

# How flow charts can help you troubleshoot hearing aid problems

By Francis K. Kuk

Dispensing professionals frequently have to solve their clients' complaints either through adjustment of the electroacoustic parameters, modification of the hearing aids, and/or counseling.

Many attempt the same solution for seemingly the same complaint, but encounter varying degrees of success each time. Such variability may be related to practitioners' incomplete understanding of the problem and/or that the solution they select is not always the right one for the same complaint—for which there may be many solutions.

Rather than arbitrarily trying different solutions, the use of flow charts offers a more systematic approach to troubleshooting. In this approach, potential solutions are

## CONSTRUCTING A FLOW CHART

Following are some procedures and rules to follow in constructing a flow chart.

### *One flow chart per complaint category*

Flow charts should be constructed *prior* to the need to troubleshoot. Then they will be ready for use when a wearer presents a complaint. For simplicity, one flow chart should be made for each category of complaint. Dispensing professionals will find it helpful either to construct their own flow charts or obtain flow charts for the most common complaints/problems, such as “inadequate gain before feedback.”

**Table 1:** Causes, procedures, solutions, and priority of evaluation for the “inadequate gain before feedback” complaint.

Causes	Procedure	Solution	Priority
Inadequate gain	Check specification	Replace model	1
Receiver touching shell	Forced feedback test	Manufacturer repair	2
Receiver tube cracked	Forced feedback test	Manufacturer repair	2
Wax at receiver opening	Visual examination	Remove wax	3
Receiver/microphone	Visual examination	Manufacturer remake	4
Leakage/HA fit	Visual, Comply wrap	Increase girth	5
Leakage/vent	Decrease vent	Decrease vent	6

attempted in a logical sequence. This may decrease variability in effectiveness, assure the quality of the intervention, and save valuable clinical time.

## WHAT IS A FLOW CHART?

A flow chart is a graphic representation of the logic involved in solving a problem or of the steps followed in providing a solution. Computer programmers use flow charts frequently in designing computer programs. In essence, computer programs are actions performed by the computer while it follows the steps and instructions specified on the flow charts.

The same principles can be applied to solving any complaint from a hearing aid wearer. The following discussion summarizes the steps in constructing a flow chart, using as an example the complaint of “inadequate gain before feedback.” (For practitioners fitting the Senso hearing aid, inadequate gain before feedback is seen as a negative number rather than “0” when one performs the feedback test.) The flow chart to solve the complaint “my voice sounds funny” is also included as an additional illustration.

### *List all the potential causes*

The completeness and effectiveness of a flow chart depend on how much the dispensing professional knows about the potential causes. The more information the practitioner has about the product, the patient, and the complaint, the more complete the flow chart will be. Table 1 summarizes the most common causes of the “inadequate gain before feedback” complaint, and then lists procedures for identifying the particular cause and the solutions available.

### *List procedure to test each potential cause*

A flow chart needs to indicate how to evaluate each potential cause. Thus, all the steps/procedures to evaluate the causes must be known in advance. Table 1 lists the main steps to check out each cause. For example, visual inspection can determine if cerumen is present or the direction in which the microphone/receiver is pointed. The “forced feedback test” may help determine if there is an internal hearing aid problem.

## Prioritize the sequence of evaluation

Not every potential cause is equally likely to be responsible for the problem. Also, the causes may be interrelated. Dispensing professionals must assign a priority to these causes so that they may examine them sequentially, thereby saving time and minimizing oversight.

Clinicians may disagree on the sequence of evaluation. Some prefer to look first at those causes that appear to be the easiest to fix. In this case, “closing off the vent” may be the simplest and quickest solution. While this may be our first line of defense against this problem, closing off the vent can also increase the perception of occlusion.

An alternative is a “bottom up” approach. That is, the most fundamental cause is considered first and the most superficial last. In this example, if the receiver touches the shell of the hearing aid, it is

easily before adequate gain is achieved. Any of these causes would make restricting the vent ineffectual. In this approach, these possibilities should be eliminated before checking for other causes.

Cerumen in the ear canal that partially blocks the receiver opening acts like a reflective surface and increases the chance of feedback. Likewise, if the receiver opening is directed at the wall of the ear canal, sounds could also be reflected back and limit the gain of the hearing aid before feedback. A comparison of the un-cut earmold impression with the actual custom hearing aid is necessary to determine if the receiver opening is directed properly (toward the eardrum and not at the ear canal wall). If the receiver is not directed properly, changing the length of the canal portion may redirect the output. The possibility of improper receiver direction should also be eliminated prior to other manipulations. Contrary to conventional practice, in using

a flow chart is constructed one action at a time. All the potential causes and the steps to evaluate each cause are arranged in a hierarchical order in a flow chart. Questions are asked to determine the next action after a specific cause is evaluated.

Typically, the questions are written to require a “yes” or “no” answer. Different categories of actions are represented by different symbols. An ellipse is used to indicate the complaint or start of the actions. Instructions, actions, etc. are indicated by rectangles or squares, whereas questions are represented by diamonds/rhomboids. A circle at the end of the flow chart indicates termination of the algorithm. Figure 1 provides the appropriate flow chart to correct for the “inadequate gain before feedback” problem.

## READING THE FLOW CHART

It is normal to find a flow chart intimidating at first sight. However, it becomes much more manageable if one simply follows the direction of the arrows and focuses on one action at a time.

In Figure 1, the flow chart starts by assuring that the hearing aid is capable of providing adequate gain. This can be determined simply by reviewing the specification sheets. A stronger model will be necessary if the hearing aid has insufficient gain. If this is not the problem, one proceeds to the next step to determine if internal problems may be resulting in “inadequate gain before feedback.” To verify that, one performs a “forced feedback” test on the hearing aid while closing off the receiver opening. If there are no internal problems (e.g., receiver touching the shell or tubing issues), the usable gain from the hearing aid should be appropriate for the degree of hearing loss. (This is reflected as “0” feedback value in all channels if one is fitting the Senso with the LP2 programmer.)

The question, “Feedback (Fb) value 0/0/0?” examines the adequacy of usable gain. A “Y” answer suggests the absence of internal problems, so the hearing aid should be evaluated for a peaky frequency response. A peaky response and/or an internal problem should alert the dispenser to return the hearing aid to the factory for repair/remake. The absence of such problems (as indicated by “N”) should lead one to examine external causes for the problem.

Cerumen partially blocking the receiver

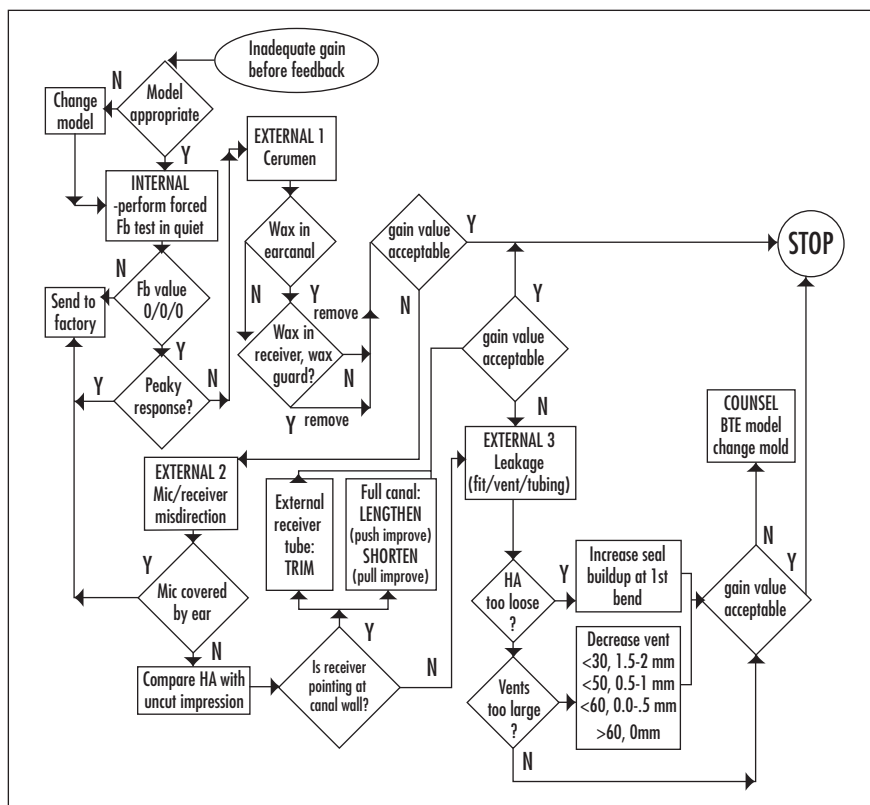


Figure 1. Flow chart for the complaint “inadequate gain before feedback.”

likely that any vibrations from the receiver will be transmitted by the shell to the microphone and result in feedback. A cracked receiver tube will cause internal feedback. A hearing aid with a peaky response will also run into feedback more

this approach, one would reduce the size of the vent or increase the size of the hearing aid last.

## Putting it together

Just as a house is built one brick at a time,

opening can increase the likelihood of feedback. It is important to rule out this potential cause prior to taking other actions. Visual inspection of the ear canal, as well as of the receiver opening, will either confirm or eliminate this possibility. If there is cerumen, after it is removed, it is necessary to perform the feedback test again with the client wearing the hearing aid. The evaluation can end if adequate gain is achieved. Otherwise, other potential causes should be evaluated.

A second potential external cause of the problem is misdirection of the transducers. The hearing aid microphone opening may be covered by the tragus. Visual examination can rule out this possibility. If microphone placement is a problem, the hearing aid should be returned to the manufacturer for re-positioning of the microphone. It is helpful to mark on the faceplate the desired microphone location. As explained earlier, the receiver opening may

problem. If no extended receiver tube is used, one may need to remake the shell of the hearing aid (or earmold) so that the receiver does not point at the canal wall.

To determine if one should increase or decrease the length of the canal portion, one may pull the hearing aid out slightly and re-measure gain before feedback. An improvement in gain (before feedback) suggests that the canal portion needs to be shortened. On the other hand, if an improvement in gain before feedback is seen when the hearing aid is pushed in, an increase in the canal length is warranted. If none of these manipulations improve the gain before feedback, one should examine the last possibility.

Checking the fit of the hearing aid would be performed first. A quick way to check is to increase the girth of the canal portion around the first bend of the hearing aid/earmold. The use of canal sleeves or Comply-Wrap™ offers a quick way to

aid. Widex Hearing Aid Company uses the hearing loss at 500 Hz as a guideline to set the vent size. For a custom product, a minimal vent size of 1.5 mm to 2.0 mm is used for hearing losses less than 30 dB HL. The vent size is decreased by 0.5 mm for every 10-dB increase in hearing loss.

A pressure relief vent or no vent at all is used for hearing losses exceeding 60 dB HL. Note that this venting guideline is the minimal vent diameter and every effort should be made to use a larger vent without risking feedback. Consequently, one should try to maintain at least this vent size when trying to overcome the “inadequate gain before feedback” problem.

If these manipulations fail to achieve the appropriate amount of gain before feedback, a behind-the-ear hearing aid should be tried because of the decreased likelihood of feedback. This will be the termination point of the attempt to stop the “inadequate gain before feedback” problem.

## “MY VOICE SOUNDS FUNNY”

The flow chart in Figure 2 starts with a determination of whether the patient’s previous experience may be contributing to the “my voice sounds funny” complaint. This can be the case, especially with new wearers or those who switch from a monaural to a binaural fitting. In addition, digital hearing aids that have a long delay can result in an “echoic” sensation to the wearer’s own voice.<sup>1</sup> Knowing this information may help the dispensing professional select the appropriate hearing aid and/or properly counsel clients *prior* to the hearing aid fitting and to the complaint being made. Because counseling is important in managing this complaint, the action “counsel and demonstrate” is recommended regardless of the answers (“yes” and “no”) to these questions.

There are at least two inter-related contributors to this complaint in a hearing aid. One has an acoustic origin (amplifier occlusion) and the other a physical origin (shell occlusion).

Acoustically, the complaint may arise if the sound pressure level in the ear canal is significantly different from what the wearer expects. This can result from excessive sound, too little sound (from inadequate gain and insertion loss), too much compression, or too much distortion in the output. Modification/correction of the output may alleviate this complaint.

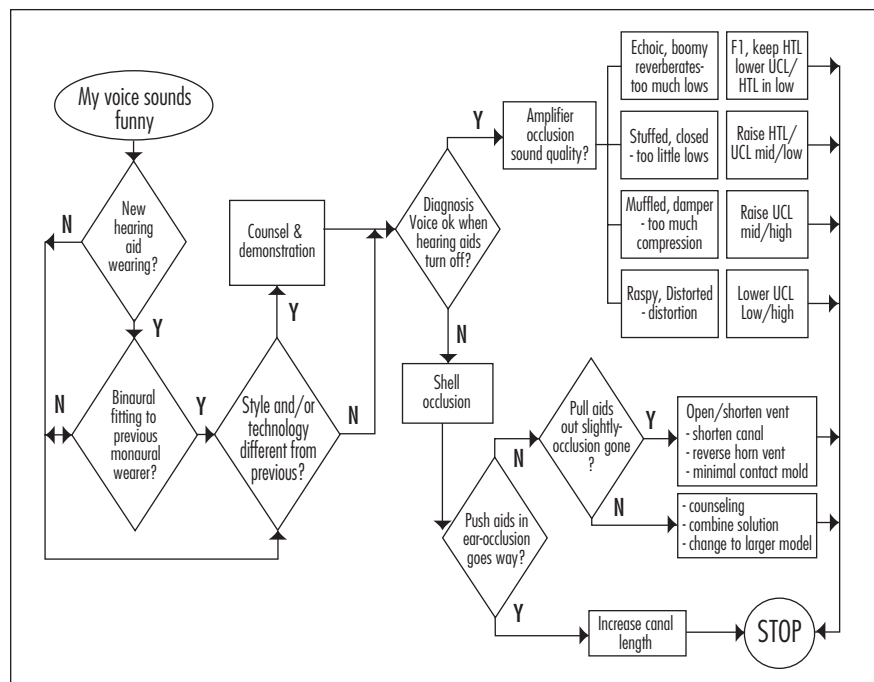


Figure 2. Flow chart for the complaint “my voice sounds funny.”

point at the ear canal wall instead of toward the tympanic membrane. This is difficult to evaluate unless one has kept an original copy of the un-cut ear impression.

In the absence of the ear impression, one may estimate the impact of any receiver misdirection by varying the length of the hearing aid canal portion. If an extended receiver tube is used and it points at the wall of the ear canal, shortening the extended receiver tube may alleviate the

ascertain this possibility. If gain before feedback improves, one can terminate the troubleshooting process. Otherwise, one needs to reduce the vent size of the hearing aid.

One can decrease the vent size of the hearing aid until acceptable gain is achieved. The question is, how much vent reduction can the wearer tolerate before occlusion becomes a problem? Unfortunately, other than trial and error, there is no standard for the acceptable vent size on a hearing

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From the physical standpoint, the presence of the hearing aid shell/earmold in the ear canal alone and how it changes the conduction of sounds to the ear can give rise to the “voice sounds funny” complaint.

For most wearers, it is a combination of acoustic and physical factors that leads to this complaint.

To decide on the proper course of action, it is important to determine at the onset if the acoustic or physical contribution is greater. To do this, have the wearer repeat the phrase “Baby Jeanie is teeny tiny” at a normal level while the hearing aids are turned off.<sup>2</sup> If the “voice sounds funny” complaint disappears (or is reduced), that suggests that the complaint may have a major acoustic contribution. If the perception persists, the physical presence of the hearing aid in the ear may be responsible for the complaint.

Knowing the sound quality of the complaint gives a further indication of the specific hearing aid parameter to adjust. It is important to ask wearers how their voice sounds. It may be necessary to ask them to imitate their perception for clarification. In many situations, subjective comments like “echoic,” “hollow,” or “boomy” generally indicate too much “loudness.” Because low frequencies contribute much more to “loudness” than do high frequencies, lowering the low-frequency gain of the hearing aid may reduce the perception. Because the wearer’s voice will be 15 dB to 20 dB higher at the hearing aid microphone than at a typical conversational distance,<sup>3</sup> one needs to lower the uncomfortable loudness (UCL) or the gain parameter for high-input level sounds.

Sometimes the “voice sounds funny”

perception may be due to inadequate output from the hearing aid. Typically, wearers use terms like “stuffed” or “closed.” This probably arises from too little output in the low frequencies, and is sometimes seen in completely-in-the-canal (CIC) hearing aid wearers. Pirzanski reported that increasing the gain in the low/mid frequency for all input levels, i.e., hearing threshold level (HTL) and UCL, alleviates this complaint in some wearers also.<sup>4</sup>

Not all complaints of “voice sounds funny” have to do with occlusion or too much sound pressure in the ear canal. Too much compression or gain reduction at high inputs can lead to the “muffled” or “dampened” sensation. Increasing the gain for high-input sounds (UCL) will alleviate this problem as long as the maximum output of the hearing aid is within the tolerance limit of the wearer. On the other hand, if the wearer describes the perception as “raspy” or “distorted,” it may suggest saturation of the hearing aid. In this case, lowering the gain at high-input level (UCL) may be helpful.

Dispensing professionals have used two “physical” approaches to solve the same problem. One is to increase the length of the ear canal beyond the second bend.<sup>4</sup> The rationale is to decrease vibrations from the cartilaginous portion of the ear canal (and thus reduce low-frequency output). The alternative approach is to shorten the ear canal and decrease the amount of occlusion of the ear canal.

Both these approaches have been successful for some. To determine the right approach in a particular case, the dispensing professional can push the hearing aid inward and ask if the wearer notices any decrease in the occlusion perception while vocalizing. If the response is positive, an increase in the canal length may be helpful. If the answer is negative, the practitioner may want to pull the hearing aids out slightly and ask if the wearer notices any improvement in the occlusion. If that improves the perception, any one of several methods, such as increasing the vent diameter, shortening the canal, or a minimal contact earmold, may be attempted. On the other hand, if pulling the hearing aid does not improve the perception, counseling and a BTE hearing aid with an open earmold may be the only solution.

## CONCLUSION

The two flow charts accompanying this article illustrate how one can solve a wearer’s complaints in a systematic manner. The merit of charting the sequence of evaluation is that the “correct” solution can be consistently identified in the least amount of time. Its use is especially helpful in large practices where there are many dispensing professionals of varying levels of skill and experience. By solving the wearer’s complaints with the aid of a flow chart, one can increase the likelihood that all the practitioners will be successful in their problem solving. (HJ)

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