

# Self-Inflating, Sound-Activated Balloon- Style Hearing Aid Coupling Device

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# Disclosures

- ❖ Funding:
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- ❖ Small Business Involved:
  - ✓ Asius Technologies, LLC
- ❖ Participants:
  - ✓ Staab/Ambrose: Co-PI; Staab: Limited consulting with SeboTek
  - ✓ Vanderbilt University - Contract via grant
- ❖ Test location:
  - ✓ Dan Maddox Hearing Aid Research Laboratory, Vanderbilt University, Nashville, TN
    - Todd Ricketts, Ph.D.
    - Telani Leuder
    - Kristen D'Onofrio

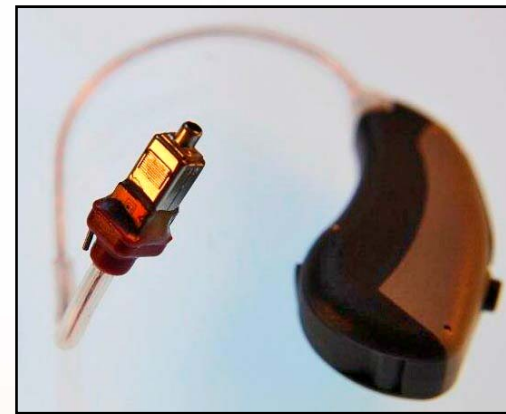
# Background

- ❖ Hearing aid coupling to the ear has improved substantially over the years.
- ❖ Still, designs continue to seek solutions for:
  - ✓ Comfort
  - ✓ One size fits most
  - ✓ Occlusion effect management
  - ✓ Increase REAR before acoustic feedback
  - ✓ Ear impression elimination
    - In-office, same session fit
  - ✓ Ear coupling for surgically-altered ear canals
  - ✓ Seal to manage the dynamic ear canal
  - ✓ Security of fit
  - ✓ Cerumen avoidance
  - ✓ Etc.

# New Coupler Development

## ❖ ADEL™ (Ambrose Diaphonic Ear Lens)

- ✓ Innovative approach to harvesting energy from a hearing aid speaker to perform work
- ✓ In this case, to inflate a folded balloon (like automobile air bag) in ear canal.



### ✓ Mechanism:

- Small diaphonic pump is attached to (integrated with) a balanced armature HA speaker

## ❖ Goal:

- ✓ Provide a universal alternative for many current hearing aid ear coupling methods

# Study

*Preliminary Report on some aspects of the study (partial)*

## **1. Proof of concept (confirm - what has been already designed)**

- ✓ Will Bubble inflate to sounds produced by the hearing aid?
- ✓ Will bubble remain inflated?

## **2. How does performance compare with existing coupling methods (*must be equal or better to be acceptable*)**

- ✓ Occlusion Effect
- ✓ Sound Isolation Properties
  - Acoustic Feedback - REAR Measurement
  - Sealing Property - REOR Measurement
- ✓ Subjective Properties
  - Comfort
  - Own voice quality
  - Retention
  - Insertion/removal ease

# Proof of Concept

## ❖ Will bubble inflate to HA produced sounds?

- ✓ Yes. Evaluated previously with known results
  - Reconfirmed in this study with design used
  - Time to inflate
    - Amplified voice: 5 to 30 sec. (can be varied)
    - To speed up inflation, use short-term HA-generated sound
  - Bubble size and inflation - Faster inflation with smaller bubble

## ❖ Pressure to Inflate and Maintain Inflation

- ✓ Inflation Goals: Good seal, minimal FB, comfortable, secure in ear
- ✓ Inflation (syringe coupled to manometer) for controlled measurements
  - Optimal pressure range: 500 - 1200 Pa (0.5 to 1.2 kPa) = 0.07 - 0.17 psi
  - Optimum pressure: 1000 Pa (1 kPa) = 0.15 psi
  - Maintenance pressure: 100 - 300 Pa (0.1 to 0.3 kPa) = 0.01 - 0.04 psi

# Coupling Performance Comparisons

- ❖ Test hearing aid - SeboTek HD 16 Easy CLICK RIC
  - ✓ Selected for ease of use and ADEL construction
    - RIC - Open fit
    - RIC - Closed fit
    - RIC - Sealed with earmold impression material
    - RIC - ADEL™ syringe inflated (for control: spkr maintained)
      - Shallow fitting balloon (n = 13)
      - Deep fitting balloon (n = 7)



Open



Closed



Sealed

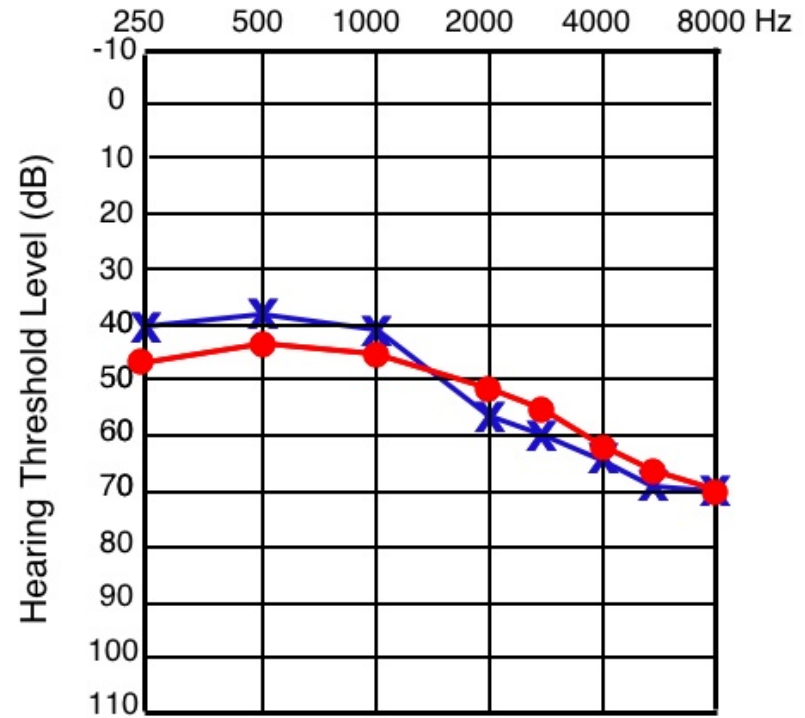


ADEL

# Subjects

## ❖ Subjects

- ✓  $n = 20$
- ✓ Mean age: 65.9
- ✓ 60% Male; 40% Female
- ✓ Sensorineural
- ✓ Hearing aid wearers





# Hearing Aid Programming

## SeboTek HD 16

- ✓ OSPL90 = 117 dB SPL      HFA OSPL90 = 112 dB SPL
- ✓ Max Gain = 51 dB      HFA-FOG = 45 dB

## Programmed:

- ✓ Audiogram at 50 dB HL from .25 to 1k, and 60 dB HL from 2 to 4 kHz

- ✓ Programmed linear

- Compression: 1:1
- Thresholds: Maximum
- Advanced Features:
  - Feedback canceler      Off
  - Ambient noise reduction      Off
  - Voice priority      Low

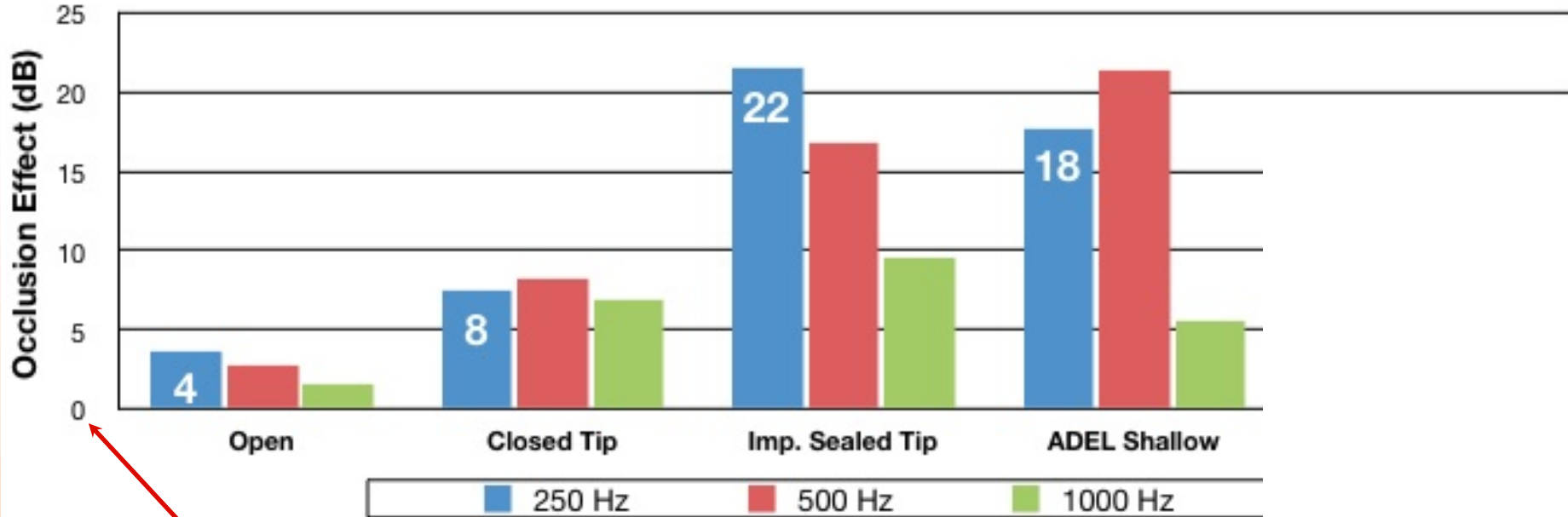


# Performance Comparison Results

# Occlusion Effect Results

❖ Question: Might bubble inserted shallow into the ear canal “absorb” vibrations and reduce OE?

✓ Measurements: Did not support



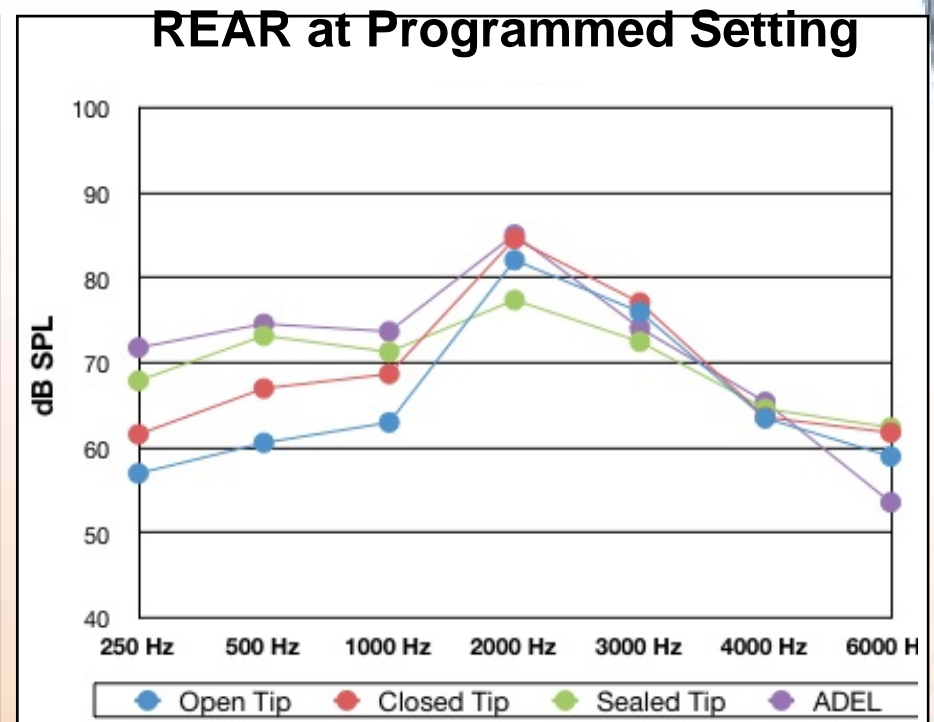
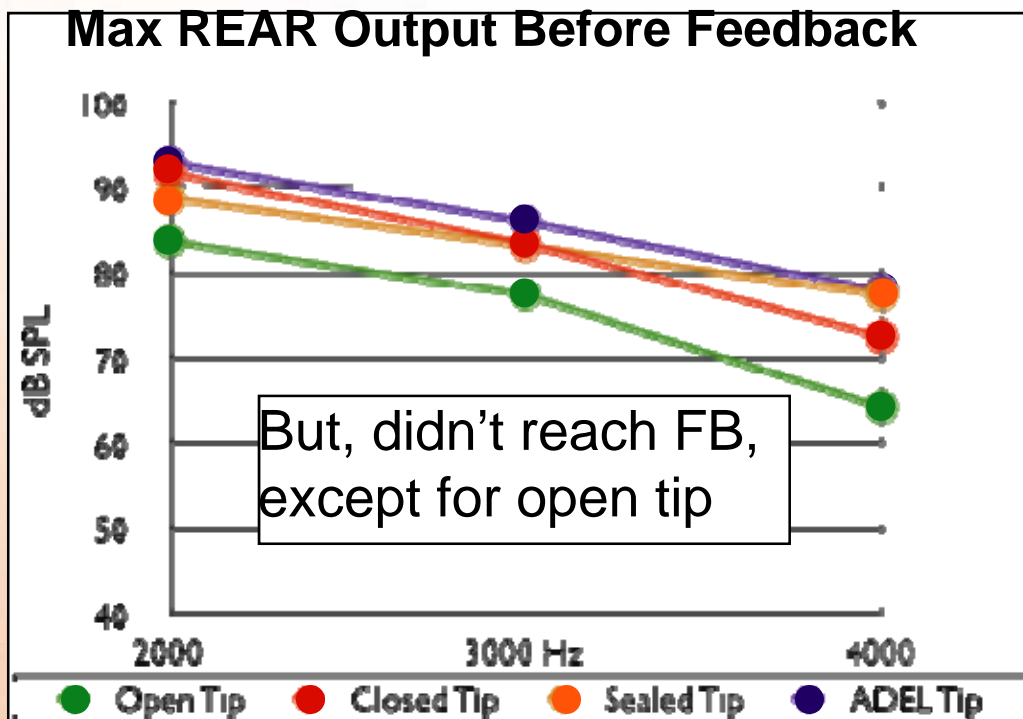
(Control: “0” is Occlusion Effect reference control to live voice, no coupling)

✓ Redesigned with bubble deep

# Max REAR Output Before Feedback

## ❖ Procedure:

- ✓ Tester used headphones in Audioscan Verifit to establish FB threshold as HA gain was increased in high band (2-4 kHz) on subject
  - Input: 65 dB SPL speech input
- ✓ Then reduced gain 1 click; jaw movement, etc., to confirm level
- ✓ From resultant graph, pulled data for 2k, 3k, and 4k, and plotted



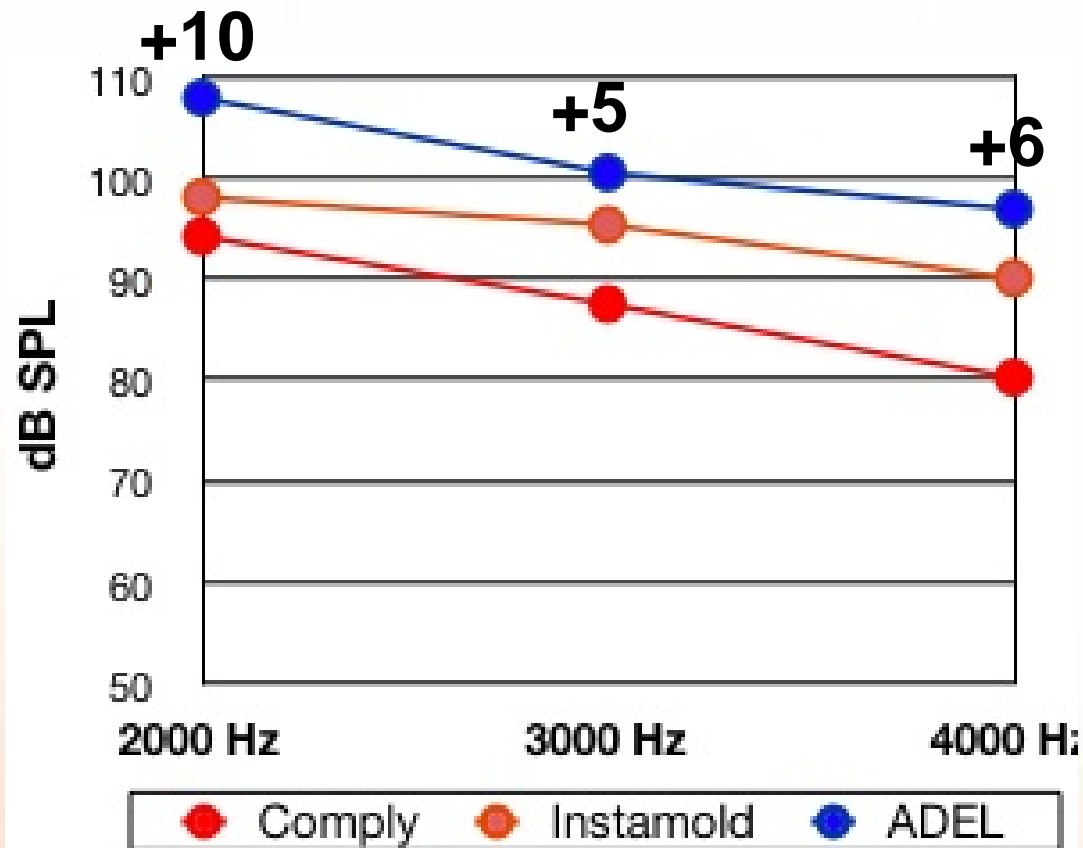
# Higher Output Aid to Test FB

## ❖ Widex Super RIC

- ✓ Programmed linear
- ✓ Three comparison conditions
  - Comply™ tip
  - Instamold™ earmold
  - ADEL deep fitting bubble



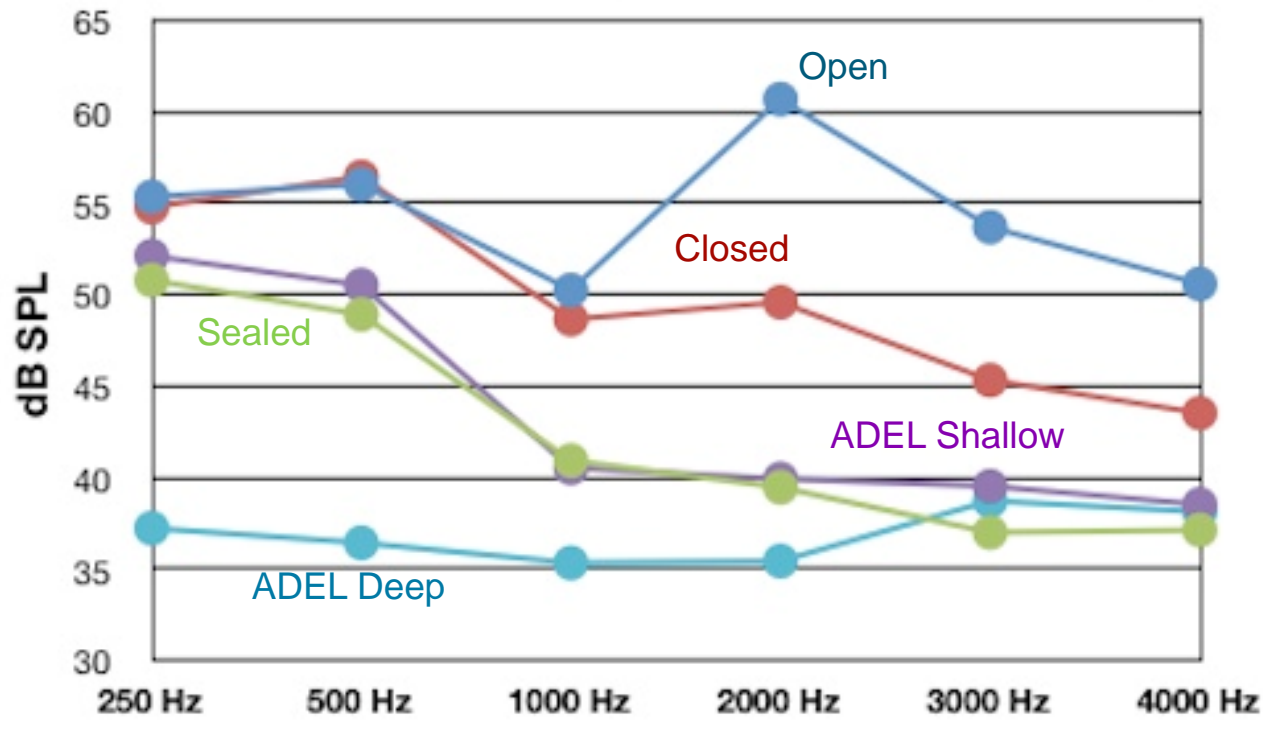
# Max REAR Output Before Feedback High Gain HA



Result: When compared to next best solution, the ADEL deep fit enabled 10 dB of additional output at 2000 Hz, 5 dB at 3000 Hz, and 6 dB at 4000 Hz.

# Sound Isolation (REOR)

## ADEL (Shallow and Deep) to Other Coupling Methods (Moderate Gain HA)



RESULT: ADEL deep showed substantially greater sound isolation in the low frequencies.

# ADEL to Other Couplers (Cont.)

## ✓ Sealing Property (REOR) Re: Sealed

- **Shallow Seal** (negative number is poorer)

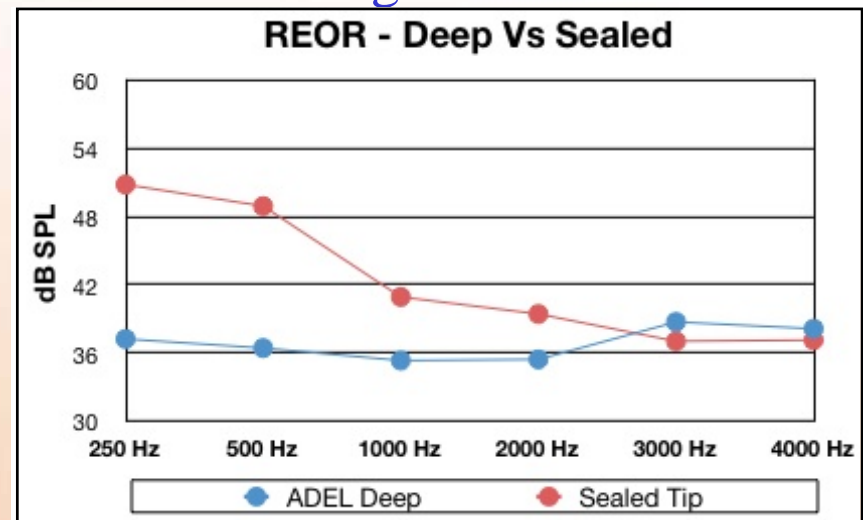
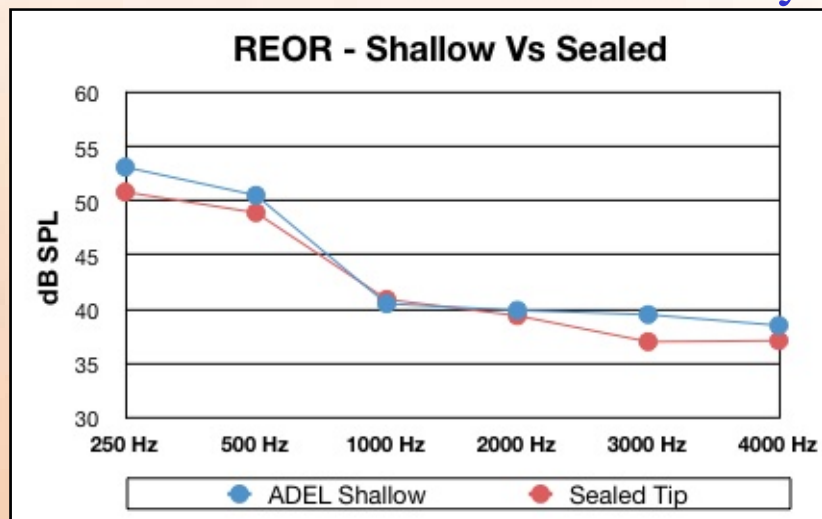
250 Hz	500 Hz	1000 Hz	2000 Hz	3000 Hz	4000 Hz
-1.3 dB	-1.6 dB	0.4 dB	-0.5 dB	-2.5 dB	-1.4 dB

□ RESULT: Comparable to a good ear plug

- **Deep Seal**

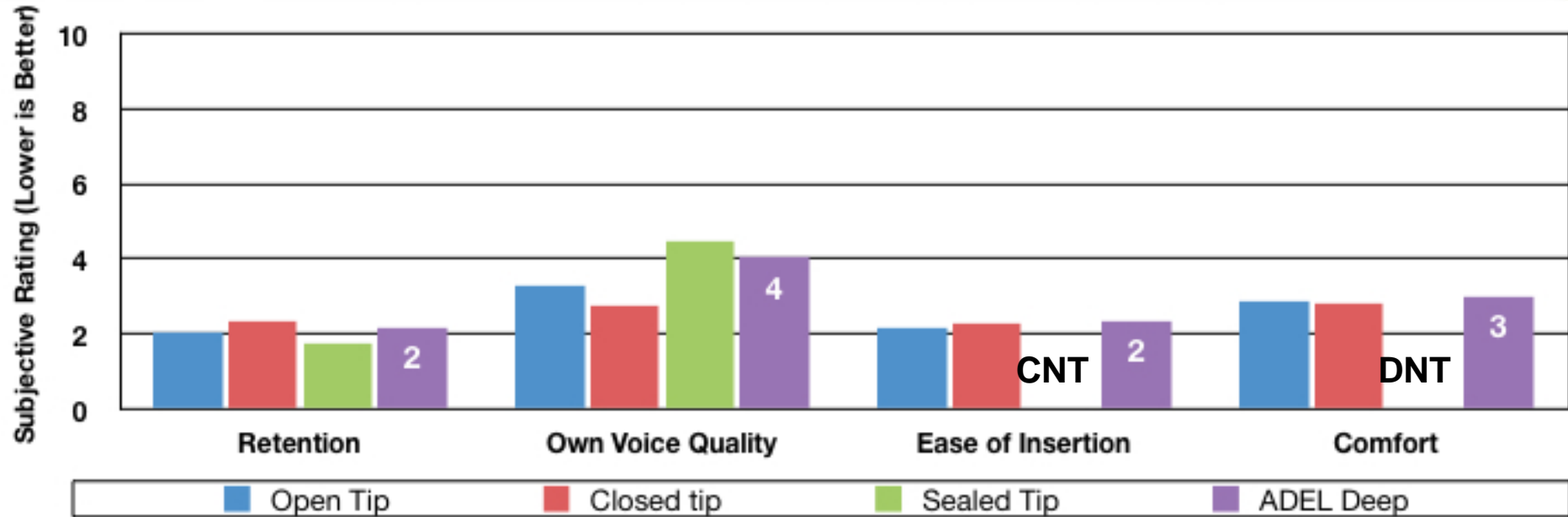
250 Hz	500 Hz	1000 Hz	2000 Hz	3000 Hz	4000 Hz
13.6 dB	12.5 dB	5.6 dB	4.0 dB	-1.7 dB	-1.0 dB

□ RESULT: Substantially better seal resulting in LF isolation





# Subjective Ratings



- ✓ RESULT: ADEL comparable with other coupling methods
- ✓ Comfort
  - Additional 4 subjects wore RIC closed and RIC ADEL deep (one to each ear) throughout everyday activities, including lunch (up to 1 hr.). Split (50/50%) as to which was more comfortable.

# Conclusions

- ❖ Balloon inflates to amplified sound from HA speaker
- ❖ Balloon pressure - maintained even in periods of silence
- ❖ Balloon appears to “mold” into nooks and crannys
- ❖ REAR output before feedback - balloon was best
- ❖ Seal - manages ear canal dynamics (chewing, speaking, etc.)
- ❖ Security in ear - retention is excellent, with comfort
- ❖ Cosmetics - comparable to current RIC hearing aids
- ❖ OE - comparable when deep
- ❖ Comfort - good as or better than other coupling methods
- ❖ No cerumen blockage of sound
- ❖ OVERALL: Good substitute for existing HA coupling

Thank you for listening...