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Welcome to the new PATH MEDICAL NEWSLETTER. This publication is intended to highlight features of our products, tips on best practices, and how-to's. We hope that you find the information valuable and would love to have your feedback and suggestions for topics. Please write to us at academy@pathme.de.

Multi-Frequency Technology for Acoustic Reflexes by PATH MEDICAL GmbH

Tympanometry is a widely used objective method to assess the middle ear status. The main function of the middle ear is to transfer the sound from air conduction in the ear canal to fluid conduction in the inner ear. Because of the impedance mismatch between air in the ear canal and fluid in the inner ear, energy is lost. To deal with the different acoustic impedances, the middle ear is designed to overcome much of the energy loss. The largest contributor to this is the area of the ear drum that is much bigger than that of the stapes footplate. Another role of the middle ear is to provide some protective mechanisms for the inner ear, including friction of ossicle joints and the acoustic reflex.

The basic idea of tympanometry is to measure the admittance or ease of energy flow into the middle ear as a function of changing air pressure. The probe that is snuggly placed into the ear canal via a probe tip contains both a speaker and a microphone and is connected to a pump that provides the pressure changes. Traditionally, a 226 Hz tone is used as a "probe tone" which is presented to the ear and the reflected sound is recorded with a microphone. It is a known fact that in certain middle ears, probe tone frequencies other than 226 Hz provide better information. Multi-frequency Tympanometry and wide band tympanometry have therefore been proposed to record tympanograms at more than one probe tone frequency simultaneously. The PATH MEDICAL devices offer the option of conducting tympanometry using four probe tone frequencies (226, 678, 800 and 1000 Hz) simultaneously.

The acoustic reflex is the activity of the stapedius muscle and/or tensor tympani muscle of the middle ear, triggered by an auditory stimulus. The muscles apply force to the ossicle chain which stiffens middle ear mechanics, much like the changing pressure in tympanometry does. It can therefore be measured with a similar setup as tympanometry, which is why both are often combined in one instrument.

To record an acoustic reflex, an acoustic stimulus is presented to the ear in addition to the probe tone either ipsilateral or contralateral which triggers the stapedius muscle of the middle ear, while an admittance trace is recorded. The stimulus can also be provided electrically by a cochlea implant. Like tympanometry, the use of other probe tone frequencies than 226 Hz can help detect the reflex in certain middle ears.

Since the sound level changes due to the reflex, as recorded by the probe microphone, is small, detecting the acoustic reflex is somewhat sensitive to artifacts. This includes both acoustic noise and test setup related effects, such as probe movement during recording. The use of more than one frequency to detect the reflex simultaneously should help making detection of the acoustic reflex more robust against artifacts. PATH MEDICAL devices therefore provide the option of a multi-frequency approach to the acoustic reflex.

Like almost any mechanical system, the middle ear moving part has mass, compliance, and resistance. This means it can only work perfectly at one frequency, usually referred to as the middle ear resonance. Its resonance frequency typically is at about 1 kHz. The acoustic reflex stiffens the middle ear mechanics, which also means it reduces its admittance and therefore moves its resonance frequency up.

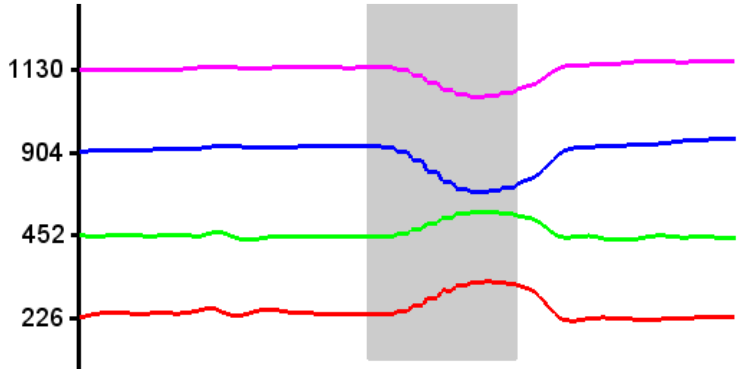

Figure 1. *Acoustic reflexes obtained at different probe tone frequencies plotting the equivalent ear canal volume changes with decrease in equivalent ear canal volume plotted upward and increase in equivalent ear canal volume plotted downward. The gray shaded area indicates the stimulus period.*

The traditional probe tone frequency of 226 Hz will almost always be lower than the middle ear resonance frequency. Below resonance, the middle ear impedance acts as a spring, which means an added stiffness would reduce its admittance. This is what acoustic reflex testing observes. If plotted as an equivalent air volume, it will decrease (plotted

upward) during the reflex as shown in the red and green tracing in Figure 1. However, if the probe tone frequency is higher than the middle ear resonance, the effect can be reversed, which means the recorded admittance (or equivalent air volume) can increase (plotted downward) during the reflex period as can be seen in the blue and pink tracings in Figure 1.

For certain middle ears, other probe tone frequencies than the standard 226 Hz may be more effective to use. The multi-frequency approach allows doing so within one measurement, and responses can be compared directly under exactly equal conditions. Combining data from multiple frequencies can also help perform reflex tests closer to threshold.

PATH MEDICAL experience with multi-frequency acoustic reflex recording indicates that it improves traditional acoustic reflex testing in several aspects:

- It allows testing atypical middle ears without the need to search for an alternative probe tone frequency manually
- It provides more robustness against artifacts, such as external noise or subject related artifacts by aligning responses of the different probe frequencies
- Internal studies indicate that more reliable responses can be recorded closer to threshold by combining traces
- Since no additional test time is needed, the additional information comes at no "cost" (i.e., even if only the standard 226 Hz response is finally used for any reason, no extra test time has been spent)

Literature

1. Kandzia, F. An optimized protocol for acoustic impedance measurements: „Simultaneous multi component multi frequency tympanometry" DGA Tagungs-CD 2015
2. Margolis, R. H.; Saly, G. L. & Keefe, D. H. Wideband reflectance tympanometry in normal adults The Journal of the Acoustical Society of America, ASA, 1999, 106, 265-280
3. Peake WT, Rosowski JJ. (1997). Acoustic properties of the middle ear. In: MJ Crocker (Eds.) Encyclopedia of Acoustics. (pp. 1337-1346) New York: Wiley