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

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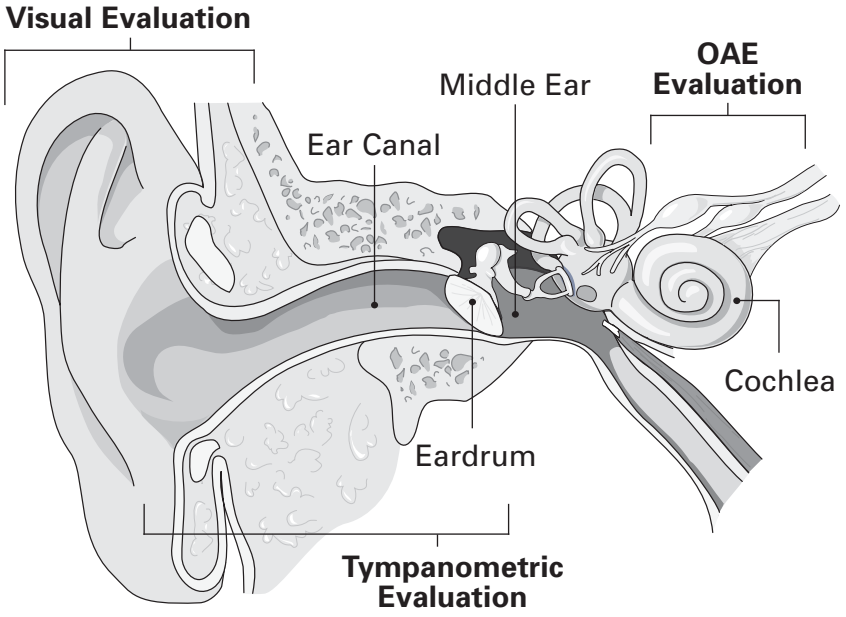
Introduction

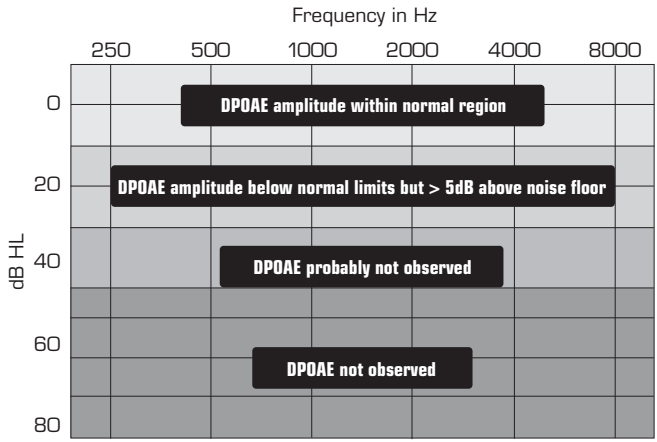
In 1978, Dr. David Kemp first showed that the cochlea (inner ear hearing organ) was capable of producing, as well as receiving, sounds. These sounds produced by the cochlea are now known as “evoked otoacoustic emissions.”

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 have a unique property of motility, which 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 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.

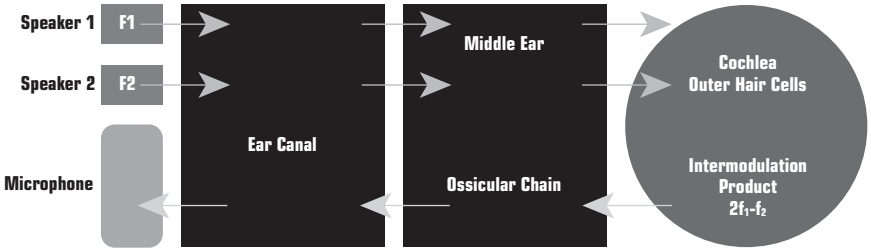
There are two types of otoacoustic emissions tests which are used clinically. These are:

1. **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 4,000 Hz range. They typically do not occur when hearing loss is about 30 dB_{HL} or greater.

2. **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 may be recorded in individuals with a greater degree of hearing loss at higher frequencies. DPOAEs are typically measured in the frequency range of 750 to 6,000 Hz although many OAE devices are capable of measuring at higher frequencies.

How are Otoacoustic Emissions (OAEs) Measured?

The test procedure typically takes less than 2 minutes for both ears. It is non-invasive 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 or tones, to the ear through a probe



Pathway of DPOAE transmission.

that is 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. A special test room is not needed to conduct OAE testing although a quiet environment is preferred.

OAE questions and additional information are available by referencing our website: **www.maico-diagnostics.com**. You can also contact the authorized Maico Special Instrument Dealer in your state.

What do OAE test results mean?

The production of OAEs by the cochlea, specifically by the outer hair cells, 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.

Most screening protocols test within the frequency range of 2 kHz to 5 kHz. Typically, screening OAEs are measured at four discrete frequency points (2 kHz, 3 kHz, 4 kHz and 5 kHz). In order to PASS, OAEs must be present and be at least 5 dB above the background noise at 3 out of 4 frequencies.

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

Considerations for OAEs

Even though OAE testing is labeled as a “hearing screening” procedure, OAE test results are not hearing thresholds and do not indicate a precise degree of hearing loss.

There are also many factors that can influence the test results such as ambient noise, ear canal noise generated by the patient’s own movements, depth of eartip 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.

“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 may not present. The test result is "Refer," and the patient may be at risk for possible communication handicaps and can benefit from further diagnostic assessment and possible rehabilitation.

How can an ENT utilize OAEs?

OAEs are the by-products of an active process that only occurs in a normal, healthy cochlea. Generally, a healthy cochlea will be associated with normal hearing levels. Therefore, if the OAE response is absent, it can be assumed that there may be 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 patient 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 and will provide easy-to-read and easy-to-interpret results.

OAE testing is effective for ENTs by providing:

- A technique to identify outer hair cell function in the cochlea.
- An indirect method to assess middle ear function.
- A tool to help differentiate between organic and non-organic functional hearing loss.
- A tool to assess difficult-to-test subjects or those that cannot be tested by conventional means. This is an objective test, requiring no patient participation.

Doctors and office personnel alike can operate the Maico ERO•SCAN with ease. Results are clearly displayed and are presented in a PASS or REFER format.

When to refer to an audiologist

Referral to a pediatric audiologist is warranted when a child:

- Does not pass a follow-up OAE screening, and there is no evidence of temporary blockage or fluid in the middle ear.
- Is experiencing chronic otitis media that is not resolved in three months or less.
- Is consistently uncooperative across two or more visits and an OAE screening cannot be completed.
- Demonstrates hearing or language delays, or when parents are concerned about the child's development, even though the child passed the OAE screening.

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, and requires diagnostic OAE equipment.

Reference: Current Procedural Terminology, CPT 2007, Professional Edition, American Medical Association, AMA Press. ISBN: 1-57947-790-9 (spiral notebook) or ISSN: 0276-8273 (binder notebook).

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.

Uses for OAE Testing in ENT Practices

- Differentiate possible cochlear versus retrocochlear pathology
- Identify suspected malingering or non-pathological hearing loss
- Detect auto-immune or sudden hearing loss
- Monitor ototoxicity of the cochlea (outer hair cells)
- Provide objective cochlear hearing screening in both non-cooperative patients and cooperative patients where behavioral testing cannot be performed
- Detect early signs of noise exposure in musicians or those exposed to high noise levels
- Detect possible late-onset hearing loss in infants and toddlers
- Screen for early effects of Ischemia on the cochlea

Suggested codes commonly used by ENTs:

386.0 MENIERE'S DISEASE
388.01 PRESBYACUSIS
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
388.44 AUDITORY RECRUITMENT
388.5 DISORDERS OF ACOUSTIC NERVE
389 HEARING LOSS
389.1 SENSORINEURAL HEARING LOSS
389.10 SENSORINEURAL HEARING LOSS, UNSPECIFIED
389.11 SENSORY HEARING LOSS
389.12 NEURAL HEARING LOSS
389.9 UNSPECIFIED HEARING LOSS
(commonly used with children who have REFER OAE test results)
V72.1 EXAMINATION OF EARS AND HEARING
(commonly used with patients who have PASS OAE test results)

315.3 SPEECH DISORDER, DELAYED DEVELOPMENT
351.0 BELL'S PALSY
380.4 CERUMEN IMPACTION
381.0 OTITIS MEDIA, WITH EFFUSION
381.02 OTITIS MEDIA, SEROMUCINOUS
381.03 OTITIS MEDIA, ACUTE SANGIUNOUS
381.04 OTITIS MEDIA, SEROUS
381.05 OTITIS MEDIA, MUCOID
381.06 OTITIS MEDIA, ACUTE, ALLERIC SANGIUNOUS
381.81 DISFUNCTION OF EUSTACHIAN TUBE
384.20 PERFORATION, UNSPECIFIED
384.21 PERFORATION, CENTRAL
384.22 PERFORATION, ATTIC
384.23 PERFORATION, MARGINAL, OTHER
384.24 PERFORATION, MULTIPLE
384.25 PERFORATION, TOTAL
385.23 OSSICLES, DISCONTINUITY / DISLOCATION

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 AURAL VERTIGO
387.0 OTOSCLEROSIS, OVAL WINDOW, NONOBLITERATIVE
387.1 OTOSCLEROSIS, OBLITERATIVE
387.90 OTOSCLEROSIS, UNSPECIFIED
388.02 TRANSIENT ISCHEMIC DEAFNESS
388.3 TINNITUS, UNSPECIFIED
388.4 OTHER ABNORMAL AUDITORY PERCEPTION
388.41 DIPLACUSIS
388.42 HYPERACUSIS
388.43 IMPAIRMENT OF AUDITORY DISCRIMINATION
389.14 CENTRAL HEARING LOSS
389.18 SENSORINEURAL HEARING LOSS, COMBINED TYPES
389.2 MIXED CONDUCTIVE AND SENSORINEURAL
389.7 DEAF MUTISM
389.9 UNSPECIFIED HEARING LOSS

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 EXAMINATION OF EARS AND HEARING (commonly used with patients who have PASS OAE test results)
V80.3 EAR DISEASES (excludes general hearing examination)
V82.9 UNSPECIFIED CONDITION

Reference: International Classification of Diseases, 9th Revision, Clinical Modification, ICD-9-CM 2005, Volumes 1 and 2, American Medical Association, AMA Press. ISBN: 1-57947-575-2

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, non-invasive, cost effective manner using OAE testing has provided all health professionals with a method of appropriately assessing hearing in their own clinical setting. Clinicians 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 as well as more accurate diagnosis.

> By integrating OAE testing into your hearing screening protocol, you decrease the need for a “wait and see” approach.

When utilized appropriately, OAE test equipment becomes a vital test modality that provides information typically not otherwise accessible. OAE testing has become a recognized, standardized, reliable and valid test option in the area of hearing screening and diagnostic evaluation.

Risk Factors for Late Onset Hearing Loss in Children

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 infections 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).

Factors Which May Contribute to Hearing Loss

- Aging
- Auto-immune disorders
- Noise exposure or occupational issues
- Ototoxic agents
- Genetic abnormalities
- Functional or non-organic factors
- Syndrome sequelae

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