

Otoacoustic emissions in the diagnostic test battery for hearing loss

BY BETH PRIEVE

So, they are great for screening, but how can otoacoustic emissions be integrated into the diagnostic test battery? **Beth Prieve** examines the role of diagnostic OAEs by asking three simple questions.

Audiologists and otolaryngologists are familiar with otoacoustic emissions (OAEs) as a newborn hearing screening tool because they have been widely used in screening programmes for more than two decades. Otoacoustic emissions are equally important for the differential diagnosis of hearing loss, but are used less often in that capacity. Although some clinicians might include them in a diagnostic test battery, they tend to apply them in a 'screening' mode, rather than a diagnostic mode. Why and how can they be used for diagnosis of hearing loss? Here are three things to remember:

1. Why are they essential for differential diagnosis of hearing loss?

Otoacoustic emissions are sounds that are generated in the cochlea, travel reversely out of the cochlea, through the middle ear and into the ear canal, where they can be measured with a miniature microphone. Otoacoustic emissions are a by-product of the mechanical transduction process in the cochlea and are linked to outer hair cell function in mammals. During the transduction process, the mechanical enhancement occurs prior to the response of the inner hair cell and firing of the auditory nerve. The unique origin for

otoacoustic emissions allows separation of cochlear mechanical issues from inner hair cell and neural pathologies. For example, if air- and bone-conduction thresholds on an audiogram are within 10 dB of each other, indicating a sensorineural hearing loss, and there are no measurable OAEs, a clinician can assume that the problem causing the hearing loss involves impaired outer hair cells. However, if an individual has a sensorineural hearing loss and OAEs with normal levels, we can conclude that the outer hair cells are fine, and the hearing loss could be at the level of the inner hair cell, auditory nerve fibre, brainstem or cortical pathways.

2. What type of OAEs do we use for diagnosis of hearing loss?

Transient-evoked OAEs (TEOAEs) and distortion product OAEs (DPOAEs) can both be used in diagnostic protocols. These two types of OAEs detect hearing thresholds of >20 dB HL with similar accuracy, although there are some slight differences. TEOAEs identify hearing loss better at 1000 Hz and 2000 Hz than DPOAEs, but DPOAEs detect hearing loss with greater accuracy at 4000 Hz. In addition, TEOAEs are not measured clinically above 4000 or 6000 Hz because of limitations due to stimulus artifact. DPOAEs can be measured to higher frequencies such as 8000 Hz [1]. New research could change these limitations, as TEOAEs can be measured to higher frequencies using stimulus cancelling techniques [2], and DPOAEs can be improved using better calibration techniques [3], allowing both types to be recorded at frequencies higher than 8000 Hz.

3. How do we use OAEs in a diagnostic test battery for hearing loss?

The protocol for measuring and interpreting OAEs is different for diagnosis of hearing

loss than it is for screening for hearing loss. In screening mode, TEOAEs and DPOAEs are interpreted over a limited frequency range, usually from 2000-4000 Hz, and a determination is made whether the OAE level is higher than the noise level (signal-to-noise ratio, or SNR). A SNR criterion is chosen (for example, 6 dB) and the ear is said to 'pass' or 'refer' if the SNR criterion is met over the frequency range. For screening, each ear is considered a 'pass' or 'refer', and ultimately, the individual is considered to have 'passed' or 'referred from' the screening.

Otoacoustic emission testing protocol and interpretation is different when used in the diagnostic test battery. Either TEOAE and/or DPOAE can be used, but measurements are made over a wider range of frequencies and the response at each frequency is assessed and compared to other test battery results. TEOAEs are measured from 1000 to 4000-6000 Hz and DPOAEs are measured from 750 to 8000 Hz. Here is a checklist to use for interpretation of DPOAEs.

1. Is the test valid?
 - a. Is the noise floor within normal limits?
 - b. Is the stimulus stable throughout the test?

If the answer to one or both of these is 'no', then the test should be repeated. If the answer is yes, then the DPOAE can be interpreted and you can proceed to question 2.

2. Is the DPOAE measurable at each frequency?
 - a. For each frequency, determine if the DPOAE level is higher than the noise floor, which means it has a positive SNR. A typical criteria is 6 dB. For every frequency at which the SNR is <6 dB, the DPOAE is considered 'absent'. At frequencies for which SNR ≥ 6 dB, the DPOAE is considered 'present'.

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b. For 'present' DPOAEs, it must then be determined whether the level is 'normal' or 'abnormally low'. For this, you need normative data across a range of frequencies. One of the best templates of normative DPOAE levels was pioneered by Gorga and his colleagues [4,5]. It was first constructed in 1997 from over 1200 ears across the ages of 1-97 years, and was confirmed in 2005 in over 200 ears. It displays whether DPOAEs have normal levels based on distributions from ears with and without hearing loss. Some OAE instruments incorporate 'normative' ranges based on young, normally hearing ears. If DPOAEs are 'present' and have levels within or higher than the normative range, the DPOAEs are present with normal levels. If DPOAEs have an SNR ≥ 6 dB, but have levels lower than the normative range, they are considered to be 'present' with abnormally low levels.

Transient-evoked OAE interpretation is the same as for DPOAEs, except that step 2b is not done. There are not normative levels for TEOAEs at this time. Reporting OAEs is done for each frequency in both ears,

and incorporated into the test battery that provide impressions of whether there is a mechanical component contributing to hearing loss.

Future directions

TEOAEs and DPOAEs measurements are being refined and better linked to mechanical transduction processes in the cochlea. TEOAEs represent a 'reflection-type OAE', and specially processed DPOAEs can measure a 'distortion-type' OAEs [6,7]. These types of OAE used together may enhance our ability to diagnose hearing loss, point to susceptibility to hearing loss from noise or ototoxic agents, or provide other important clues to general health.

References

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