devices were available for clinical applications. Since 1995 the OAE devices have undergone a tremendous transformation. We have a wide variety of screening and diagnostic OAE devices available for every type of clinical application and facility.

What are Otoacoustic Emissions (OAEs)?

Otoacoustic emissions are sounds produced either spontaneously or evoked by the cochlea, specifically the outer hair cells, and measured in the outer ear canal. The outer hair cells unique property of motility, produce either spontaneously or in response to acoustic stimulation (sound) mechanical energy within the cochlea. This energy is transmitted back through the middle ear mechanism and the tympanic membrane and converted into an acoustic signal in the ear canal. These emissions are then measured or detected in the ear canal by utilizing a very small microphone contained within a probe assembly.



Relationship between audiogram and DPOAE pure sensory hearing loss.

Our perception of sounds (hearing) relies on a specific chain of events to occur. First, sound is passed through the ear canal and reaches the eardrum where, through the middle ear and vibratory motion, it is transmitted to the cochlea or inner ear. Within the cochlea this vibration is transmitted throughout the entire hearing organ stimulating thousands of tiny nerve hair cells (outer and inner). The neural signal from these tiny hair cells is

then sent to the hearing nerve (eighth nerve) and forwarded from the lower to upper auditory areas of the brain where the sound is perceived.

A byproduct of this outer hair cell stimulation is otoacoustic emissions. OAEs only occur in a normal cochlea with normal hearing sensitivity. If there is damage to the outer hair cells, which produce hearing loss, then the OAEs will not be present. Generally it is a good rule of thumb to remember OAEs will be present if hearing is at least 30 dB or better.

There are three types of otoacoustic emissions. These are:

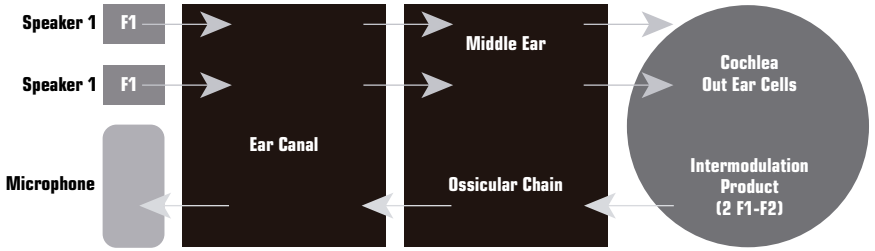
1. **Spontaneous (SOAEs):** These are recorded without any presentation of a stimulus and are not typically of any clinically use. They occur in about 35 to 50% of normal hearing ears.

2. **Transient (TEOAEs):** These are evoked responses from stimulating the cochlea with a transient signal such as a click or tone burst acoustic signal. TEOAEs are a wide frequency response in the 500 to 5,000 Hz range. They typically do not occur in hearing loss of about 30 dB or greater.

3. **Distortion Product (DPOAEs):** These are evoked response OAEs from stimulating the cochlea with two simultaneously presented pure tones of different frequency. This type of OAE can be recorded in individuals with greater degree of hearing loss, at higher frequencies with more frequency specificity. DPOAEs are obtainable in the frequency range of 500 to 8000 Hz. They typically do not occur in hearing losses greater than 30 dB.

How are Otoacoustic Emissions (OAEs) Measured?

The test procedure typically takes less than 2 minutes for both ears. It is noninvasive and does not require sedation for the patient. The OAEs, whether TEOAEs or DPOAEs are measured by presenting a series of very brief acoustic stimuli, usually clicks, to the ear through a probe that is

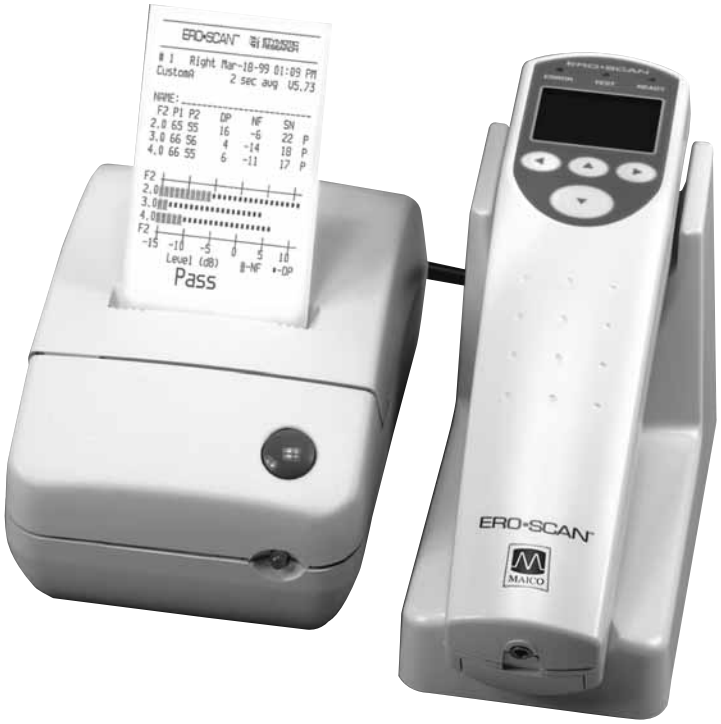


Pathway of OAE transmission.

inserted within the outer ear canal. Within this probe assembly there is a loudspeaker that generates the acoustic stimulus and a microphone that measures the resulting OAEs that are produced within the cochlea and then transmitted back through the middle ear into the outer ear canal. The resulting emission is picked up by the microphone, analyzed, digitized and processed by the specially designed OAE hardware and software. The recorded OAEs, which are very low-level, are differentiated from the ambient background noise by the software provided within the equipment.

What do OAE test results mean?

The production of OAEs by the cochlea, specifically by the outer hair cells of the cochlea, is thought to be the by-product of the active processes of the cochlear mechanisms. The ongoing clinical significance of OAEs is that they are reliable, consistent, valid evidence of the vital sensory process arising within the cochlea. OAEs only occur in a normal cochlea with normal sensory function. “Pass” test results represent that OAEs are present, and one can assume the individual's hearing is at least 30 dB or better. If there is damage to the outer hair cells producing a mild hearing loss, then OAEs are not present. The test result is "Refer," and the patient is at risk for possible communication handicaps and can benefit from further diagnostic assessment and possible rehabilitation.



The EroScan's noise rejection algorithm is the most effective on the market – allowing for reliable testing in up to 70 dB of background noise.

Misconceptions about OAEs

Since it is labeled as a “hearing screening” procedure, some practitioners assume that the OAE results are hearing thresholds or indicate a precise degree of hearing loss. This is not the case. The OAE that we record is a very tiny acoustic signal that is generated by the activated outer hair cells of the inner ear. For example, if we were to try and duplicate the loudness level of these signals or emissions using the common screening audiometer, the level of the emissions would in many cases be close to 0 dB Hearing Level and in many cases would be below the 0 dB indicator on the audiometer. Therefore, there are many factors that can influence the test results such as ambient noise, ear canal noise generated by the patients own movements, depth of ear tip insertion from the test device probe, condition of the middle ear or debris in the ear canal itself. Anything that can affect the transmission of sound going in and/or coming back out of the inner ear will have an influence on our ability to measure an otoacoustic emission.

Fortunately, the technology that is incorporated into OAE test devices can overcome some of these obstacles. When the test probe is properly inserted into the patient’s ear canal, the precision and replication of the results is remarkable. Acoustic Engineers have devised ways for computer-like processors to reduce and eliminate the biggest obstacle – noise. Computer averaging algorithms allow us to measure those tiny sounds coming from the inner ear and we can therefore deduce the absence or presence of an acoustic emission. Since we do know that emissions are typically absent beginning with mild to moderate hearing losses, it gives us an excellent opportunity to intervene and come up with a strategy to further evaluate the patient and determine the nature of the hearing loss.

How can a physician utilize OAEs?

OAEs are the by-products of an active process that only occurs in a normal, healthy cochlea. Generally, healthy cochlea will be associated with normal hearing levels. Therefore, if the OAE response is absent, it can be assumed that there is a high risk for hearing loss (mild or worse) that would require additional testing. It should be noted that, in addition to a cochlear problem, OAEs are usually absent in the presence of middle ear pathology. Knowing that if OAEs are absent in a child suspected of having middle ear pathology, it is imperative that an otoscopic exam and/or a tympanogram be performed to rule out this possibility.

If middle ear pathology is confirmed, a repeat OAE can be administered after successful resolution of the middle ear problem to ensure normal cochlear function. Therefore, any time it is necessary to rule out a hearing loss as a contributing factor to speech and language delay (or any other condition), an OAE test can add a valuable piece of clinical data contributing towards an accurate diagnosis.

The Maico EroScan: no need for diagnostic interpretation. The equipment is automated to generate a quick Pass/Refer response

OAE testing is effective for physicians by providing:

- A technique to identify infants and young children at risk for hearing loss.
- An indirect method to assess middle ear function.
- The ability to immediately address parental concerns and rule out hearing loss without an audiologist referral.
- A tool to differentiate between organic and non-organic hearing loss.
- A tool to assess difficult-to-test subjects or those that cannot be tested by conventional means. For example, No response is required from the child. Pure tone audiometry requires a response e.g., raising a hand or dropping a block. Teaching a child is often time consuming and difficult.

Many individuals have been successfully trained to operate OAE devices. It does not take much time to learn the proper techniques necessary to perform a successful OAE test. Results are clearly displayed and are most often presented in a PASS or REFER format.

Most screening protocols test within the frequency range of 2 kHz-4 kHz. This represents frequencies most critical for normal speech and language development. Typically, OAEs are measured at three discrete frequency points (2 kHz, 3 kHz and 4 kHz). In order to PASS, OAEs must be present at each frequency point and be at least 5 dB above the background noise at all three frequencies.

How can you bill for OAEs and what is the reimbursement for the procedure?

Starting in 1996, the Current Procedural Terminology (CPT) codes allowed for full reimbursement for either TEOAE or DPOAE testing. To date health care reimbursement has varied in terms of cost of reimbursement, but no problems have been encountered if the appropriate codes are utilized. The CPT codes used for OAE testing are:

CPT Code #92587: Evoked otoacoustic emissions; limited (single stimulus level, either transient or distortion products). This is the most typical code utilized. This would be considered a screening code.
CPT Code #92588: Comprehensive or diagnostic evaluation (comparison of transient and/or distortion product otoacoustic emissions at multiple levels and frequencies. This is for diagnostic OAE testing. Requires diagnostic OAE equipment.

Reference: Current Procedural Terminology, CPT 2001, Professional Edition, American Medical Association, AMA Press. ISBN: 1-57947-108-0 (spiral notebook) or ISBN: 1-57947-109-9 (binder notebook).

In a recent survey among offices performing OAE testing, the average office charge for CPT Code #92587 ranged from $60.00 to $100.00. The typical insurance reimbursement for this procedure code ranges from $50.24 to $101.64. The typical office charge for CPT Code #92588 ranged from $70.00 to $120.00. The typical insurance reimbursement for this procedure ranged from $67.34 to $133.44.

In most facilities the average number of OAEs performed is 25 to 50 per month. Assuming an average of 30 OAEs were performed each month (using CPT Code #92587) and were reimbursed at the national average rate of $62.00 per test, the reimbursement would amount to $1,860.00 per month and $22,320.00 per year. The equipment would easily pay for itself in 2 to 4 months time. Remember this is only an estimate with most facilities performing well over 30 OAE tests per month.

In addition to utilizing the correct CPT Code it is important to use the correct diagnosis codes in conjunction with the testing. The following diagnosis codes are provided.

Internal Medicine/General Practice Uses

- Infant or pediatric screening and/or diagnostic testing
- Differentiate cochlear versus retrocochlear pathology
- Rule out malingering or non-pathological hearing loss
- Meniere's Disease (MD) or Endolymphatic Hydrops (EH)
- Autoimmune or sudden hearing loss
- Monitor ototoxicity of the cochlea (outer hair cells)
- Cochlear hearing screening in non-cooperative patients or in patients where behavioral testing cannot be performed
- Detection of early signs of noise exposure in musicians or those exposed to high noise levels
- Detect late-onset hearing loss
- Confirm functioning versus non-functioning PE tubes

Common Diagnostic Codes

39.39 SPEECH DISORDER, DELAYED DEVELOPMENT
351.0 BELL'S PALSY
40.40 CERUMEN IMPACTION
381.0 OTITIS MEDIA, WITH EFFUSION
381.02 OTITIS MEDIA, SEROMUCINOUS
3.03 OTITIS MEDIA, HEMORRHAGIC
3.04 OTITIS MEDIA, SEROUS
3.05 OTITIS MEDIA, MUCOID
3.06 OTITIS MEDIA, ACUTE, ALLERIC HEMORRHAGIC
81.81 UNSPECIFIED EUSTACHIAN TUBE DISORDER
1.01 OTITIS MEDIA, WITH TM RUPTURE
385.23 OSSICLES, DISCONTINUITY/DISLOCATION
20.20 PERFORATION, UNSPECIFIED
20.21 PERFORATION, CENTRAL
20.22 PERFORATION, ATTIC
20.23 PERFORATION, MARGINAL, OTHER
20.24 PERFORATION, MULTIPLE
20.25 PERFORATION, TOTAL
386 VERTIGINOUS SYNDROMES AND OTHER DISORDERS OF VESTIBULAR SYSTEM
386.0 MENIERE'S DISEASE
386.01 ACTIVE MENIERE'S DISEASE, COCHLEOVESTIBULAR
386.02 ACTIVE MENIERE'S DISEASE, COCHLEAR
386.03 ACTIVE MENIERE'S DISEASE, VESTIBULAR
386.04 INACTIVE MENIERE'S DISEASE
386.11 BENIGN PAROXYSMAL POSITIONAL VERTIGO
386.12 VESTIBULAR NEURONITIS
386.19 OTHER PERIPHERAL VERTIGO
387.0 OTOSCLEROSIS, OVAL WINDOW, NONOBLITERATIVE
10.10 OTOSCLEROSIS, OBLITERATIVE
387.90 OTOSCLEROSIS, UNSPECIFIED
1.01 PRESBYACUSIS
1.02 TRANSIENT ISCHEMIC DEAFNESS

388.1 NOISE EFFECTS ON INNER EAR
388.11 ACOUSTIC TRAUMA (EXPOSIVE) TO EAR
388.12 NOISE-INDUCED HEARING LOSS
388.2 SUDDEN HEARING LOSS, UNSPECIFIED
388.3 TINNITUS, UNSPECIFIED
388.4 OTHER ABNORMAL AUDITORY PERCEPTION
40.40 ABNORMAL AUDITORY PERCEPTION
40.41 DIPLACUSIS
40.42 HYPERACUSIS
40.43 IMPAIRMENT OF AUDITORY DISCRIMINATION
40.44 AUDITORY RECRUITMENT
5.5 DISORDERS OF ACOUSTIC NERVE
389 HEARING LOSS
389.1 SENSORINEURAL HEARING LOSS
10.10 SENSORINEURAL HEARING LOSS, UNSPECIFIED
10.11 SENSORY HEARING LOSS
10.12 NEURAL HEARING LOSS
14.14 CENTRAL HEARING LOSS
18.18 SENSORINEURAL HEAIRNG LOSS, COMBINED TYPES
2.2 MIXED CONDUCTIVE AND SENSORINEURAL
7.7 DEAF MUTISM

In addition, the following codes may be utilized, especially for newborn or infant hearing screening.

V41.2 PROBLEMS WITH HEARING
V71.0 OBSERVATION AND EVALUATION FOR SUSPECTED CONDITIONS NOT FOUND
V72.1 EXAMINATIN OF EARS AND HEARING
V80.3 EAR DISEASES
V82.9 UNSPECIFIED CONDITION

Reference: International Classification of Diseases, 9th Revision, Clinical Modification, ICD-9-CM 2001, Volumes 1 and 2, American Medical Association, AMA Press. ISBN: 1-57947-150-1

Conclusion

Since 1995, OAE testing has become a vital and important test procedure. Across a wide variety of health care specialties and facilities (audiology, otology, pediatrics, speech pathology, educational) this test procedure has added a tremendous amount of diagnostic information to our battery of audiological tests. The information derived from OAE testing provides site-specific information regarding the cochlear or inner ear integrity and to some degree middle ear status.

The importance of assessing hearing in a timely, noninvasive, cost effective manner using OAE testing has provided all health professionals with a method of appropriately assessing hearing in their own clinical setting. We are now able to screen and assess more individuals due to the availability of this technology, which in return, has allowed for the identification of more individuals with hearing loss and for better diagnosis.

It is my experience in using OAEs, both as a newborn infant hearing screening and diagnostic method, in a busy audiology and otology setting, that OAEs are a tremendous asset. Furthermore, I have used OAEs in pediatric settings and have found it to be a fast, reliable, accurate and cost effective method of testing. This single method of testing has truly revolutionized hearing screening and our ability to assess and screen cochlear function. The ability for the pediatric community to utilize this testing modality I feel is important and a very necessary component in the overall ability for the early identification of hearing loss. Furthermore, it ensures those individuals that need further diagnostic testing are identified and subsequently referred to their appropriate specialist.

Additionally, I would like to state the decision of which type of OAEs (Transient or Distortion Product) is very important. The difference between the two is that Distortion Product OAEs are frequency specific and will closely approximate pure tone audiometric test results. In theory OAEs will provide earlier information regarding cochlear function than behavioral test results. The preferred OAEs modality used in most clinical facilities is currently Distortion Product Otoacoustic Emissions (DPOAEs) due to this frequency specificity.

Finally, if utilized appropriately, this equipment will become a vital test modality which will provide you with information typically not accessible within your office. OAE testing has become a recognized, standardized, reliable and valid test option especially for the pediatric population in the area of hearing screening and sensitivity.

Risk Factors for Late Onset Hearing Loss

The JCIH recommends the following indicators for use with neonates or infants (29 days through two years). These indicators place an infant at risk for progressive or delayed-onset sensorineural hearing loss and/or conductive hearing loss. Any infant with these risk indicators for progressive or delayed-onset hearing loss who has passed the birth screen should, nonetheless, receive audiologic monitoring every six months until age three. These indicators are:

1. Parental or caregiver concern regarding hearing, speech, language, and/or developmental delay.
2. Family history of permanent childhood hearing loss.
3. Stigmata or other findings associated with a syndrome known to include a sensorineural or conductive hearing loss or Eustachian tube dysfunction
4. Postnatal infectious associated with sensorineural hearing loss including bacterial meningitis.
5. In-utero infections such as cytomegalovirus, herpes, rubella, syphilis, and toxoplasmosis.
6. Neonatal indicators – specifically hyperbilirubinemia at a serum level requiring exchange transfusion, persistent pulmonary hypertension of the newborn associated with mechanical ventilation and conditions requiring the use of extracorporeal membrane oxygenation (ECMO).

Additional Resources

The Deafness Research Foundation & National Campaign
for Hearing Health
1050 17th Street NW, Suite 701, Washington, DC 20036
(202) 289-5850 www.hearinghealth.net

National Institute on Deafness and Other Communication Disorders
31 Center Drive, Bethesda, MD 20892
(800) 241-1044 www.nidcd.nih.giv

Beginnings for Parents of Children Who Are Deaf *or*
Hard of Hearing, Inc.
P.O. Box 17646, Raleigh, NC 27619
(919) 850-2746 www.ncbegin.com

National Association of the Deaf
814 Thayer Avenue, Silver Spring, MD 20910
(301) 587-1788 www.nad.org

American Speech-Language-Hearing Association (ASHA)
10801 Rockville Pike, Rockville, MD 20852
(800) 638-8255 www.asha.org

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