

Chapter Nine

Cochlear Implants and Options for Persons with Profound Hearing Impairment

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INTRODUCTION

A revolution in the treatment of deafness began with the combined efforts of otologists and engineers in the 1950s and 1960s (1–4) when they sought to apply technical skill with emerging technology. A greater revolution, however, occurred in professional thinking about rehabilitative options, which could and should be offered to persons with profound hearing impairment. For a group whom hearing aids could not stimulate and no surgical treatment had been appropriate, the era of cochlear implants heralded a dramatic alteration in approach. Even the crude stimulation provided by the early implants was a new possibility for breaking down barriers of silence.

The revolution in thinking was that adults with adventitious profound hearing impairment should be targeted for rehabilitative efforts. The limitations in capability of hearing aids for this group implied that adults with profound impairment were frequently offered powerful behind-the-ear (BTE) or body aids that pro-

vided only vibrotactile, rather than auditory, stimulation to the ear. True auditory stimulation was beyond the existing hearing aid technology. Due to frustration, the disappointing results experienced with hearing aids often caused both client and clinician to suspend further efforts to improve communication or enhance knowledge.

Under these circumstances, even the crude envelope cues delivered through the electrical stimulation of an early single-channel implant were a significant forward step. The advance, however, demanded that audiologists develop appropriate therapeutic methods to maximize utilization of the new codes. This drive to develop treatment methods for persons with cochlear implants had consequences for care of the broader hearing-impaired populace. A renewed emphasis was placed on training methods to develop auditory and auditory-visual skills. Counseling to facilitate adjustment to newly fit devices became necessary. Thus, more and more, audiologists were being asked to provide information about devices and therapy for those with severe and profound impairment.

This chapter will discuss the options that have developed, and can be offered to the adventitiously deafened. The issues that will be addressed are:

- Who is a candidate for these specialized rehabilitative efforts?
- What age should a candidate be?

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- What processing strategies are available to provide sensory stimulation?
- What risks, costs, and benefits are entailed?
- What are the steps in rehabilitative planning?
- What alternative devices are available when a cochlear implant is not feasible?
- What rehabilitative plans should be developed for individuals?

CANDIDACY FOR REHABILITATION

A clinical audiologist encounters many persons with suboptimal adjustment to severe or profound hearing loss. For these individuals, obtaining the most appropriate auditory aid, if feasible, is usually the first order of business. Nonetheless, such efforts may meet with limited success, resulting in minimal auditory information availability. Despite the best efforts using conventional amplification, there may be poor communication, as well as the psychological, vocational, and social consequences associated with adventitious deafness.

The persons who should be invited to participate in rehabilitation are those who display knowledge deficits and dysfunctional communication methods. It may be less important to determine candidacy based on a set of audiometric data than on an observed breakdown in communication and motivation to improve one's status. The traditional approach to selecting candidates for cochlear implant evaluation has required the individual with hearing impairment to meet several criteria: profound sensorineural hearing loss of cochlear site; postlingual onset of deafness; extremely poor word recognition in open-set test paradigms; sufficiently good health to withstand the challenge of anesthesia and surgery; radiologic findings—usually using magnetic resonance imaging (MRI)—indicating a patent cochlea; “normal” psychological examination results; and realistic expectations for benefit from an implant.

The issue of attribution of the loss to damage in the cochlea is based in large part on historical information and audiometric data. Of particular use, if available, are serial audiograms, which may depict the decline of hearing over a time period, in addition to site-of-lesion examinations, such as brainstem auditory evoked potential results. It is imperative that the person with severe or profound hearing loss be given the full otolaryngologic and audiologic diagnostic examination required for sensorineural lesions to verify the etiology, and to assure that

the eighth nerve is viable. Many clinicians use promontory stimulation¹, a procedure in which electrical stimulation is delivered by a needle electrode placed on the promontory of the middle ear (5–7), or evoked potentials resulting from such signals (8,9) to verify responsiveness of the auditory nerve.

Obviously, thorough medical evaluation is crucial to determination of candidacy, so that treatable causes of deafness, such as lues, have been fully assayed prior to expending efforts in counseling and rehabilitation. Thus, treatment of these potential candidates is clearly a team effort (10–12), in which the audiologist and physician are synergistically involved in evaluating the impediments to a variety of rehabilitative options.

These criteria for contemporary cochlear implants are undergoing modification, by virtue of the demonstrated success of such devices. The accumulation of data indicating higher expectations for performance on speech recognition tasks (13,14), has caused the Food and Drug Administration (FDA) to propose expanded eligibility for implants to those persons who have “severe” impairment. The selection of the latter term may be unfortunate because, in this application, they did not intend the audiometric definition of severe degree, that is, 56–70 dB Hearing Level, HL (15, p. 105). The intended meaning of “severe” in this application concerns better speech recognition than heretofore accepted for cochlear implant candidacy. At this time, the aided ability to recognize up to 30 percent words correctly in sentence material, such as the Central Institute for the Deaf (CID) Sentences or the more difficult Iowa Sentences, still may permit an individual to be considered for a cochlear implant. The work of Shallop, Arndt, and Turnacliffe (16) and Brimacombe, Arndt, and Staller (17) provides indications that this is the correct direction in which to move, provided that careful subject selection is followed. This revolutionary change is intended to reflect the improved performance obtained by many persons who previously had implants with the most recent generation of cochlear implants.

Persons with postlingual onset of deafness (i.e., acquisition of profound hearing loss after learning language) have been shown to be more successful users of cochlear implants than persons of pre- or perilingual onset. Nonetheless, there have been numerous demonstrations indicating that persons with prelingual or congenital onset of profound hearing loss can benefit substantially from use of a cochlear implant (18–23). The

¹Kessler MA, Spitzer JB, Preece J, Kveton JF. Psychoacoustic testing via promontory stimulation in cochlear implant candidates. (Unpublished).

determination of whether a person with prelingual impairment should be implanted is influenced by the degree of motivation to hear sound and social circumstances (involvement in hearing versus deaf society), and must be weighed against minimal-to-moderate speech discrimination and sound awareness obtained even with multichannel implants (23).

Another category of persons for whom technology offers new opportunities for restoration of hearing sensation are those with bilaterally severed eighth nerves most often due to excision of acoustic neuromas. This situation may apply to persons with neurofibromatosis (24). For such persons, a cochlear implant is inappropriate because the acoustic nerve is interrupted by disease and/or surgical intervention. An investigational device, an auditory brainstem implant (ABI), provides electrical stimulation at the level of the cochlear nucleus (25). The findings to date indicate that performance with a brainstem implant is comparable to that of single-channel cochlear implants. That is, brainstem implants provide sound awareness that supports lipreading to a potentially effective level for communication. This type of processing does not permit fine discrimination for speech recognition without visual cues.

It is also necessary to consider that some persons who may present themselves for evaluation for an implanted device may be disqualified on auditory (i.e., too much hearing or speech recognition in excess of the criterion), medical (e.g., poor health, could not qualify for surgery, ossified or fractured cochleae, intractable otologic disease), or psychological (including psychologic disorder, unrealistic expectations) bases. Such persons may nonetheless be in need of rehabilitation, and aspects of the present chapter are pertinent.

Age Considerations

Age was once a major consideration in candidacy for implants. Cochlear implants are now offered to adults of any age, without a specific upper age limit. More differentiating than chronological age is medical status. There are healthy persons in their 80s (the oldest, we understand was 89.7 years old at the time of implant) who have been implanted successfully with FDA-approved implants (personal communication with Nancy Brehn of the Cochlear Corporation). For implants under investigational trials, a stricter age selection criterion applies. Typically, in such studies an upper age limit of 70 is applied.

At the other end of the age continuum, cochlear implantation has been successfully applied with children

(26–28). In the most obvious application—in which a child who has acquired language is suddenly deafened, as occurs in cases of meningitis—the response is frequently excellent, in parallel to that obtained in adventitiously impaired adults. In these cases, however, due to rapid osteogenesis, careful evaluation to determine patency of the cochlea is required. Despite efforts to assess the individual, the growth of new bone within the cochlea may limit the depth of electrode insertion (29) or require use of electrodes designed specifically with this problem in mind (30).

For children who are congenitally impaired, all aspects of the evaluation and habilitation are complex (31). The evaluation process and determination of amenability to habilitation are extended over a sufficient time period for conditioning of replicable responses to sensory stimuli. The cochlear implant team must ascertain that the child will be capable of responding to electrical stimulation in a manner that will permit processor programming. Further, the parents and the school system must enter into an agreement for the long-term process of education coordinated with the implant team. Given these and other caveats, the careful selection and therapeutic steps that are undertaken have yielded very rewarding auditory (32,33) and speech and language (27,28) results. For an in-depth discussion of the issues regarding, and ramifications of, cochlear implants in children, the reader is directed to Owens and Kessler (34) and Geers and Moog (35).

ALTERNATIVES IN PROCESSING STRATEGIES

The delivery of the signal and the mode of electrical stimulation in cochlear implants are undergoing continual refinement. A variety of devices has appeared on the market (some in investigational status). Some of these devices, such as the 3M/Vienna, have failed to fulfill their early promise and are now no longer offered to clients.

A summary of the predominant processing modalities and current devices is presented in **Table 1**. Devices may be compared based on the number of electrodes and mode of stimulation. While it seems intuitive that the more electrodes, the better, the finding of clinical application is that multichannel devices are superior to single channel implants, but a maximal number of electrodes has yet to be revealed. Excellent performance has been documented with a 4-channel device, the Ineraid, while

Table 2.

Examples of significant recent findings with contemporary cochlear implants.

Study	Implants	Study Design	Significant Findings
Gantz et al. (40)	3M/House Vienna Nucleus WSP Ineraid, Storz	N=54	Multichannel devices shown to provide superior performance compared to single channel devices (3M/House, Vienna).
Cohen et al. (41)	Nucleus	Small sample	Telephone performance showed open-set speech recognition
Dorman et al. (42)	Ineraid	Small sample	Telephone performance achieved open-set ability
Waltzman et al. (43)	Nucleus WSP, Nucleus MSP Ineraid 3M/Vienna	Prospective, randomized	Clear advantage of multi-channel over single-channel (3M/Vienna) device. Improved performance with MSP over with WSP.
Schindler & Kessler (14)	Clarion	Clinical trial	Open-set speech discrimination
Chouard et al. (30)	Digisonic	Preliminary report (clinical trial is not required in France)	French device achieves practical results in this trial. Authors also present a version of the device, which is designed for implantation in ossified cochleae.

reduced from pre-implantation assessment to that at the time of stimulation (47). The level of reduced handicap as assessed at 3-months postimplantation was maintained at the final assessment in the study—2-years. In addition, the veterans' significant others also responded to questions about the handicapping effects of hearing loss. They reported observing significant reductions in handicap from pre- to postimplant time intervals, as well.

Quality of life is also measured using questionnaires. In the VA study, quality of life was assessed at the same intervals as handicap measurement. The questionnaire examined such issues as attendance of social functions, satisfaction with relationships, feelings of isolation, and participation in various activities, such as recreation. The veterans reported a significant improvement in quality of life from pre-implant to the time of stimulation. In parallel to the changes in handicap perception, the improvements were maintained until at least the 2-year measurement. Again, the veterans' significant others also reported that they observed a significant improvement in quality of life.

Perhaps as cogent regarding benefits of implantation is assessment of consumer satisfaction (48). Persons with cochlear implants (N=17), users of a variety of single- and multichannel devices, responded to a survey regarding their satisfaction with their implant. Seventy percent indicated that they wear their device "always" or "practically always." These individuals expressed "very positive" overall feelings about the benefit obtained.

Only 18 percent felt that the use of the implant was "mostly negative," with the problems outweighing the benefits. Significantly, 88 percent (15 of 17) of this small sample asserted that they would definitely go through implantation again if they had to make that choice. Large scale studies of this nature are required to ascertain an insight into the consumer satisfaction response of users more broadly.

Some benefits are more difficult to measure, but can only be estimated. What is the value of restoring a person's ability to work or retain a job? What is the cost of failing to do so? What is the value of obtaining education commensurate with one's intellectual potential? On a more esoteric basis, what is the value of enhanced quality of life, such as the ability to hear one's child's (or grandchild's) voice? Or to monitor one's own voice effectively? Among our adults with implants, we have had individuals return to and complete college, and retain work or achieve promotion.

Nonetheless, in the evolving environment of healthcare, it is essential that the efficacy of many medical and rehabilitative treatments be demonstrated to be fiscally sound. Formal analysis of cost effectiveness of multichannel cochlear implants was described recently by Wyatt and his coworkers (49). We used a theoretical approach to calculate the quality-adjusted life-year (QALY) to estimate the value of cochlear implantation in adventitiously impaired adults and compare it to health benefit relative to the costs of other surgical procedures, such as

coronary artery bypass graft, implantable defibrillator, and heart transplantation. Some aspects of the calculations (e.g., risk of complications), can be precise, based on previous research. Other aspects, such as life expectancy, are based on population statistics and reasonable assumptions. In this manner, Wyatt et al. derived a cost per QALY of \$15,593 (this figure has a true value that lies between \$12,000 and \$30,000). The cost per QALY compared very favorably with frequently applied cardiac procedures, which ranged from \$29,200 to \$64,033. The cost per QALY would be affected in the future by changes in the major cost factors, price of the implant device and surgical fees.

When considering cost effectiveness for other subject groups, Wyatt et al. made the point that when working with persons with either shorter or longer life expectancy (i.e., with the elderly or children), the calculated cost per QALY changes. The cost per QALY calculation of \$30,776 for an elderly individual with a 10-year life expectancy still falls within a range that is acceptable in current healthcare circumstances. Dependent upon the extent of postimplantation rehabilitative benefit, and with the expectation of reduced costs of special education and higher long-term earnings, the cost per QALY for children would be expected to be very low.

Cost/benefit analysis has not been done for less invasive forms of rehabilitation, such as intensive communication therapy, or devices, such as vibrotactile or assistive listening devices. For some appropriate individuals, these approaches may yield very high benefits at lower costs than implantation. Certainly, in persons for whom implantation is not an option, these methods are necessary, so that cost-effectiveness data are needed to support their reimbursement by third-party payers.

PRACTICAL ASPECTS OF REHABILITATION: STEPS IN THE MANAGEMENT

Initial Counseling and Evaluation

When a person with severe or profound impairment is seen by an audiologist or otologist, the initial task is to get a thorough history of the person. This phase should entail inquiry about the etiologic influences (often several factors, rather than one, are historically important), pattern of hearing loss, previous hearing aid/assistive device use, and previous cochlear implant evaluation. (We have found that many candidates have been evaluated elsewhere and continue to “shop around” for a variety of

reasons.) From the initial meeting, it is important to ascertain the candidate’s information level about deafness in general and implantation in particular. In our program, the candidate and family have been sent informational materials prior to the first meeting, so that they can read in advance and bring questions to the session. From the beginning, we find that improvement of information about implants and the process of being evaluated to determine candidacy are necessary topics of discussion. During this session, it is possible for the clinicians to formulate initial impressions about the maturity of the candidate, insight into the impact of deafness, family supportiveness, and emotional atmosphere in which the deafened individual lives. Taken together, these observations can have an impact on the length, depth, and intensiveness of the counseling that takes place in the context of the cochlear implant evaluation. The following example illustrates the importance of careful interview and initial counseling:

The case of a recent client illustrates the importance of this phase in the evaluation process. F.S., a 52-year-old man, was referred to us as a post-meningitic case, with a sense of urgency in view of the threat of osteogenesis. Upon interview, however, we found out that the individual had been in a motorcycle accident and sustained head trauma (temporal-parietal skull fracture) and subsequent unilateral hearing loss (degree?) several years prior. He had never used a hearing aid on that side. Following sinus infection, he contracted meningitis, at which time the hearing was lost in both ears; this report caused suspicion about the integrity of one side post-trauma, and aided in the selection of the ear to be targeted. Equally important, in the initial session we observed many indications of depression. The person was seeking a “quick fix” for his deafness, was not attempting to lip-read, and was impatient with the prospect of an evaluation process. Thus, in our first encounter with this man, we determined the ear of preference and the need for intensive supportive counseling. In each session scheduled for evaluation, we also allotted time to discuss the importance of lipreading without, as well as eventually with, an implant. Benefits and limitations of implants, discussed with all of our program participants, were emphasized and also served as a vehicle to facilitate adjustment to deafness and promote support of significant others.

The first steps in evaluation entail basic hearing testing and examination wearing a powerful behind-the-ear hearing aid. Thresholds for tones and speech, under

headphones and aided in soundfield, are obtained. Speech recognition is assessed using phonetically balanced word lists and sentence materials, such as the CID or Iowa Sentences. Responses to these materials are used to determine if the person falls into the general category of candidacy applied both nationally, in the FDA criteria, and in accord with local criteria, such as human studies protocols, if applicable.

During the initial evaluation phase, the candidate is encouraged to use a sensory device, such as a powerful hearing aid or vibrotactile aid. For many persons, this period of stimulation may be the first after years without such input. With adults (in parallel to reports for children), sound awareness may be an awakening of interest in communication and motivation in rehabilitation (50). Thus, while providing the individual with stimulation during a trial, we are also informing that person of some of the alternatives to cochlear implantation.

Psychoacoustic and Electrophysiologic Examinations

The extent of psychoacoustic testing is variable at different clinical settings. The content of evaluation protocols has become progressively more streamlined as cochlear implants have passed from investigational to accepted clinical treatment. Psychoacoustic tests evaluate open- and closed-set discrimination and recognition for a variety of stimuli, including speech and environmental sounds. Such examinations continue to be necessary to establish a performance baseline and permit comparisons against known results of persons with cochlear implants. The most widely applied tests of this type are the Minimal Auditory Capabilities (MAC) Battery (51) and the Iowa Battery (52).

An important element in developing a profile of performance pre-implantation is assessment of communication ability with and without an assistive device. Speech recognition ability is measured in each of three conditions (lipreading alone, lipreading with assistive device on, and acoustic signal alone) to determine the extent of benefit derived. In particular, the comparison of scores of lipreading alone versus lipreading with the assistive device demonstrates the extent of enhancement derived from auditory stimulation. A person with little performance difference between the latter conditions derives little benefit from the device worn. The hope is that, should the candidate proceed to be implanted, the performance difference will widen, having achieved an improved performance in the lipreading with cochlear implant condition. There is considerable evidence that

the people who tend to benefit the most from use of a cochlear implant are those who lip-read well unaided prior to surgery (53).

Speechtracking (54) is a method that has been used to assess speechreading and conversational fluency. The technique requires the person with hearing impairment (*A*) to work with a partner (*B*). *B* reads a passage of text, which *A* is required to repeat verbatim. The pair work as a team, with *B* repeating the stimulus or rephrasing as much as necessary for the accurate repetition of the text. Their success is rated by the number of words per minute transmitted between them. Due to the variability of speakers and effectiveness in applying communicative strategies, it is not reasonable to compare speechtracking performance across clinics (55). However, the rehabilitative potential of this technique is apparent, as will be discussed later in this chapter.

Electrophysiologic measurements also have a role in candidate selection. Brainstem auditory evoked potentials (BAEP) are used in adults to confirm profound level of loss. Evoked potentials using electrical stimuli are of great utility in evaluation of children, and are often used to finalize the selection of the side to be implanted (8).

Electronystagmography (ENG) is used to assess the residual vestibular function. In many persons with severe or profound sensorineural hearing loss, vestibular function is markedly diminished or absent. ENG has two purposes in the implant candidate. First, it assists in determining viability of the vestibular portion of the eighth nerve; if a caloric response is obtained, it assists in deducing the responsiveness of the nerve. The absence of responses, however, may not really be informative as the end organ may be the affected locus, rather than the nerve.

Second, the results of ENG assist in counseling regarding the possibility of dizziness postoperatively. It is less likely that any perceptible dizziness will be experienced by the person without measurable caloric responses, than by the one who has even minimal activity. The possibility of postoperative dizziness is of great concern to many people, and has been discussed, perhaps emphasized to excess, among members of the deaf community. As noted in the data by Cohen and Hoffman (38), a very minor occurrence of dizziness has been encountered in large clinical samples, but it is of further reassurance to the person to understand the degree of responsivity of his or her own balance system.

Promontory stimulation is a test that remains controversial as far as the extent to which it contributes to the overall decision-making process. At some clinics, it is

not felt to be very useful (56), although technical factors may play a part in those reports. In other implant programs, promontory stimulation is looked upon as a significant measure that assists in the choice of ear (6). The application of psychoelectric measures, such as loudness and pitch discrimination, gap detection, and tone decay, have been proposed as useful prognostic indicators of postimplant performance (57); findings that have not been replicated consistently.

The aspect of the evaluation that continues to elude the examining audiologists and otologists is adequate prediction of implant performance for any given candidate. For group trends, analysis of pre-implant data as predictors of postimplant outcomes has yielded findings that emphasize pre-implant demographic, intellectual, and lipreading ability. For example, our study (58) indicated that the factors most correlated with implant success were demographic variables (such as occupational category), psychological measures (intelligence score on the WAIS), high motor speed, and pre-implant speechreading and speechtracking scores. Similarly, Waltzman et al. (53) found that intelligence quotient, age at time of implantation, length of profound deafness, length of overall deafness, and lipreading ability were the factors most strongly correlated to the overall composite index. The quest remains to determine, for a given person inquiring about cochlear implantation, what factors will provide insight into the eventual postimplant performance.

Consultation by Other Specialists

Many cochlear implant teams consult with other specialists for assistance in making the decision regarding implantation. A neuropsychologist contributes to the profile of the candidate by assessing intelligence, mood state, and other factors, dependent upon the goals agreed upon with the other team members. In some instances (12,59) additional assessment includes measures of processing time, verbal fluency, linguistic sophistication, personality, and depression. These measures allow the team to view the candidate from another perspective and to determine if impressions regarding the candidate's intellectual function and ability to cope with new processing strategies, situations, and challenges coincide with these aspects when measured objectively.

Our team includes frequent consultation with an optometrist, in view of the importance placed on the ability to lip-read. In view of our finding (12, p. 10) that 64.7 percent of a late-deafened sample required change in prescription to maximize lipreading or to perform well on

videotaped lipreading tests, we continue to find benefit in involving an optometrist early in the evaluation process. This specialist is of special importance in evaluation when congenitally impaired or syndromic individuals are candidates applying for implantation, due to the known co-occurrence of sensorineural hearing loss and visual impairments (60).

Counseling

As can be seen from the chapter to this point, counseling occurs throughout the cochlear implant team's relationship to the candidate. Nonetheless, there are specific topics that must be covered to develop adequate knowledge in the candidate to permit his or her full participation in the decision-making process.

In order to determine which device should be implanted in a given individual, a reasonably complete description of the available implants should be presented. In some programs, where they may have selected to work with only one implant or do not have a research program entailing investigational devices, this issue is not relevant. However, in programs in which devices with different features are offered, the candidate needs to be aware of the known benefits of each. There may be ramifications of receiving an investigational device that a particular candidate finds unacceptable or threatening; on the other hand, some people find the prospect of obtaining the most up-to-date type of implant to be the most hopeful and exciting route. In many implant programs, the opportunity to meet users of various implants is given to prospective candidates in order to allay fears and see the benefits tangibly.

Another aspect that should be an integral part of counseling is use of assistive listening devices (ALDs), such as FM units, telecommunication devices for the deaf (TDDs), and vibrotactile devices. The candidate should know that ALDs are, for some people, an alternative to implantation. In many instances, performance can be enhanced by using an ALD in conjunction with an implant; the latter practice, increasing in frequency, has proven especially effective when connecting an FM device to an implant to improve signal-to-noise ratio and communication across distances. In this regard, promoting trials with, or acquisition of, ALDs during the evaluation phase may bolster the candidate's motivation and provide immediate improvement in quality of life. Further, if the decision is to not implant this individual, some positive impacts have already been seen that may encourage the candidate to follow through on alternative recommendations.

Vibrotactile devices offer an interesting alternative to cochlear implants for some people. The rationales and ramifications of their use are very different for children and adults. In adults, vibrotactile aids are sometimes elected for persons who are unable to receive an implant due to medical contraindications. In our experience (48,61), adults who were adventitiously impaired prefer not to use a vibrotactile device if there is any feasible auditory input. Indeed, while it can be demonstrated to the person that improved speech discrimination and recognition are possible in combined modality (i.e., vision plus tactile stimulation) trials, the device may still be rejected because it is “not hearing.” In spite of these comments, there are many reports of very successful use of a vibrotactile device by adults (62) and children (35).

The discussions with the implant team and previously implanted device users are also intended to foster realistic expectations of the potential benefits of implantation. Through written materials, videotapes, and meetings with people with implants, the candidate must come to understand that cochlear implants have limitations, some of which parallel their experiences with hearing aids, such as difficulty in discriminating or recognizing speech in noisy backgrounds. The concept of restoration of “normal” hearing must be abolished. We have experienced several instances wherein a potential candidate revealed unshakable, unrealistic hopes for outcomes with an implant, such as no longer needing to lip-read or being able to participate in meetings without any constraints. We have encountered candidates in whom such unrelenting, unrealistic expectations were irrational and potentially very destructive, and may have set the individual up for instability of behavior or dire consequences due to possible disappointment postimplantation. If such thoughts do not modify based on counseling about the nature of sound, the variability of the performance of persons with implants, and the continued need to integrate visual and acoustic cues, the candidate may be disqualified on this basis alone.

The risks of implant surgery should be discussed by the otologist, and whenever necessary, reiterated by the audiologist. The risks, as described earlier, may include initiation or exacerbation of tinnitus. This problem can be a very grave concern. Tinnitus has been known to be masked by implant use (63), as well as worsened, so that the full spectrum of possibilities should be addressed in counseling. For example, Tyler (64) reported on perceptions of tinnitus handicap by subjects in the VA Cooperative Study of cochlear implants (43). Of the 22 subjects

who reported tinnitus pre-implant, 9 reported a reduction, while 3 indicated an increase in their tinnitus 2-years postimplant. An additional 3 subjects reported severe tinnitus at 2-years postimplant.

COMPONENTS OF THE REHABILITATION PLAN

The extent to which aural rehabilitation for adults is needed postimplantation remains a controversial issue. It is clear that many adults adjust to implanted sound, beginning within the first few days following stimulation, achieving sound awareness and varying degrees of speech recognition. Some are delighted to obtain open-set speech recognition from this early time period. These initial gains are held well at subsequent assessment intervals, at least to a 2-year postimplant measurement point (43).

Nonetheless, the goals of rehabilitation should not be limited to improvement of speech recognition. The results of previous assessment should also be used to determine the full rehabilitative needs, such as consonant confusions in lipreading or (postimplant) errors in combined modality conditions. Speechreading improvement is a feasible goal, as demonstrated in studies by Massaro et al. (65). The level at which training begins, and the intensiveness of such therapy, should be dictated by the patterns of errors the person demonstrates in vision-only or combined modality trials. Broader communication therapy, including training in assertiveness and “repair strategies,” should be reviewed with the majority of persons with implants or users of other assistive devices. Tye-Murray (66) described the techniques taught to improve understanding when there is a communication failure: the person with hearing impairment should ask the communication partner to

1. repeat the missed word or phrase,
2. simplify the sentence,
3. rephrase the stimulus,
4. give a key word, or
5. break the sentence into two parts.

The individual with hearing impairment should practice these techniques, using them singly or in combination to achieve conversational fluency. An attractive means for this type of practice is through speechtracking with materials of interest to the person with the implant and his or her partner. Such practice can be carried out as a form of

self-directed home therapy, which the user will find very rewarding as speed of communicating information becomes faster and less strenuous, and the repair strategies are absorbed into routine behavior.

Training in recognition of the new electrical code, in parallel to traditional auditory training, is especially necessary for low-functioning persons. They may need guidance beginning at the level of discrimination of presence versus absence of sound, or number of syllables in a signal. Such performance was the rule rather than the exception during the widespread use of single-channel cochlear implants. With multichannel implants, low-functioning persons (i.e., those demonstrating only minimal improvement with their implant over pre-implant aided speech recognition) are increasingly infrequent and should be targeted for intensive training.

Family counseling, begun during the pre-implant phase, is still required in the weeks and months following stimulation. There are readjustments in the way the family interacts that should be facilitated by discussion in group sessions. The audiologist can help to develop understanding of new roles that family members may assume. The development of communication ability in the person with the implant, with increasing independence and assertiveness, causes a restructuring in the family and alteration in previous patterns of interaction. The person who may have been minimally involved in conversations, even in important decision-making discussions, may now demand inclusion. The power structure is often dramatically altered, with a period of upheaval following implantation. So that they have a sense of continuing to participate in the care of the family member with hearing impairment, it is sometimes possible to enlist family members as assistants in maintaining the implant components or other ALDS. These changes may evolve more smoothly in some family groups than in others, but in some cases, both an audiologist and psychologist may need to participate in family counseling.

SUMMARY

In this chapter, the options for persons with profound hearing impairment were discussed. The advances in cochlear implants have made it possible for many people to reenter hearing society and achieve improved independence and quality of life. The alternatives among implant devices, as well as other ALDs, have improved greatly in the last three decades, and it is clearly a major

goal of counseling to fully inform the prospective candidate of the options available. As a reflection of the forward strides in device design, people with implants now frequently achieve open-set speech recognition and conversational ability over the telephone. The need for therapy is highly variable, and should be offered commensurate with assessed communicative deficits. The rehabilitative program should address areas of assessed deficits in knowledge and performance, and strive to assist the individual with hearing impairment to achieve his or her full potential.

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