

# A Guide *to* Otoacoustic Emissions (OAEs) *for* School Nurses



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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.”

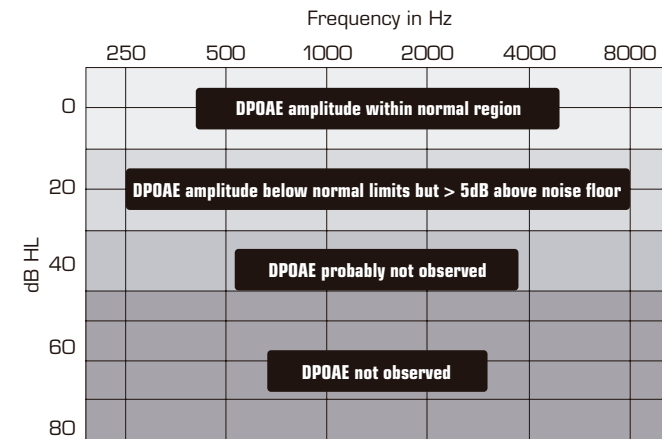
Since 1978, a tremendous amount of energy has gone into investigating otoacoustic emissions (OAEs). There are numerous research articles published on OAEs and related clinical topics. In 1995 a variety of FDA-approved otoacoustic emission devices were available for clinical applications. Since 1995 the 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 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.

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.



*Relationship between audiogram and DPOAE pure sensory hearing loss.*

There are three types of otoacoustic emissions. These are:

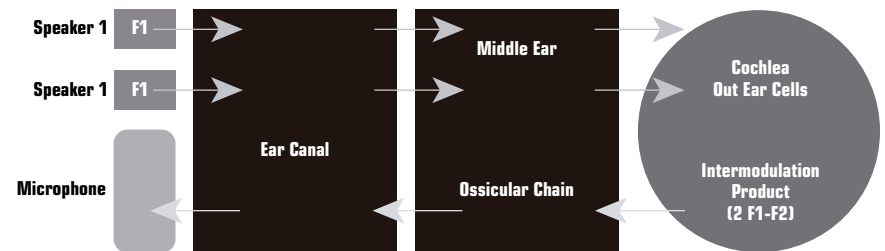
- 1. Spontaneous (SOAEs):** These are recorded without any presentation of a stimulus and are not typically of any clinical use. They occur in about 35 to 50% of normal hearing ears.
- 2. Transient (TEOAEs):** These are evoked responses from stimulating the cochlea with a transient signal such as a click 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.

“We have been using the Maico Ero-Scan for more than a year to perform hearing screenings on 3, 4 and 5 year olds in our Southwest Florida community. The Ero-Scan is both user friendly and kid friendly – even when children have ‘tubes’ in their ears, and regardless of the child’s ability or language. Since hearing is such an important part of language development, use of the Ero-Scan helps us to help our children be ready to read and socialize when they enter kindergarten.”

—Shirley Losch, RN, BS, NCSN  
Health Coordinator Child Care of Southwest Florida

## 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

Oftentimes non-audiology health professionals are confused about the outcomes of the OAE test. Since it is labeled as a "hearing screening" procedure, laypeople assume that the 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 patient's 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 School Nurse or Head Start Program 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, then 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 an effective tool for the nurse in the following ways:

- As a method to identify infants and young children at risk for hearing loss
- As an indirect method to assess middle ear function
- As a tool to monitor cochlear function in subjects who have or are taking medication that is potentially ototoxic.
- As a tool to differentiate between organic and non-organic hearing loss.
- As 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 to 4 kHz. This represents the critical “speech” frequency range. 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. This is the PASS/REFER criterion I recommend and that is supported by most research studies. I do not recommend any PASS/REFER criteria that require less than three out of three frequencies to PASS (e.g. two out of three).

## 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.

In addition, it may be possible to obtain grants at the state and national levels that address early intervention.

### **Hearing Screening Success Story**

A young girl was screened at a Fort Myers Pre-School and received a hearing referral. Her mother had difficulty accepting that her child had a hearing problem but reluctantly followed up with her pediatrician. During the exam, the doctor discovered that the child had a severe inner ear infection that, left unchecked, could have gone unnoticed indefinitely. Since the child had not experienced any ear discomfort or pain, the initial screening was the only thing that prevented compromised hearing.

*—Lee County School Readiness Coalition, Lee County, FL*

## 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.

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

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 a large school based hearing screening program and have found it to be a fast, reliable, accurate and cost effective method of testing. This single method of testing has truly revolutionized audiology and our ability to assess and screen cochlear function. The ability for the educational (school) 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 family physician or audiologist.

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.

## Additional Resources

### **The Deafness Research Foundation & National Campaign for Hearing Health**

1050 17<sup>th</sup> Street NW, Suite 701, Washington, DC 20036  
(202) 289-5850 [www.hearinghealth.net](http://www.hearinghealth.net)

### **National Institute on Deafness and Other Communication Disorders (NIDCD)**

31 Center Drive, Bethesda, MD 20892  
(800) 241-1044 [www.nidcd.nih.gov](http://www.nidcd.nih.gov)

### **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](http://www.ncbegin.com)

### **National Association of the Deaf**

814 Thayer Avenue, Silver Spring, MD 20910  
(301) 587-1788 [www.nad.org](http://www.nad.org)

### **American Speech-Language-Hearing Association (ASHA)**

10801 Rockville Pike, Rockville, MD 20852  
(800) 638-8255 [www.asha.org](http://www.asha.org)

### **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).

## Sample Referral Letter

*Please feel free to use this letter when referring a child to a doctor.*

Dear Doctor,

I am referring \_\_\_\_\_ for further evaluation because he/she failed our hearing screening procedure in our school. We are using a new technique for hearing screening called “Evoked Otoacoustic Emissions.” This new technology provides us with a means to quickly and objectively screen a child’s hearing as while it records a physiological response directly from the cochlea. This frequency’s specific recorded response from the cochlea has a direct correlation to the health of the outer hair cells that are responsible for us to hear low amplitude sounds.

For example, a “Refer” recording with OAE equipment typically means one of two things. Either

- The child as a potential sensory neural hearing loss – or
- The child has a form of middle ear disease that affects our ability to record response from the inner ear

In contrast, a “Pass” recording is obtained only when the outer hair cells of the cochlea are healthy and the middle ear system is functioning normally. Generally speaking, a child’s peripheral hearing system has to be normal or within a normal range to pass this hearing exam.

As in the past, our protocols for referring a child are not based on a single hearing test, but on an initial screening that is followed up with a second screening. This process is put in place to ensure that the lowest possible “false positive” referral rate. If you have any further questions, please feel free to contact me.

Sincerely,

School Nurse



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