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Best Practice #2

Verifying Open Canal Hearing Instruments with AVS

Why is AVS good for verifying Open Canal Hearing Instrument?

The reference microphone of the Aurical Visible Speech unit does not adjust the output from the speakers therefore; the leakage from the open canal hearing instrument does not affect the ability to collect accurate response curves. The reference microphone measures the level presented on the VU meter, and the VU meter is used to determine the stimulus output. However; leakage from the open canal hearing instrument affects the VU meter none to minimally.

What is an Open Canal Hearing Instrument?

An open canal hearing instrument is a device that provides amplification with minimal occlusion of the patient's ear canal. Most open canal hearing instruments fit hearing losses of no worse than 30 to 50dB HL at 500 Hz or lower and 65dB in the high frequencies, making them ideal for patients with a mild to moderate sloping hearing loss. Different hearing instrument manufacturers have different criteria for the maximum hearing loss that can be fit. Also, keep in mind that as feedback suppression improves these criteria may be expanded. The open canal hearing instrument can be coupled to a slim tube and "airdome" or tulip tip, #13 tubing with a custom earmold (with a large vent or an open style), or a bored out earmold like the GN Resound FlexVent. The purpose of the open canal fitting is to leave the ear canal unoccluded which will result in more comfort for the patient. The patient will have fewer complaints regarding the quality of his/her voice and the feeling of his/her ears being "plugged up". They will also have a more natural experience during swallowing and chewing.

What is the function of an Open Canal Hearing Instrument?

Open canal hearing instruments are designed for individuals with minimal to no low frequency hearing loss. Low frequencies are allowed to leak out of the ear. Depending on the type of feedback suppression built into the hearing instrument, these instruments can have quite a bit of gain for the high frequencies. A hearing instrument with a gain reduction type of feedback suppression will usually have less overall headroom than a hearing instrument with a phase cancellation type of feedback suppression. If the hearing instrument is set to the maximum gain, there can be some high frequency leakage as well due to the openness of the ear canal.

Effects of Leakage on Real Ear Measurement

1. **Effect of Leakage on Traditional Real Ear Measurements (Aurical REM)**
   With traditional real ear measurements, the reference microphone monitors the intensity of the speaker output and makes adjustments accordingly. The leakage from the open canal hearing instrument picked up by the reference microphone causes the REM system to reduce the output of the speakers[1]. Because the output is reduced by the REM system, the results obtained are likely to fall short of the desired targets. The audiologist then increases the gain in order to meet the target and by doing so, improperly fits the patient. Most manufacturers have modified their REM systems to include an OpenREM method that calibrates the output of the speakers using the reference microphone, stores the calibration, and then disables the reference microphone during collection of real ear data. (Note: OpenREM is implemented in Aurical software version 2.50 and later.)

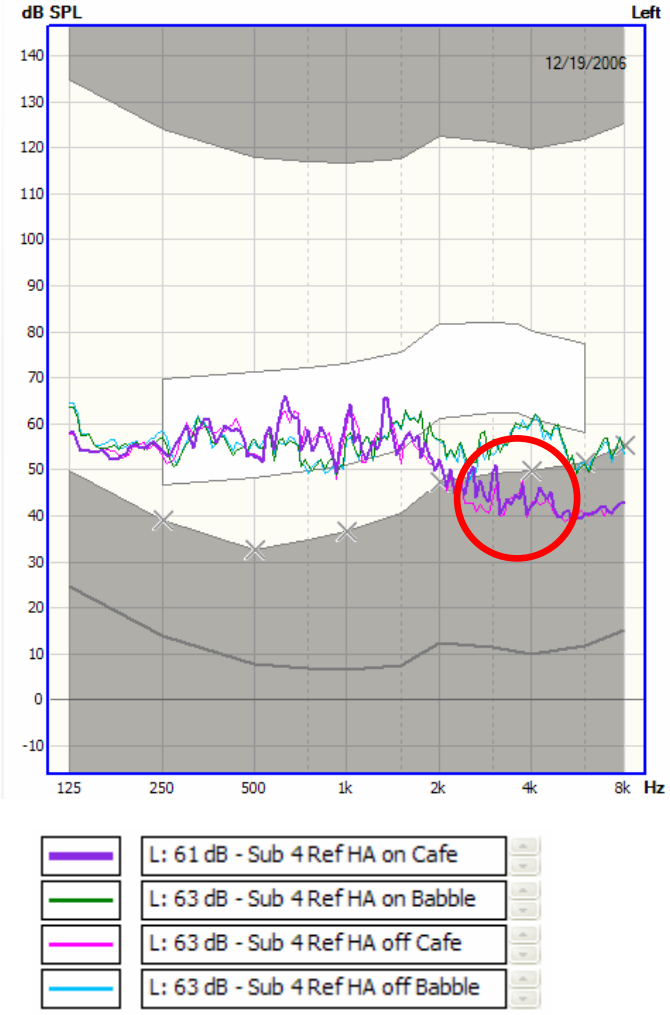
2. **Effect of Leakage on the Aurical Visible Speech**
   The Aurical Visible Speech reference microphone, unlike the Aurical REM, does not make adjustments to the output of the speakers. Instead, the input to the reference microphone adjusts the level presented on the VU meter. Open canal hearing instruments affect the VU meter none to minimal (~ <2 to 3 dB). There are several aspects of the fitting that may increase the leakage and in so doing, directly affect the VU meter:

   a. **Audiogram**
      The severity and configuration of the hearing loss will affect the amount of gain needed and ultimately the amount of leakage from the open canal fitting. As the number of frequencies that need amplification increase and the activity of active feedback suppression increases to avoid feedback allowing the gain needed due to the severity of the hearing loss, the amount of leakage also increases.

   b. **Stimulus Type**
      The RMS value of the VU meter is an average of all frequencies. If there is only a slight leakage at the 2000 to 4000 Hz frequency region, when the leakage is averaged with all the other frequencies only a minimal affect will be displayed by the VU meter. If the stimulus selected has more high frequency content, more of a leakage effect may occur at the high frequency region (i.e. Café stimulus file has more high frequency energy than the Babble stimulus file) due to the amplification provided to this frequency range. Therefore, a greater leakage affect may occur in this region but the VU meter (because it is an average) may show a small affect.

c. Frequency Range Most Effected

The frequency range most affected by the high frequency leakage is between 2000 to 4000Hz (the typical feedback risk frequencies).

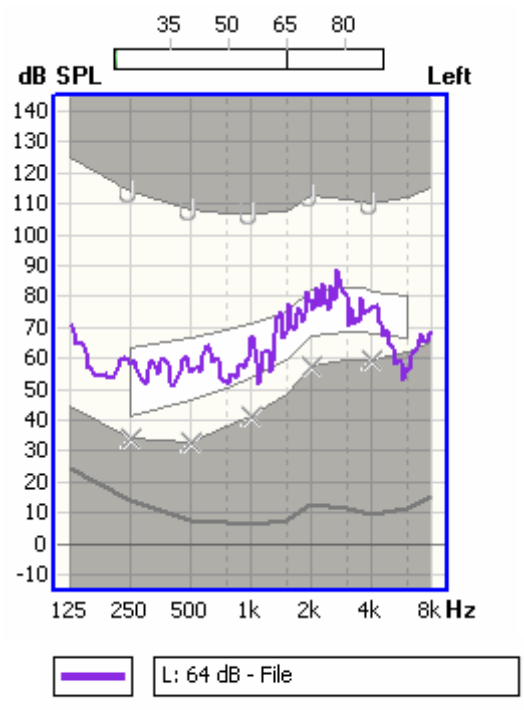


Note: The top 2 curves show the amount of leakage using the Babble stimulus. The bottom 2 curves show the amount of leakage using the Café stimulus. Audiogram thresholds are represented by the "X"s.

Verifying the Open Canal Hearing Instrument

1. Meeting the Audibility Area in the Low Frequency Range

Open canal hearing instruments are designed for individuals with minimal low frequency hearing loss. If the response curve in the low frequency range does not match the audibility area, it is not recommended that the hearing instrument gain be increased in order to fit to this area. The open canal hearing instrument is designed to let the low frequencies leak out of the ear, trying to fit the low frequency region of the audibility area will ultimately lead to distortion, and the individual will not be satisfied with the sound quality of the hearing instrument. Remember the patient will utilize their residual hearing for the low frequencies.

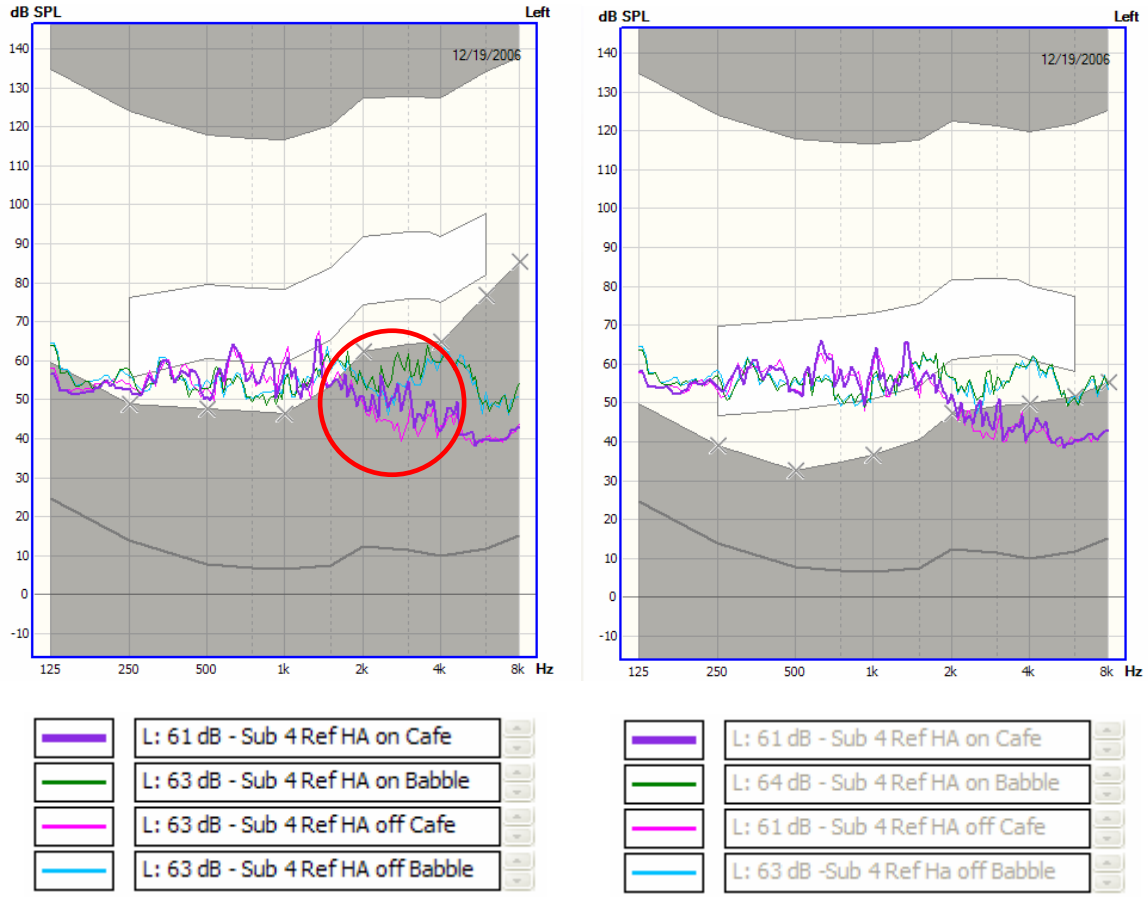


2. Determining the Amount of Leakage

As described above, the amount of leakage is related to the amount of gain and the stimulus file used to collect the data. In order to discern the effects of the open fitting on the VU meter, we recommend that two curves be collected with the probe tube over the reference microphone (same position used for probe tube calibration), one with the HA off and the other with the HA on to determine the amount of leakage from the HA.

- Place the probe tube over the ref mic (same placement as for probe tube calibration).
- Turn HI Off, select the stimulus to be used and collect the response curve.
- Turn HI On, select the same stimulus and collect the response curve.
- The difference between the two curves is the amount of leakage.

The left SPLogram demonstrates some leakage from 2000 to 4000 Hz for the Café stimulus and a slight leakage for the Babble stimulus. The right SPLogram displays no leakage present for either stimulus.



Reference

Lantz J, Drylund Jensen O, Haastrup A & Ostergaard Olsen S (2007) Real-ear measurement verification for open, non-occluding hearing instruments. Intl J Audiol (in press).

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