Managing an “Own Voice” Problem That Has an Amplifier Origin

Francis Kuk*

Abstract

The complaint from hearing aid wearers of hollowness in the sound of their voice is typically associated with excessive low-frequency sound pressure level (SPL) in the ear canal. Increasing the vent diameter and/or reducing the gain in the low frequency would typically minimize this complaint. This paper reports on a case where the origin of hollowness was insufficient low-frequency gain compared to a previous hearing aid fitting. It describes the systematic process that was followed in uncovering the origin of the patient’s hollowness complaint. Clinicians might follow a similar objective approach in their fine-tuning process to resolve wearer complaints.

Key Words: Ampclusion effect, hollowness, occlusion effect, own voice problem

Abbreviations: CIC = completely in the canal; REAR_voc = real-ear aided response during vocalization

Sumario

La queja de los usuarios sobre la cualidad de voz hueca que se percibe con el uso de sus auxiliares auditivos está típicamente asociada a un nivel excesivo de presión sonora (SPL) en las frecuencias graves dentro del canal auditivo. El incremento en el diámetro del orificio de ventilación y/o la reducción de la ganancia en las bajas frecuencias consigue minimizar esta queja. Este artículo reporta un caso donde el origen de esta característica en la voz fue una ganancia insuficiente en las frecuencias graves, en comparación con el auxiliar auditivo previo. Describe el proceso sistemático que se siguió para descubrir el origen de la queja del paciente sobre la apreciación de oquedad en su voz. Los clínicos podrían seguir un enfoque objetivo similar en su proceso de resolver las quejas de los usuarios.

Palabras Clave: Efecto de amplificación-oclusión, oquedad, efecto de oclusión, problema con la propia voz

Abreviaturas: CIC = completamente en el canal; REAR_voc = respuesta amplificada en oído real durante la vocalización

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The problem of ampclusion (Painton, 1993) or the perception of “hollowness” in one’s own voice with hearing aid use has largely been attributed to the earmold/shell occluding the ear canal (shell origin) and excessive low-frequency sound pressure level (SPL) in the hearing aid wearer’s ear canal as she or he vocalizes (see Kuk and Ludvigsen, 2002; Sweetow and Pirzanski, 2003, for a review). In order to systematically manage the ampclusion complaint, Kuk and Ludvigsen (2002b) proposed a five-step protocol that attempts to (1) minimize the potential occurrence and negative reaction to the ampclusion complaint by setting proper expectation or counseling (step 1), selecting the optimal hearing aid/earmold configuration (step 2), and ensuring that the fit is optimal (step 3); (2) determine if the complaint needs intervention (step 4); and (3) properly diagnose the origin of the complaint and provide appropriate resolution (step 5) without compromising the fit of the hearing aids to other sounds including speech. The present case study exemplifies how the use of this protocol allowed the author to uncover that the “hollow voice” complaint may also originate from insufficient low-frequency gain in the hearing aid.

The patient was a 65-year-old male with a bilaterally symmetrical sensorineural hearing loss. The audiometric thresholds were 50 dB HL at 250 Hz and 60 dB HL for frequencies at and above 500 Hz. The etiology of the loss was unknown. Amplification was not attempted until the patient was in his early 50s. The patient was fitted with binaural digital 3-channel CIC (completely-in-the-canal) style hearing aids about five years prior to his latest hearing aid trial. High satisfaction was reported with the use of the manufacturer’s recommended default settings. A pressure-relief vent was used on the hearing aids.

Recently, the patient replaced his hearing aids with binaural digital 15-channel CIC hearing aids. The default gain setting and a pressure relief vent were used. The patient’s audiologist reported that the simulated real-ear output from the hearing aid at 40, 65, and 90 dB SPL was within the residual dynamic range of the patient. His initial reaction to the hearing aids was positive. However, he felt his “nose was stuffed” and he “was talking through the throat” as he spoke. The audiologist’s attempts to increase the vent diameter and decrease the low-frequency gain did not resolve the complaint.

**CASE BACKGROUND**

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**ACTIONS TAKEN**

The “Ampclusion Checklist” (Kuk and Ludvigsen 2002b; see Appendix A) was administered in order to understand the origin of the complaint. Since the patient had purchased the hearing aids and the audiologist reported no problems with the physical fit and simulated real-ear output, Steps I to III on the checklist were omitted. The results on Steps IV and V were indicated on the checklist in Appendix A with the pre-intervention responses underlined and the post-intervention responses boxed.

We first made sure that the sound quality of the hearing aids for listening to conversational speech was appropriate (Step IV, question 3, in checklist). A discourse passage from the Connected Speech Test (CST; Cox et al, 1987) was played to the patient at an audiometer dial setting of 50 dB HL. The patient was instructed to listen to the passage and judge the sound quality of the hearing aids on three dimensions—“loudness,” “quality/naturalness,” and “distortion”—using only three response options on each dimension. Response on the loudness dimension indicates if the overall...
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loudness of the hearing aid needs adjustment. Response on the quality/naturalness dimension indicates if additional frequency shaping (or tonal balance) is necessary. Response on the distortion dimension indicates whether the gain setting for high input levels (or output) needs to be adjusted. In this case, the patient selected the middle response on all three dimensions (i.e., “comfortably loud” on the loudness dimension, “clear and natural” on the quality/naturalness dimension, and “crisp and bright” on the distortion dimension), suggesting that the assigned electroacoustic settings were sufficient for listening to conversational speech. A brief background for the choice of these dimensions (and response options) used in Steps III and IV is provided in Appendix B.

The next step was to characterize the patient’s amplclusion complaint (Step IV, questions 4 to 6) and to determine the level of intervention that was required (Step IV, question 7). First, the patient was asked to repeat the phrase “Baby Jeannie is teeny tiny” at his typical vocal effort and judge the quality of his voice as he spoke with the hearing aids in situ (a sound level meter [SLM] is recommended to help patients monitor and maintain their voice level). This phrase was chosen for its resemblance to typical speech and the abundance of /i/, the vowel with the lowest formant frequency. For question 4, which addressed the sound quality of the patient’s own voice during vocalization, the patient chose “too soft” on the loudness dimension, “too tinny” on the quality/naturalness dimension, and “muffled” on the distortion dimension. These comments, as evidenced on the “Solution Identification Worksheet” in Appendix B, would suggest either insufficient gain/output in the low frequencies or that the compression ratio in the low frequency was too high (too much gain reduction, thus giving the “muffled” perception).

Not surprisingly, on question 5, the patient selected “talking through my nose/head” and “stuffed up” to describe his voice problem. He rated his voice a “3” on question 6 (which is a 1–10 scale with “1” being the worst-sounding voice and “10” being the best or most natural voice) and assigned a category of “2” on question 7 (which is a 1–5 scale with “2” indicating that “It’s [the own voice problem] moderately noticeable and distracting, but I can adapt to it”). The choice of this response category reflected that amplclusion did interfere with the patient’s use of the hearing aids, even though he may be able to adjust to it over time. The author’s experience suggests that a rating of “2” or less would require immediate intervention (changes on shell or hearing aid gain settings or both). More empirical evidence is needed to determine whether a different criterion may be necessary.

The last step (Step V) attempted to determine the origin of the complaint. This was facilitated by questions 8 to 11. Question 8 asked the patient to compare his voice between the hearing aid “on” and “off” conditions. Question 9 asked the patient to compare his voice between wearing one and both hearing aids. Question 10 asked the patient to compare his voice between loud and soft speech. Question 11 asked the patient to compare the effect of physical manipulation of the hearing aids in the patient’s ears. The patient indicated that his voice problem “sounded worse when the hearing aid was off.” This would occur when the acoustic output of the hearing aid changed the perception (i.e., amplifier origin). Otherwise, no change in perception would be reported. He also indicated that the problem was “worse with one hearing aid” (suggesting a lower overall output was less desirable than output from both ears), “worse when speaking softer” (suggesting a lower output from the hearing aid was worse), and “pushing them in sounds better” (suggesting that a tighter seal or a smaller residual ear canal volume, which may have resulted in a higher SPL in the ear canal, was more desirable). These responses would suggest that insufficient gain/output may be the main reason for the amplclusion complaint.

The “Occlusion Manager” submenu on the manufacturer’s software module was activated to resolve the complaint once the source of the complaint was identified. It is suitable for amplclusion complaints that have an amplifier origin (i.e., inappropriate gain settings) and not a shell origin. When in use, gain below 500 Hz can be adjusted in a pairwise manner (Kuk, 2002). Briefly, the paired-comparison procedure allows the patient to compare the “hollowness” of his voice at the current settings on the hearing aids to an alternate setting (e.g., more lows) while repeating “Baby Jeannie is teeny tinny” at a normal volume. Preference for a setting leads
to more changes in the same direction for the next round of comparison until the patient
reverses his preference for a fixed number of times (e.g., five times). In-house experience
suggests that this module is over 80% effective in minimizing occlusion complaints when they are amplifier based. In this example, the patient selected approximately 10 dB more gain below 500 Hz than the default recommendation (as shown by the manufacturer’s fitting software).

The outcome of the low-frequency gain increase (through the Occlusion Manager) can be measured subjectively with the “Ampclusion Checklist.” The responses on the “Ampclusion Checklist” are shown after the intervention (answers are boxed). The intervention resulted in a comfortable loudness and a clear, natural, crisp, and bright sound quality. A rating of “8” was assigned on question 6 (1–10 subjective rating), and a category of “4” (“It is hardly noticeable unless I focus my attention to it”) was selected for question 7 (1–5 subjective categories). In addition, the patient rated the hearing aids as “comfortably loud with a clear, crisp and bright sound quality to environmental sounds” on question 12 (on sound quality to conversational speech). The effect of intervention was successful in minimizing the patient’s own voice complaint without compromising the performance of the hearing aids to conversational speech.

**WHY THE DIFFERENCE?**

It would have been ideal if the audiologist could measure the real-ear output of the 3-channel and 15-channel hearing aids in order to understand the reasons for such a complaint and to document the reasons for the positive outcome. Because the audiologist did not have easy access to a real-ear system, such measurements were made on the author’s ears with hearing aids of the identical style and models (3-channel and 15-channel CIC style). The said hearing aids were set to the patient’s audiogram, and a continuous ANSI speech-shaped noise at 65 dB SPL from the Frye 6500 real-ear system was used as the test signal. Figure 1 shows the real-ear aided output of the 3-channel and the 15-channel hearing aids. The 3-channel hearing aid has more output below 800 Hz than the 15-channel hearing aid. However, both hearing aids have similar output above 1000 Hz.

A similar difference in the real-ear aided output during vocalization (REAR$_{voc}$) was also observed between the 15-channel and the 3-channel hearing aids. Figure 2 compares the REAR$_{voc}$ during vocalization of /i/ between the 15-channel and the 3-channel hearing aids. The author sustained vocalization for 5 sec, and the vocalization produced during the middle 3 sec was frequency averaged using a custom MATLAB program. In addition, three repetitions of each measure were

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**Figure 1.** Real-ear aided output of the 15-channel (solid line) and the 3-channel (dotted line) hearing aids to a composite ANSI speech-shaped noise presented at 65 dB SPL.

**Figure 2.** Real-ear aided output during /i/ vocalization measured with the 15-channel (solid line) and the 3-channel (dotted line) hearing aids.
collected. The 3-channel hearing aid yielded approximately 5 dB more output than the 15-channel hearing aid at around 300 Hz where the peak occlusion effect has frequently been reported.

The interaction between the hearing loss of the patient, the specificity of processing on the hearing aids (3-channel versus 15-channel), and the patient’s prior history with amplification may be responsible for the current observations. Recall that the patient’s threshold was 50 dB HL at 250 Hz but 60 dB HL at and above 500 Hz. In the 15-channel hearing aid, the channels with the center frequency at 250 Hz and 500 Hz were each assigned different gain based on the threshold values. In the 3-channel hearing aid, all the frequencies below 800 Hz were grouped into the low-frequency channel. Despite the 10 dB threshold difference between 250 Hz and 500 Hz, both frequencies received the same gain at 500 Hz. In other words, the patient had been receiving more gain at 250 Hz in the 3-channel hearing aid than in the 15-channel hearing aid.

The difference in gain specificity alone may not be the major reason for the patient’s complaint. Rather, the fact that the patient was accustomed to the extra low-frequency (and sound quality) of the 3-channel (over the 15-channel) hearing aids may have triggered this complaint. To this end, it is extremely important during fine-tuning to be familiar with the patient’s amplification history, including the electroacoustic characteristics of the previous hearing aids for referencing purposes.

CONCLUSIONS

This case illustrated several important points in managing the ampclusion complaint:

- A systematic approach to fine-tuning may uncover uncommon/unconventional reasons for the ampclusion complaint.
- Objective measures (such as real-ear measurement) are important tools to confirm and/or reveal the physical basis of fine-tuning changes on hearing aids.
- The Ampclusion effect is not always a result of excessive sound pressure level in the ear canal. This case illustrates how insufficient sound pressure level in the ear canal may also be a cause of the complaint.
- The increased frequency specificity on a hearing aid does not always guarantee increased satisfaction.
- Prior experience with hearing aids plays an important role in the ampclusion effect (as in other subjective perception tasks).

REFERENCES


Appendix A. Ampclusion Checklist

The response options that were underlined were reported during pre-adjustment of hearing aid settings. The response options that were boxed were reported after adjustments on the 15-channel hearing aids.

Name: _____________________________                    Date: ____________________

Hearing Aid Model: (R)_____________________   (L)_________________________

Step I: Set right expectations (prior to hearing aid selection)

- Ask the wearer: Say “Baby Jeannie is teeny tiny” with fingers in ears (or pressing tragus)
- Explain and counsel wearer

Step II: Choose optimal hearing aids (at hearing aid selection)

- Hearing aid hardware requirement
  - Carefully designed multiple channels (>2 channels) with steep, narrow filters
  - Mechanisms to minimize potential of input and output saturation distortion
  - If digital, short group delays (less than 10 msec)
- Hearing aid processing requirement
  - Nonlinear (wide-dynamic-range compression [WDRC]) hearing aids allowing automatic gain change, e.g., reduced gain at high inputs
  - Flexible and discrete gain adjustment in lows
  - Active feedback cancellation
- Other considerations
  - Select-A-Vent option
  - Canal length for comfort and ease of insertion

Step III: Ensure adequacy to external sounds/fit (at hearing aid fitting)

1. Check to ensure output of hearing aids meets insertion gain targets for SOFT NORMAL LOUD sounds

2. Ask the wearer: How is the physical fit of the hearing aids ( earmolds) in your ear?
   - Too tight          J ust right          Too loose

Step IV: Establish the need for intervention (at follow-up)

3. Ask the wearer: (discourse passage at conversational level) How do your hearing aids sound to external sounds?
   - Loudness: too loud comfortably loud too soft
   - Quality/naturalness: too boomy clear and natural too tinny
   - Distortion: crackling/raspy crisp and bright muffled

4. With the hearing aid(s) in the wearer’s ears, ask the wearer: How does your own voice sound to you when you say “Baby Jeanie is teeny tiny”?
   - Loudness: too loud comfortably loud too soft
   - Quality/naturalness: too boomy clear and natural too tinny
   - Distortion: crackling/raspy crisp and bright muffled
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5. **Ask the wearer:** Which of the following adjectives describe your perception of your own voice?
   - fine
   - louder
   - hollow
   - echoic
   - raspy
   - distorted
   - muffled
   - talking under water
   - talking through my throat
   - talking through my nose
   - talking through my head
   - talking through my nose
   - talking through my head
   - talking through my throat
   - stuffed-up
   - dull
   - can’t hear own voice
   - Others (specify): ______________________________________________________

6. **Ask the wearer:** On a rating scale from 1 to 10 with “1” the most unnatural and “10” the most natural, how would you rate your voice with the hearing aids?
   (most unnatural) 1 2 3 4 5 6 7 8 9 10 (most natural)

7. **Ask the wearer:** How much does your voice problem affect you (if appropriate)?
   1 - It’s very noticeable and very distracting. I cannot adapt to it.
   2 - It’s moderately noticeable and distracting, but I can adapt to it.
   3 - It’s noticeable but not distracting.
   4 - It’s hardly noticeable unless I focus my attention to it.
   5 - It’s not there (very natural).

**Step V: Diagnosis of amplification origin (at follow-up)**

8. **Ask the wearer:** Turn off your hearing aids. With the hearing aids in your ears, repeat the phrase “Baby Jeanie is teeny tiny.” Compare the quality of your voice between the hearing aids “on” and “off” positions. Is there a difference?”
   - “OFF” sounded better (amplifier origin)
   - “OFF” sounded worse (amplifier origin)
   - No difference (shell origin)

9. **Ask the wearer:** Is your voice worse with one hearing aid or both hearing aids?
   - Worse with one
   - Worse with both
   - No difference between one and two

10. **Ask the wearer:** Does your voice problem change if you speak louder or softer?
    - Worse when speak louder (saturation/excessive gain)
    - Worse when speak softer (insufficient gain)
    - No difference (shell origin)

11. **Ask the wearer:** Does your voice problem change if you push the hearing aids in deeper or pull them out slightly?
    - Push in sounds better (increase length/seal)
    - Pull out sounds better (vent/leak/shorten length)
    - No difference (amplifier origin?)

12. **Ask the wearer:** How would you rate your hearing aids (#6 and #7) after the adjustments? How do they sound to external sounds (#3)?
Appendix B. Solution Identification Worksheet

As a background note, the three dimensions (and the available options) used in Steps III and IV of the “Ampclusion Checklist” were used to identify the electroacoustic basis of specific patient complaints. They were selected from a larger collection of adjectives/descriptors that hearing aid wearers used when reporting sound quality problems to our in-house audiologists. These descriptors were recorded along with the recommended electroacoustic adjustments to alleviate the complaints. The result is the “Solution Identification Worksheet.” This is a combined (two-tier) 3 x 3 matrix that shows the electroacoustic parameters (frequency channel [low, mid, and high] by gain parameter [soft, normal, and loud]) that may be adjusted in order to minimize the complaints listed within the matrix. The first half of the display summarizes complaints that require a gain increase in the appropriate gain parameter. The bottom half summarizes complaints that require a gain decrease. To use the worksheet, the patient finds the descriptor on the Worksheet that best describes his or her problem, and the audiologist adjusts the electroacoustic parameters that are associated with that complaint. Some descriptors are located in more than one cell because more than one parameter has been shown to be effective in minimizing the complaint. Although no formal statistics were collected on the effectiveness of using this worksheet, informal sampling of opinions among our in-house audiologists and dispensing customers who used this worksheet suggests that the recommendations are effective in over 80% of the cases. It is also of interest to note that similar solutions have also been proposed by other authors (e.g., Jenstad et al, 2001).

Instructions: Please circle the phrases that best describe your sound perception with your hearing aids.

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<td>Can’t Understand</td>
<td>Endings of Words Unclear</td>
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