About Otoacoustic Emissions

What are Otoacoustic Emissions?
Otoacoustic emissions (OAEs) are sounds measurable in the ear canal of normal, healthy ears, and are produced by the outer hair cell activity in the cochlear. These sounds are small, but potentially audible, sometimes amounting to as much as 30 dB SPL.

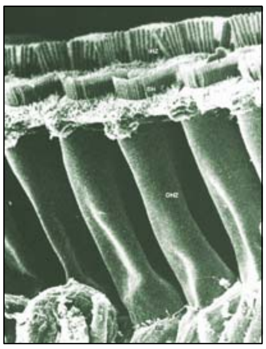
It is important to note that otoacoustic emissions do not contribute to hearing, but are *by-products* of the active process in the cochlea, in which motility of the outer hair cells tunes the basilar membrane and amplifies weak sounds.

OAEs are clinically significant in that they provide information about the integrity of the cochlear and outer hair cell function.

History
The discovery of OAEs has been attributed to the work of Kemp in the late 1970's. He used a simple microphone coupled to the external ear and recorded sounds present in the ear canal after the presentation of click stimuli. The discovery of OAEs by Kemp was anticipated by both Gold in the late 1940s and Békésy in the early 1950s.

OAE has since become a clinically useful tool, especially in paediatric assessment and neonatal hearing screening.

Pathways
The OAE pathway is similar to that of the normal progression of sound through the ear to the cochlear. In the normal hearing ear the stimulus travels through to the cochlear and activates the outer hair cells. This activity produces movement (or sound) that travels back out to the ear canal via the middle ear chain and ear drum and is then measured as OAEs. That is, OAEs are created by the motion of the eardrum driven by vibrations in the cochlea.

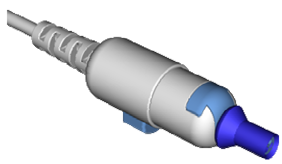


Outer hair cells - movement of these genrates OAEs

Consequently, OAEs can be detected only when the middle ear is operating normally. OAEs are generated only when the Organ of Corti is in normal or in near normal condition. They can emerge spontaneously, but more commonly follow acoustic stimulation

While OAE indicates normal cochlear mechanics, it provides no information about the retrocochlear processes or function.

Recording OAEs
Recording OAEs requires that a sensitive, low noise microphone be sealed in the external ear canal. Recording of emissions elicited by an acoustic stimulus also requires that there be one or two speakers to deliver the stimuli. The microphone records the sound present in the external ear canal. The type of signal analysis employed depends on the type of emissions to be recorded but aims at extracting the low level OAE from the background noise.



A lightweight probe for recording OAE in infants. It contains a tiny microphone and speaker.

Types of OAEs
There are two types or categories of OAE; spontaneous otoacoustic emissions (SOAE) and evoked otoacoustic emissions (EOAE).

Spontaneous otoacoustic emissions (SOAE)
SOAE are low level, tonal signals measured in the ear canal in the absence of any known stimulus, and are usually inaudible to the persons form whose ears they are detected.

SOAEs are of limited use clinically because they are not measurable in all ears, and appear at discrete and unpredictable frequencies. However the presence of an SOAE indicates hearing within normal limits near the frequency at which it appears, and may in addition influence behavioural testing as well as measurements of other types of OAEs.

Evoked otoacoustic emissions can be broken down into 2 types that are used clinically; Transient-evoked otoacoustic emissions and Distortion Product Otoacoustic Emissions.

Transient-evoked otoacoustic emissions (TEOAEs)
TEOAEs are elicited by the presentation of a brief stimulus such as clicks or tone bursts to the ear. They can be recorded in nearly all persons with normal hearing. When a click is used to elicit the response, the resultant waveform is, like a fingerprint, idiosyncratic.

TEOAEs are highly non-linear. Their pattern of growth is consistent with the operation of the cochlear amplifier, which provides most gain for low level inputs, and lends support to the notion that OAEs arise from outer hair cell activity.

TEOAEs do not correlate with behavioural audiometric thresholds. Thus it is not possible to predict hearing thresholds based on TEOAE thresholds. However, since the presence of TEOAEs correlates strongly with normal hearing, the most common clinical application involves click stimulation at moderate intensity levels for the purpose of hearing screening or differential diagnosis.

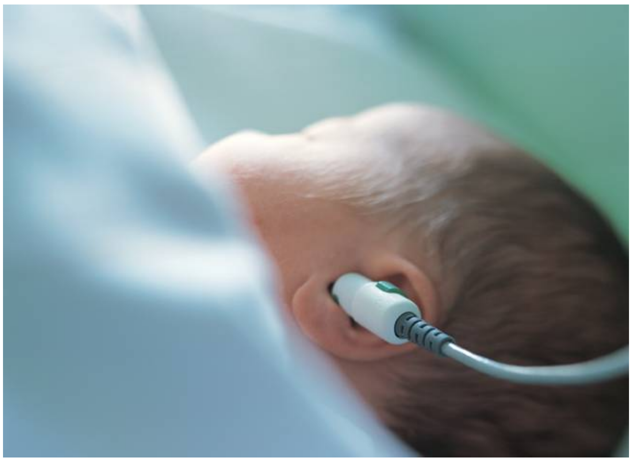
Distortion Product Otoacoustic Emissions (DPOAE)
DPOAEs are tones produced by the ear in response to two simultaneous pure-tone stimuli known as primary tones. The OAE is the resultant “distortion” occurring along the basilar membrane produced by the primary tones.

The distortions are described mathematically and the most common distortion product measured is at the frequency described by 2f1-f2. The cochlea also produces distortion products at other frequencies however the 2f1-f2 is the strongest, and is the only one utilised for clinical purposes at present.

The primary tones of the stimuli are called f1, representing the lower frequency pure-tone and f2 representing the higher frequency tone.

Uses of OAE’s
The primary clinical applications of OAE are for the identification of hearing loss and differential diagnosis.

Identification of hearing loss
The presence of TEOAEs indicates hearing threshold levels better than 30dBHL, and correlates best with good hearing in the mid-frequency range. It is not possible to rely on the TEOAE spectrum to predict threshold levels by frequency. TEOAEs are well suited and widely accepted for the purpose of screening hearing.



TEOAEs tend to be about 10 dB greater in newborns, thus providing a simple and fast way to screen for hearing impairment..

It has been hoped that DPOAEs would allow clinicians to predict behavioural thresholds, but this is not yet the case. However, there is correspondence between DP-gram configurations and audiogram configurations (i.e. in ears with sensory hearing loss, DPOAEs are reduced or eliminated only for the stimulus frequency regions coincident with the impaired region). Thus DPOAEs can give a better frequency specific impression of cochlear integrity than TEOAEs, and are well suited to monitoring of cochlear function.

Differential diagnosis
While OAEs have not proven good predictors of retro-cochlear disorders, they do provide the opportunity to document normal or near-normal cochlear function. This makes them useful in pinpointing site of lesion, as well as in making management decisions.

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