FLEX VENTING: MORE THAN JUST YOUR AVERAGE VENT

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WIDEX high definition hearing

INTRODUCTION

Vent modifications are a common solution for the occlusion effect. Studies have shown that with incremental increase in vent diameter there were decreases in objective occlusion (Kuk et al 2005, MacKenzie 2004, Kiessling et al. 2005). Many manufacturers now offer an "open fit" solution for those patients with either normal thresholds or a mild loss in the low frequencies. Open fit instruments are typically fit with a cosmetically appealing thin tube extending from the receiver to the ear canal using a non-occluding silicone tip. The cosmetic appeal has led to a larger number of fittings on those with poorer low frequency thresholds, increasing the need for more gain in the lower frequencies. To meet this need a generic solid type silicone tip has been used up until now. More recently, custom molds adapted to fit a thin tube have come into use. These types of molds are closed on the medial end and are typically hollow. A hollow mold used with a #13 tube described by Jespersen and Groth (2004) demonstrated that the acoustic mass of a shorter vent (1mm) in a hollow mold was smaller than the acoustic mass of a longer vent (20mm) in a solid mold resulting in a reduction of the occlusion effect. Since that time, more hearing aid and earmold manufacturers are offering this type of earmold as a custom solution to thin tube hearing aid fittings. It is important to understand what effect venting may have on the performance of an instrument with a hollow mold as compared to the use of a more traditional earmold in order to provide appropriate venting recommendations as they may be different between the two types of earmolds.

Objectives

Compare the vent diameters of 0mm, 1mm, 2mm and 3mm for a hollow earmold and a traditional solid earmold on the following indices:

1. Available gain
2. Output: compare the effect of vent diameter and length on the low frequency output of the instrument (REAR).
3. Occlusion Effect: both objective and subjective (REOR)
4. Sound Attenuation: observe the effect of vent diameter and length on the level of sound transmission into the ear canal. (REOR)

METHOD

Subjects

- 11 adults with normal middle ear function
- 3 with normal hearing
- 8 with high frequency hearing loss and experienced hearing aid wearers

Hollow Mold

- Constructed using laser fit technology (CAMISHA)
- Designed for use with thin tube
- Average length of 13mm
- Shell thickness of 0.7mm (resulting vent length = 0.7mm)

Solid Mold

- Constructed using laser fit technology (CAMISHA)
- Designed for use with thin tube for the research project
- Length of a CIC (22mm on average) resulting in a longer vent length (22mm) than hollow mold

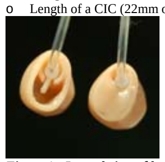

Figure 1: Lateral view of hollow mold and solid mold

Figure 2: Side view of solid mold and hollow mold

Evaluation Procedure

- Subjects were evaluated with both types of earmolds during one two-hour test session.
- Measurements were conducted in a 10' x 10' x 6'6" sound-treated IAC test booth.
- Probe microphone measures were made using a Frye Fonix 6500 Hearing Aid Test System; Quick-Probe II.
- Three types of stimuli were used:
  - Own voice production of /i/; level monitored by sound level meter, REOR
    - A custom MatLab program was used to record and average a 3 second segment.
  - Speech weighted noise presented at 85 dB SPL, REOR
  - Composite noise presented at 60 dB SPL, REAR
- For REAR measures, same settings used for each subject:
  - sensogram of 75/75/75/75
  - omni directional; noise reduction off; feedback cancellation off
- Type of earmold counterbalanced (hollow or solid).
  - Vent conditions measured: 0mm, 1mm, 2mm, and 3mm
- Subjective assessment of own voice conducted using the phrase "Baby Jeanie is teeny tiny." using a 1-10 rating scale: 1 = very hollow; 10 = natural.

RESULTS

Difference in available gain

With the feedback cancellation in the off position, the available gain was measured for each vent size in both earmold types. The difference in available gain between each earmold type and vent is shown in Figure 3. Some observations were:

- There was a slight difference with the 0mm vent (1-2 dB) above 1000 Hz
- The greatest difference was between 1600-2500 Hz:
  - 7-10 dB with a 1mm vent (peak at 1600 Hz)
  - 13-14 dB with a 2mm vent
  - 10-13 dB with a 3mm vent
- Differences at 1600-2500 Hz between solid and hollow mold were statistically significant indicating greater available gain for the solid molds: for example at 1600 Hz [F(1,10) = 271.6, p<0.001, η^2=.096, power=1.0].

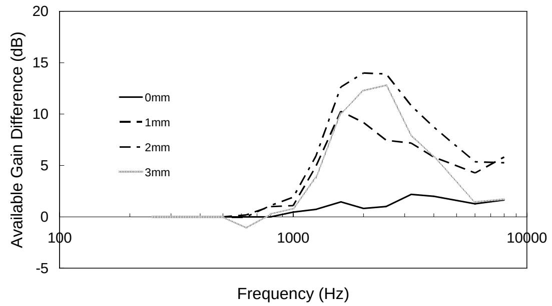

Figure 3: Difference in available gain (solid mold minus hollow mold) feedback cancellation off

Difference in output

With the hearing aid set the same for each test subject, the output, REAR, was measured for each earmold type and vent condition. The difference between the output of the solid earmold and hollow earmold is shown in Figure 4. Some observations were:

- Compared to the solid earmold, output at 200 Hz in the hollow mold. was reduced by:
  - 19 dB with a 1mm vent
  - 21 dB with a 2mm vent
  - 17 dB with a 3mm vent
- The difference in output at 200 Hz between the solid and hollow mold was statistically significant indicating less output for the hollow mold: [F(1,10)=226.1, p<0.001, η^2=0.96, power=1.0]
- Without the use of feedback cancellation, the lower available gain with a 2mm and 3mm vent in the hollow mold reduced the output by 5-7 dB at frequencies above 1000 Hz compared to the solid mold.

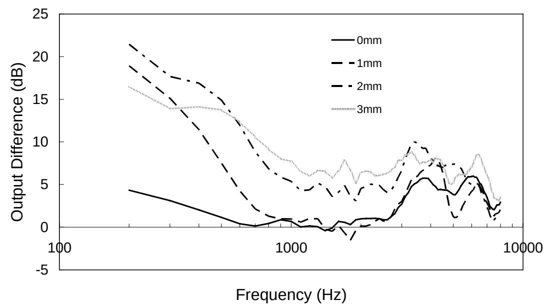

Figure 4: Difference in output between hollow mold and solid mold (solid absolute output minus hollow absolute output)

RESULTS (cont.)

Difference in subjective occlusion

A scatter plot of individual data and median data for each earmold compared to subjects' rating of own voice hollowness is shown in Figure 5. Some observations were:

- Median rating improved as vent diameter increased for each earmold type.
- Median rating for hollow mold was 3 to 5 rating steps higher than median ratings for solid mold.
- Subjectively, for most subjects, the hollow mold appeared to provide more occlusion relief than the solid mold.

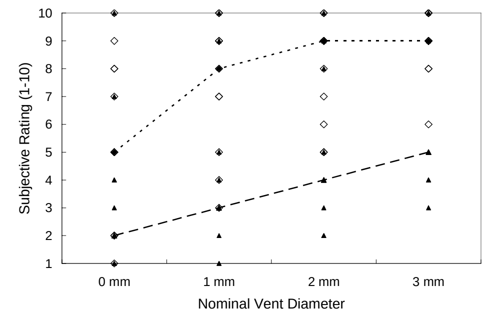

Figure 5: Scatter plot for subjective rating (1-10 scale) of own voice; REOR; hollow earmold (open diamonds), solid earmold (filled triangles) and vent conditions: 0mm, 1mm, 2mm, and 3mm; median ratings connected with dotted line for hollow mold and dashed line for solid mold

Difference in Objective Occlusion Effect

The occlusion effect was measured by taking the occluded vocalization response (REOR) and subtracting the un-occluded vocalization response (REUR) for each earmold and vent condition. The difference in objectively measured occlusion between the solid earmold and hollow earmold is shown in Figure 6. Some observations:

- The 0mm condition with the hollow mold had approximately 4 dB less occlusion than with the solid mold at 500 Hz and below.
- There was approximately 8 dB more occlusion with the solid earmold with the 1mm, 2mm and 3mm vents.
- The peak difference of occlusion varied by vent size: 344 Hz for 1mm, 430 Hz for 2mm, and 689 Hz for 3mm.
- The difference between the solid mold and hollow mold was statistically significant (indicating greater occlusion for the solid mold): for example, at 344 Hz [F(1,10)=24.2, p<0.001, η^2 = 0.71, power = 1.0].
- The difference in occlusion effect was statistically significant for vent size: for example, at 344 Hz [F(3,30)=33.55, p<0.001, η^2 = 0.77, power = 1.0]

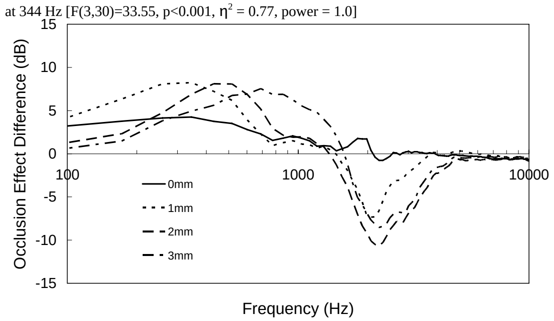

Figure 6: Difference in occlusion effect between solid mold and hollow mold (solid occlusion effect minus hollow occlusion effect)

RESULTS (cont.)

Difference in attenuation characteristics

The attenuation characteristics (or insertion loss) of each earmold/vent type was calculated by subtracting the real ear unaided response (REUR) to an 85 dB SPL composite noise from the real-ear occluded response (REOR) for each vent and earmold condition. The attenuation characteristics of the hollow mold were then subtracted from the solid mold and the difference shown in Figure 7. Some observations:

- There was approximately 5 dB more attenuation with the un-vented solid mold when compared with the hollow mold across most frequencies.
- With venting, the attenuation differences were similar between the vent sizes above 2000 Hz with a peak of 15 dB difference at 2000 Hz for the 1mm condition.
- Below 2000 Hz, there was a significant change in attenuation characteristics between the vent sizes with the least amount of attenuation for a 3mm vent.
- The difference between the solid and hollow mold was statistically significant:
  - 800 Hz: [F(1,10)=33.5, p<0.001, η^2 = 0.77, power = 1.0]
  - 2700 Hz: [F(1,10)=149.52, p<0.001, η^2 = 0.94, power = 1.0]
- The vent size effect was also statistically significant:
  - 800 Hz: [F(3,30)=72.6, p<0.001, η^2 = 0.88, power = 1.0]
  - 2700 Hz: [F(3,30) = 164.6, p<0.001, η^2 = 0.94, power = 1.0]

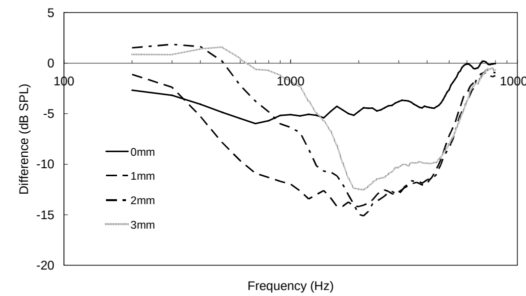

Figure 7: Difference in attenuation characteristics (solid mold minus hollow mold)

CONCLUSIONS

This study examined the difference in available gain, output, occlusion effect and sound attenuation between a hollow earmold with a short vent (0.7mm) and a solid mold with a longer vent (22mm). The key observations from these measures include:

- There was less available gain in the higher frequencies with the hollow mold than with the solid mold.
- The use of a hollow mold was more effective in reducing low frequencies than the solid mold.
- There was more objective and subjective reduction in occlusion with a hollow mold than with the solid mold.
- The solid earmold attenuated more external sounds than the hollow mold. Therefore, the solid mold would have less possibility of external sounds interacting with the hearing aid.

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