Selection, Rehabilitation and Follow-up of the Adult Cochlear Implant Recipient in a Private E.N.T. Clinic

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The cochlear implant investigation directed by Dr. William F. House in Los Angeles now includes a number of co-investigator centers across the United States. A major factor in the expansion of this investigation, as well as the increasing numbers of successful implant recipients, has been that a cochlear implant program has been shown to be both practical and feasible in private clinics and rehabilitation centers. The Houston Ear, Nose and Throat Hospital Clinic became a co-investigator with the House Ear Institute in 1978, and since that time sixteen adult patients have been implanted. The purpose of this paper is to discuss the selection, rehabilitation and follow-up of adult implant patients in a private E.N.T. clinic. Variables affecting both patient selection and postsurgical rehabilitation are discussed, and an overview of our implant program from the initial patient evaluation through follow-up is presented.

It has been over twenty years since House implanted his first patient with a single gold hard-wired electrode in the early 1960's. Since that time, well over 300 adults and children have received the single-electrode cochlear implant developed by House and Urban and described by Brackman (1976), House (1978), House, Berliner, and Eisenberg (1979), and Porter, Lynn, and Maddox (1979). The past five years, in particular, have seen a rapid expansion of the clinical trials phase of the cochlear implant investigation directed by House. A number of co-investigator centers across the United States, as well in some foreign countries, are now performing the procedure and reporting similar success (Campos, 1981; Maddox & Porter, 1983a). An important aspect of the expansion of the cochlear implant investigation has been that implant rehabilitation programs have been shown to be both

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practical and feasible in private clinics and rehabilitation centers in addition to funded research facilities (Luetje, 1981).

The purpose of this paper is to discuss the selection, rehabilitation and follow-up of the adult cochlear implant recipient in a private ear, nose and throat clinic.

PATIENT SELECTION

The determination of candidacy for the cochlear implant is not a simple one, and should only be made after a careful consideration of residual hearing acuity, benefits afforded by the use of conventional amplification, patient motivation and additional rehabilitative needs. The initial work-up for potential adult implant recipients is usually scheduled for a period of two to three days. A comprehensive history is collected and a complete ear, nose and throat examination, routine audiometric evaluation (including impedance audiometry and in some cases ABR), and electronystagmography are performed. All patients then undergo a detailed hearing aid evaluation with appropriately fitted hearing aids for both ears utilizing custom earmolds. The use of custom, well-fitted molds is critical as the evaluation should not be compromised by using less than optimal amplification due to feedback associated with ill-fitting molds or stock molds. In addition to aided warble tone thresholds, patients are evaluated on standardized tests of closed-set word discrimination, stress pattern recognition, and environmental sound recognition and discrimination developed by the House Ear Institute, and described elsewhere (House, 1976; Thielemeir, Brimacombe, & Eisenberg, 1982; Maddox & Porter, 1983a). Patients may also be given the *Sound Effects Recognition Test* (SERT) developed by Finitzio-Heiber, Matkin, Cherow-Skalka and Gerling (1977), and/or selected subtests of the *Minimal Auditory Capabilities Battery* (Owens, Kessler, Telleen, & Schubert, 1980). Each patient's performance is compared to that of the "typical" implant user and a determination is made as to whether performance may be improved through the use of the implant or if aided performance with conventional aids is superior to that which could be expected from the implant (Edgerton, Prietto, & Danhauer, 1983).

The evaluation of residual hearing and benefits afforded by the use of conventional amplification is not as simple as it may initially seem. Some subjects, who at first receive questionable or severely limited benefits from amplification, may show substantial gains in performance after a period of training in the use of minimal auditory cues. This is particularly true in subjects who either have not used amplification for a long period of time or who have never used a hearing aid. Patients who achieve test scores above that expected by chance alone may be enrolled in a formal program of rehabilitation similar to that given to implant recipients (but using appropriately fitted hearing aids) and eventually achieve levels of performance

better than what would be expected from the use of an implant. This is an important and rewarding aspect of a cochlear implant program as in many cases these patients have been discouraged from using a hearing aid in the past or a hearing aid has never been discussed as a possibility.

While there are cases in which conventional amplification gives no useful assistance, more frequently, some cases have aided performance that is far superior to that of even the most successful implant recipients. These patients typically do not present a problem in the selection process, since it is relatively clear whether they are, or are not, potential implant candidates. The majority of potential implant candidates that have been evaluated at our clinic have been found to receive more benefits from hearing aids than could be expected from the implant. In over five years of patient evaluation, only sixteen adult patients have been selected for implantation out of over forty who have been evaluated. A problem may be encountered in the evaluation of subjects who show minimal but definite responses with conventional amplification for one or both ears. At the present time, subjects who are able to achieve an aided speech reception threshold or who have some measurable open-set speech discrimination with an aid at normal conversational levels may not be assured of receiving further benefits from the implant (Berliner & House, 1981; Edgerton et al., 1983; Maddox & Porter, 1983a).

Additional problems are encountered with subjects who receive some benefit from amplification for one ear, but who show no benefit for the other ear. Although there are a number of implant recipients who successfully use the implant in conjunction with conventional amplification at the unimplanted ear, it is difficult, if not impossible, to predict the additional benefits afforded by use of the implant prior to surgery. Furthermore, the evaluation of subjects with congenital losses frequently requires a completely different approach and test instruments compared to subjects with acquired losses (Eisenberg, 1982). In some cases, the decision regarding implant candidacy may be a subjective decision made by the informed patient and his family after careful counseling regarding the potential benefits and limitations of the cochlear implant (Maddox & Porter, 1983b).

The bulk of experimental data relating implant performance to hearing aid performance has been obtained from adults with acquired losses, and has been shown to be remarkably consistent over a large number of patients with diverse histories and etiologies (House, 1976; House, Berliner & Eisenberg, 1979; House, 1980; Berliner & House, 1982; Thielemeir et al., 1982; Maddox & Porter, 1983a). Therefore, counseling the adult with acquired hearing loss relative to the potential benefits and limitations of the use of the implant presents few difficulties. On the other hand, patients with congenital, or early childhood losses, must frequently be counseled on an individual case basis due to the diverse reactions to electrical stimulation which have been reported by Eisenberg (1982). While some patients may be expected

to potentially achieve performance levels near that of patients with acquired losses, other patients with congenital losses, especially those who have had limited hearing aid use or who have never used an aid, may realistically expect only a rudimentary awareness of environmental sounds and speech from use of the implant. Expectations for congenital patients with little, if any, oral speech are vastly different from congenital patients who have relatively good oral language skills and reasonably intelligible speech.

While a growing number of both adults and children with congenital losses have been successfully implanted, the incidence of "nonusers" is higher for congenital or early childhood losses than for acquired losses. A major determinant of eventual usage status seems to be whether the patient can make meaningful use of the information provided by the implant after a period of training in the use of minimal auditory cues. Contrary to what might be expected, "nonusers" do not score significantly more poorly than successful "users" on tests of environmental sound recognition, closed-set word discrimination and stress pattern recognition (where applicable), or sound field warbled pure tone thresholds with the implant. The implication is that some patients are simply not capable of making meaningful use of auditory cues in their day-to-day lives after many years, or perhaps a lifetime of silence (Maddox & Porter, 1983b).

Important distinctions between successful implant users with congenital losses and congenital subjects who are eventual nonusers are that the successful users tend: (a) to have been identified at an earlier age, (b) to have used amplification with some success as a child, and (c) to have been educated in oral or total communication programs rather than strictly manual communication programs. Early identification, and at least some early auditory experience, do seem important for many subjects with congenital losses to achieve eventual success with an implant (Maddox & Porter, 1983b).

Another important consideration for congenital losses is the ability of the rehabilitative staff to accommodate the additional needs of the congenitally deaf person. Of necessity, the postsurgical rehabilitation for congenital subjects is much more complex and of a longer duration than that for acquired losses. If the rehabilitative staff has the resources and both the staff and the patient can accomodate an often lengthy time commitment for the rehabilitation, subjects with congenital losses should be considered good implant candidates, provided other aspects of the selection criteria are met and the subject is highly motivated (Eisenberg, 1982; Maddox & Porter, 1983b).

When a patient's performance with amplification is poorer than that which could potentially be expected from the use of an implant, the patient is then referred for polytomography of the temporal bones and internal auditory canals in order to rule out any structural abnormalities of the cochlea which might preclude implantation. In addition, all patients

receive a complete evaluation of their communication abilities, including speechreading, voice quality and monitoring, and basic language skills. Selected patients may be referred for psychological evaluation to rule out personality aberrations or cognitive disorders which might interfere with successful implant use; and, when possible, an interview is arranged between the patient and a current implant user. It should be stressed that the ear selected for implant surgery is always the ear which resulted in the poorest hearing aid performance.

At the end of this evaluation, the rehabilitative staff and the surgeon make a determination as to the candidacy of the patient, the patient's rehabilitative needs, expectations and motivations of the patient and family, and the approximate type and duration of rehabilitation required following surgery. Recommendations are discussed with the patient and family, and if the patient elects, surgery is scheduled.

REHABILITATION

Each implant center must make a determination as to the scope and type of rehabilitative services which can be offered. This determination is important for all implant centers, as it will also affect patient selection. Some rehabilitative services may be coordinated by referral through other programs or agencies, although this may require careful monitoring. The rehabilitative process associated with the cochlear implant actually begins during each patient's initial contacts with the physician and the rehabilitative staff. The goals during this phase of the process are primarily concerned with assessment of the patient's communication skills, residual hearing acuity, expectations and motivation, and formulating a projection of anticipated type and duration of rehabilitation required following surgery.

Formal rehabilitation with the cochlear implant does not begin until eight to ten weeks following surgery. During this healing period, local patients and family members may continue in regular counseling and orientation sessions, and all patients are carefully monitored for any changes in tinnitus or occurrence of vertigo as well as other possible complications of routine mastoid surgery. Except for post-operative examinations by the physician, follow-up of out-of-town patients is maintained either by phone or letter.

The initial rehabilitation program is designed to provide patients with the minimum training necessary to ensure that their external processor is adjusted appropriately and to ensure that they are beginning to critically listen to sounds and developing basic skills in the use of auditory cues provided by the implant. It should not be regarded as a complete rehabilitation program for all patients. Advanced auditory training, speechreading, voice or speech production therapy may not be included for all patients during this initial orientation program (Norton & House, 1979; House,

Berliner, Luxford, Eisenberg, Thielemeir, Graham, & Edgerton, 1982; Maddox & Porter, 1983a).

While these types of advanced training would benefit any profoundly hearing-impaired subject, they are not felt to be critical to the use of the implant for all patients. Some patients with acquired losses may require little more than periodic counseling and routine follow-up beyond the period of initial rehabilitation. On the other hand, implant subjects with poor speechreading skills or voice quality, and all congenital or early childhood losses will require advanced and sometimes lengthy training beyond this period which has been called "basic guidance."

The purposes of the basic guidance program are: (a) to set and adjust the external stimulator, or processor; (b) to fit and adjust the external coil and microphone; (c) to instruct the patient in the use of the equipment; and (d) to begin training the patient to critically listen to environmental sounds and speech using the implant. The total time required for the basic guidance period is approximately twenty to thirty hours, but may vary considerably from one patient to another. An important development in the external hardware has been the replacement of the coil-holding apparatus mounted on the frames of glasses or a headband with a newer system involving the use of rare earth magnets, first described by Dormer, Richard, Hough, and Nordquist (1981) and developed by House and *3M* along with the new "Alpha" processor systems currently being used. What was once a sometimes difficult or "tricky" task for the audiologist, often involving a consulting optician, and a lengthy time factor, is now a relatively simple matter of selection of the proper strength magnet for the external coil and positioning of the microphone. As a result, basic guidance for more recent implant recipients is simpler and requires less time than in the past.

Approximately one-third of the time required for basic guidance instruction is spent by the audiologist in setting and adjustment of the external processor based upon direct electrical threshold and uncomfortable loudness measurements, answering questions and reviewing operation of the external controls, adjustment and fitting of the external coil and microphone, and completion of all required audiological evaluations. Another third of the time is spent by the speech pathologist in training the patient to begin to critically listen to speech including monitoring of his/her own voice, utilize minimal auditory cues, recognize and discriminate common environmental sounds and integrate auditory cues as an aid to speechreading. The specific activities and therapeutic techniques utilized in this training have been discussed elsewhere (Norton & House, 1979; House et al., 1982; Lynn, Porter, & Maddox, 1983).

The remainder of time devoted to basic guidance is spent by the audiologist, speech pathologist and/or physician in either discussion with family members, training the patient in various techniques to use in home practice, or assisting the patient in determining the most convenient manner of wear-

ing the processor or positioning the microphone. Telephone use with the implant is explained, and patients are taught a code system enabling use of the telephone. Whenever possible, written instructions covering the materials discussed are given to the patient and family, and patients are given instructions and demonstrations explaining how to troubleshoot the unit, change batteries, precautions to observe, etc. In addition, home assignments for the patient and family are given throughout the basic guidance period and patients are required to keep a daily diary of their experiences with the implant. The home assignments are designed to give the patient experience in critical listening tasks and also assist in determining if the unit is appropriately set and that the patient understands the operation of the unit and external controls. The daily diary is used to monitor patients' progress as they gain more experience and become better accustomed to the use of the processor (Norton & House, 1979; Maddox & Porter, 1983a).

For the period of basic guidance, out-of-town patients are scheduled for full day or half day sessions on a daily basis for at least one week at the clinic, but rarely longer than two weeks. Local patients may also follow this schedule, but could attend daily sessions of one to two hours each for two or three days, and then return to the clinic twice a week for one to two hours until basic guidance is completed. Patients are usually allowed to take the processor home and use the implant outside of the clinic after the first or second day.

ADDITIONAL REHABILITATION

Following the completion of basic guidance instruction, the rehabilitative staff makes a determination as to whether the patient would benefit from additional therapy in areas not covered by the basic program. Rehabilitative training ranging from voice therapy, speechreading, and speech production to language therapy may be suggested in addition to further auditory training in environmental sound discrimination and utilization of minimal auditory cues. The determination of any additional training is made on an individual case basis, and is dependent upon each patient's rehabilitative needs and progress made during the basic guidance period. Out-of-town patients may be referred to speech and hearing professionals in their own area for additional rehabilitation, and are not required to return to our clinic for all rehabilitative training.

For the first sixteen adult patients implanted at the Houston Ear, Nose and Throat Hospital Clinic, the total rehabilitation time, including basic guidance has ranged from 18 hours up to 120 hours, with the mean duration of training being 36 hours. Nine patients did not receive additional training beyond basic guidance, and seven patients received from 22 to 90 hours of additional training over a period of three months to one year. Additionally, some of the earlier implant patients had received one to three months train-

ing with a hearing aid or were enrolled in speechreading, voice monitoring, etc. prior to implant surgery. Those patients requiring extended periods of additional rehabilitation either had congenital hearing losses, were very poor speechreaders, had experienced a number of years of limited hearing aid use, or had never used a hearing aid prior to receiving the implant. Also, the time requirement for earlier patients was longer than that for more recent patients due to problems encountered in adjustment and fitting of eyeglasses and the coil holding apparatus which is no longer required.

FOLLOW-UP

For a period of six months following the basic guidance program, patients are expected to maintain close contact with the clinic by means of monthly reports, home assignments and daily diary summaries. In addition, patients may need to return for minor adjustments and/or repairs. At the end of six month's use of the implant, all patients are required to return for one day to complete an audiological evaluation, a check of unit settings, electrical threshold measurements, and additional counseling. The patient is checked for any changes in tinnitus or vertigo, and questionnaires are completed regarding the use and benefits of the implant, general health and employment changes that may have occurred. One year after beginning use of the implant, patients return again for one day to complete further testing which may also include a psychological evaluation for selected patients. After this evaluation at the end of one year, patients continue to be followed on an as needed basis; however, all patients are expected to return at least once annually for the duration of their use of the implant.

Follow-up of implant recipients is an important aspect of a cochlear implant program. Maddox and Porter (1983a) compared presurgical hearing aid performance, implant performance during basic guidance, and implant performance after six months in a paired group of adult implant patients. On tests of environmental sounds recognition, closed-set word discrimination, and stress pattern recognition implant performance during basic guidance was not significantly better than presurgical hearing aid performance. However, hearing aid performance was at the chance level and implant performance was found to be significantly better than chance. It was not until after six months use of the implant that implant performance was significantly better than hearing aid performance; and, implant performance after six months was significantly better than during basic guidance. Other investigators (Thielemeir et al., 1982) have reported similar gains in implant performance over time. These results indicate that implant performance improves significantly as the patient becomes more accustomed to the implant and develops a more critical sense in the use of minimal auditory cues. It seems clear that in addition to rehabilitation therapy, directed experience in critical listening is important in achieving

successful results with a cochlear implant.

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