On-Ear Verification of Open Fittings

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Learning Objectives

• Correctly identify and objectively verify an open fitting condition with any patient.
• Correctly identify open fit candidates using real ear measures.
• Correctly fit open fit candidates using real ear measures.

What Is An Open Fitting?

• Any style of hearing instrument (and its associated “plumbing”) that creates minimal occlusion of the ear canal when worn.

Staab, W., Open Earmold Hearing Aid Fittings”, HHTM January 2016
McCabe, E., Galster, J. “Reducing Occlusion In CIC’s With Custom Venting” online pdf
Why An Open Fitting?

• Primary value:
  – Addresses occlusion and own voice complaints
    • Particularly for patients with little hearing loss in the lower frequencies
  – Provides a more natural sound quality

• Primary limitation:
  – Increased feedback potential will limit available gain
  – Best suited for high frequency loss

Digital/Thin-Tube/RIC

• Contributions:
  – Digital feedback management technology has facilitated greater access to more useable gain in an open ear canal environment
  – Thin-tube and RIC styles have advanced the cosmetic acceptance of the BTE form
  – Comfortable, non-occluding ear tips make these products easier to fit, adjust to and wear
As A Result.

- In the first quarter of 2016:
  - RIC products accounted for 64.5% of sales
  - BTE products accounted for 80.7% of sales

Not All RIC/Thin-Tubes Are Open

The six possibilities of BTE couplings used in today’s fittings

What Is An “Open” Instrument?

• “Open” should NOT be defined by hearing aid design
  – Thin Tube
  – RIC

• “Open” defined by hearing aid coupling to the ear:
  – If coupling does not occlude the ear canal, it is an “Open” fitting

METHODS FOR CONFIRMING AN OPEN FITTING

1) The Real Ear Unaided Response (REUR) vs. the Rear Ear Occluded Response (REOR)
Probe tube placement

• Begin with otoscopic inspection of ear canal
• Place probe tip within 5mm of the eardrum
• Placement methods include:
  – Visually-assisted positioning
    • Use anatomy of external ear to guide positioning

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Video tab: “Probe tube Placement”
Method For Determining an “Open” Fit

Once the probe tube has been properly inserted into the ear canal, select “Speechmap” in the On-ear column of the Verifit test selection menu.

REUR

On-Ear result obtained when only the probe tube is in the ear canal
REOR (Open dome)

On-Ear result obtained when the probe tube and a muted open-dome RIC instrument is in the ear canal.

REUR & REOR Superimposed

Note that the two measurements are virtually identical, indicating that the physical presence of the hearing instrument/plumbing does not change ear acoustics.
REOR (Closed Dome)

On-Ear result obtained when the probe tube and a muted single-wall closed-dome RIC instrument is in the ear canal.

REUR & REOR Superimposed

Now, the two measurements are not identical, indicating that the presence of the hearing instrument/plumbing is indeed changing ear acoustics.
REOR (Ventless Earmold)

On-Ear result obtained when the probe tube and a muted BTE with a Double-walled power dome is in the ear canal.

REUR & REOR Superimposed

Note the significant difference between the two measures when this magnitude of occlusion is present.
METHODS FOR DETERMINING AN OPEN FITTING

2) OCCLUSION EFFECT TEST
Occlusion Test Result: Open Dome

Occlusion Test Result: Closed Dome
Occlusion Test: Power Dome

OPEN FIT ACOUSTIC CONSIDERATIONS

1) VENTING
Comparative Vent Effects

Effect of vent diameter and open fitting on hearing aid output


NAL-NL2
OPEN FIT ACOUSTIC CONSIDERATIONS
2) EAR CANAL RESONANCE

Comparative Vent Effects

- 10dB loss of gain near 1KHz
- No loss of ear canal resonance

Hearing Journal, November, 2006
Ear Canal Resonance

Difference in probe measures obtained in a Zwislocki coupler driven with steady state noise between a response obtained with the probe sealed at the coupler opening (zero line) and a response obtained with the probe simply placed in the coupler (measured line).

In an Open Fit, There Are Several Pathways to Get SPL to the Eardrum

• Direct pathway
  – Sounds that reach the eardrum unprocessed by the hearing aid

• Amplification (Indirect) pathway
  – Sounds that reach the eardrum via the output signal of the hearing aid

Acoustic Pathways

Frequency Response

Amplitude (dB)

Frequency (Hz)

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The Advantage of REAR Measurement

- An REAR displays the combined acoustic pathway result
  - It measures and displays the aided SPL at the probe tube tip regardless of how that SPL was delivered
- An REIG displays only the hearing aid pathway

OPEN FIT VERIFICATION CONSIDERATIONS
If an Open Fitting Is Present. . .

• Pre-fit (in the test box) is off the table
  – There is no such thing as an “Open” coupler
• All fitting measures need to be done on the ear
• “Concurrent” calibration (equalization) should not be used

Impact of sound calibration method

For open fitting:

• Outflow from ear canal received by reference mic.
  • Lowers speaker output
• Resulting measured output will be reduced
Open Fitting Recommendation

- Use ‘stored’ equalization instead of ‘concurrent’ equalization
  - Presents the calibration signal independent from the speech signal
  - Hearing aid is on the ear, but muted during the calibration signal event
  - Thus, outflow from ear canal cannot affect speaker level and your measurement

**OPEN FIT VERIFICATION PROCEDURE**

1) VERIFYING PATIENT CANDIDACY

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**Patient Candidacy**

- Select “Speechmap” from the On-Ear menu
- Enter audiogram into verification system
- Select a fitting target (i.e., NAL-NL2)
- Place the probe tube only in the patient’s ear(s)
- Run and record the REUR for 65dB speech
- Compare the displayed LTASS to the displayed target
OPEN FIT VERIFICATION PROCEDURE
2) VERIFYING AIDED PERFORMANCE (ON-EAR)

Open-Fit On-Ear Verification Procedure

Select “Speechmap” in the On-ear column of the Verifit test selection menu.
Audiogram Being Used In This Example

1) Select “Open” in Instrument menu
2) Place probe mic and HI on ear per usual

Turn OFF or Mute the Hearing Instrument

3) Select Play in Test 1 and store equalization when prompted

Once Equalization is completed, turn ON the hearing instrument
Re-equalizing sound field

If sound field changes at any time during testing, including if patient or clinician moves, the sound field eq must be repeated.

Click the “EQ” button to interrupt the running test to allow a new equalization to be stored.

4) Run Test 1: Calibrated Soft Speech

Adjust HI gain until best target match has been achieved
5) Run Test 2: Calibrated Average Speech

“Showing” unaided speech banana (grey) helps define HI difference
6) Run Test 3: MPO

Adjust hearing aid output to approximate MPO target on Speechmap Screen

Optional: Run REUR in Test 4

Actual unaided speech in ear canal (gold) vs. predicted unaided speech (grey)
Optional: Run REUR In Test 4

Actual unaided (gold) and aided (pink) normal conversational speech in ear canal

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Education tab: “Speechmapping As A Fitting and Counseling Tool”
Articles tab: “Speechmapping As A Fitting and Counseling Tool”
Directional Mic Test
OPEN FITTING CONSIDERATIONS
ON EAR AND TEST BOX MODES

Directionality Test (ON EAR)

Rear speaker
Aided ear with probe tube positioned
Verifit in On-ear directional mode

Equal distance
On Ear Directional Mic Test Result

Aided On Ear REAR for Speech Compared to On Ear Directional Mic Test

Frequency Range of Aided Region

Frequency Range of Aided Region
On Ear Directional Mic Measurement Considerations

• Open venting will likely mask directional mic functionality in the lower frequencies
• Directional mic port angle can effect the magnitude of curve separation
  – The closer to horizontal, the better the curve separation
• Head and pinna effects play a role in the directional mic result obtained.

Directionality Test Test Box

Adjust HA Stabilizer until front and rear mic ports are parallel to test box floor

Putty-less TRIC adapter couples RIC and Thin Tube products to wideband .4cc coupler
Directional in Test-box - RIC

Front speaker

Rear speaker

Axis of microphone openings

Recommended Positioning – Verifit2

Directional Test Speaker

Directional Test Speaker

Front Speaker
Directional Test Box Result

Measured Response to Front Speaker Signal

Measured Response to Rear Speaker Signal

Aided On Ear REAR for Speech Compared to Test Box Directional Mic Test

Frequency Range of Aided Region

Frequency Range of Aided Region
Interested in learning more?
Visit the education and article section of Audioscan’s expo page on AudiologyOnline
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Education tab: “The Verifit Directional Mic Test: Evaluating Modern D Mic Technologies”
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Noise Reduction Test
On Ear and Test box
Digital Noise Reduction Properties

- Digital algorithm programmed to recognize “non-speech” elements of incoming stimulus
  - Operates independently in bands
  - Analyzes incoming signal modulation
- Can vary in terms of time constants
  - Typically, slow attack, fast release

On Ear Noise Reduction Test Result
Aided On Ear REAR for Speech Compared to On Ear Noise Reduction Test

Test Box Noise Reduction Test Result
Aided On Ear REAR for Speech Compared to Test Box Directional Mic Test

Frequency Range of Aided Region

Frequency Range of Aided Region

Summary
Key Open Fit Verification Considerations

• An open fitting exists when any hearing aid is coupled to the ear in a way that does not occlude the ear
  – Defined more by plumbing than HA style
  – An occlusion-free ear canal can be verified
    • REUR/REOR test
    • Occlusion effect test

• There are several important acoustic properties associated with open fittings
  – Vent effects
  – Ear canal resonance
  – Combined acoustic pathways
Key Open Fit Verification Considerations

• Regarding open fit verification:
  – Pre-fitting (test-box Speechmap) is not an option
  – Concurrent microphone equalization (in REM) is replaced with stored microphone equalization
  – All fitting/fine-tuning steps will need to be completed On-Ear

Key Open Fit Verification Considerations

• Advantages associated with the REAR:
  – Can be used to “verify” open-fit candidacy
  – Displays an aided result that accounts for the combined acoustic signal conditions unique to an open fitting
Key Open Fit Verification Considerations

• Directional mic can be verified On-Ear with an auxiliary speaker
  — Demonstrates the effects of open venting on directional performance
  — Shows the value of D-Mic under these conditions
• Noise reduction can be verified On-Ear
  — Demonstrates the effects of open venting on this feature
  — Shows the value of noise reduction under these conditions.

Key Open Fit Verification Considerations

• The test box can still be a valuable tool in open fit verification
  — Test box directional mic test results can be compared to REAR results to identify directional mic advantage potential
  — Test box noise reduction test results can be compared to REAR results to identify noise reduction advantage potential
Thank You!

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