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INNOVATIVE APPROACHES TO SELECTION OF ADULT COCHLEAR IMPLANT CANDIDATES

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Cochlear implantation offers hope for profoundly deaf individuals who have not been able to benefit from conventional amplification. As public awareness of increased use of cochlear implants (CI) grows, professionals such as audiologists, deafness rehabilitation specialists, otologists, and speech-language pathologists will encounter CI candidates on an increasing basis. The full potential of the CI prosthesis may not be achieved if necessary medical, audiologic, rehabilitative, and psychological services are not provided.

Hearing loss affects at least 14 million Americans, of which an estimated 200,000 have profound sensorineural deafness (Schein, 1977). The increasing number of hearing-impaired persons, including the elderly population, makes hearing loss a major concern for our society.

Communication via aural/oral means is difficult or impossible for the segment of the profoundly deaf sensorineural group who derive no benefit from hearing aids. Although the size of this sub-group is uncertain, individuals within it do not obtain any benefit from the use of hearing aids, since they cannot effectively utilize their little (if any) residual hearing. The ability to detect environmental sounds, to identify prosody, i.e. duration, stress, and intonation (Lehiste, 1970), and to decode even gross aspects of speech, e.g. presence or absence of voicing, frication, and/or stop vs. continuant consonants (Pickett, 1980), is not possible in this sub-group of profoundly deaf persons. With such significantly impaired auditory sensation and frequent lack of aural rehabilitation, hearing aids provide no benefit. Therefore, it is not surprising that many of these individuals who have hearing aids do not use them.

CI research addressing comprehensive evaluation procedures has been limited due to lack of uniformly accepted criteria for evaluation. The purpose of the present paper is to describe a unique comprehensive evaluation protocol for the adventitiously profoundly deaf patient who is a candidate for a CI. In the present protocol, the emphasis on non-auditory factors in the selection process is very important.

Cochlear Implant Prosthesis

The CI is an electronic prosthetic device used to provide auditory sensation to deaf patients by converting sound energy to electrical energy which then stimulates the auditory nerve with coded electrical impulses (Balkany, 1983; Staller, 1985). The system (Figure 1) can be divided into four component parts: the external speech processor and microphone, the signal transfer hardware, the neural interface, and the perceptual system of the implantee.

The perceptual mechanisms used by the implantee in response to electrical stimulation of the auditory nerve are critically important to the operation of the whole system (Millar, Tong, and Clark, 1984). Since the perceptual mechanism varies among individuals, highly successful implantees will be able to use the unnatural auditory signal for speech perception by adopting heuristic strategies incorporating auditory, visual, linguistic, and non-linguistic information. Other implantees may need to be provided with stimuli that match percepts stored in long-term memory. Rehabilitation is the catalyst in both situations.

Although the CI does not provide normal hearing for the implanted patient, the renewed ability to hear environmental sounds and some aspect of speech rhythm and intensity at conversational level allows for better communicative

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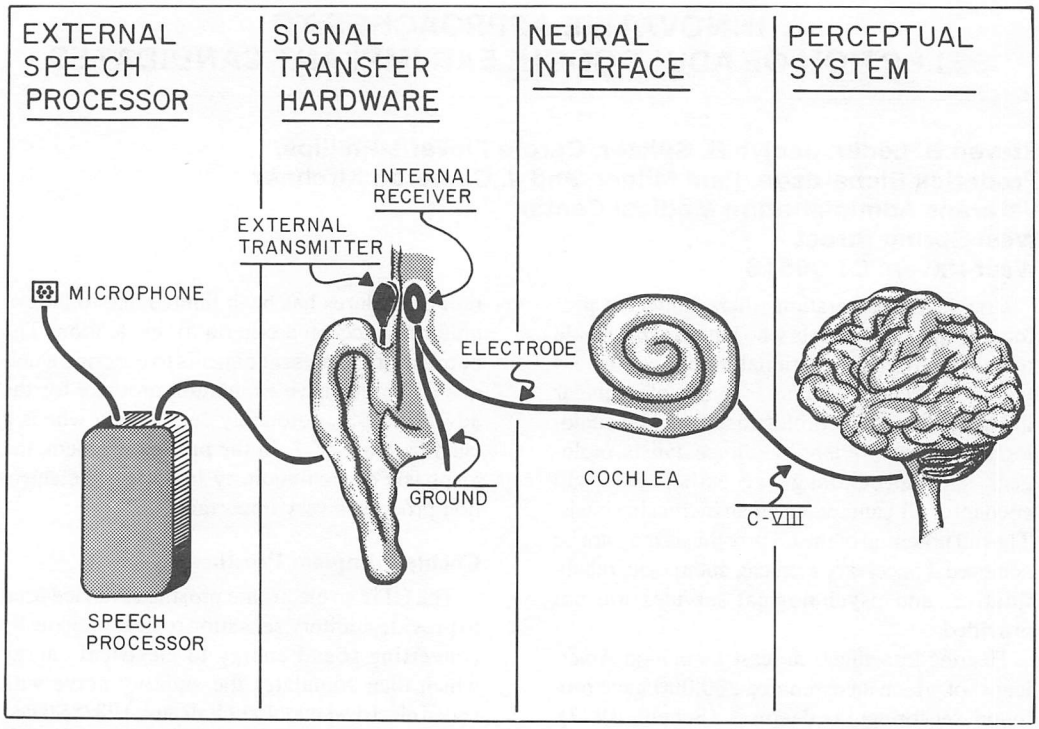
Figure 1

The four component parts of the cochlear implant system.



performance. For the patient whose evaluation indicates that cochlear implantation would be a valuable part of the total rehabilitation program, enhanced function will result from combination of the improved auditory signal, continued use of visual input and cognitive integration, and the post-stimulation rehabilitation program. The combination of these factors will facilitate integration of the adventitiously profoundly deaf person back into the hearing world with the potential for improved vocational adjustment.

The Cochlear Implant Team

Introduction of the CI has created a need for the services of a multidisciplinary evaluation team, consisting of an audiologist, otologist, rehabilitation medicine physician, aural rehabilitationist, speech-language pathologist, clinical psychologist, and program coordinator, to address the benefits of the device and the application of diagnostic findings to rehabilitative recommendations.

The audiologist is responsible for obtaining hearing aid and rehabilitation history, performing diagnostic audiological evaluations, ascertaining level and adequacy of residual hearing, documenting effectiveness of powerful hearing aids, counseling the CI candidate and family regarding test results, and providing alternative recommendations when appropriate. Post-surgery, the audiologist is responsible for optimal fitting of the CI, providing training in device adjustment and maintenance, documenting post-implant audiological results, and providing appropriate aural rehabilitation in conjunction with the aural rehabilitationist and speech-language pathologist.

The otologist's major responsibilities, in addition to the surgery, are to determine the feasibility of implantation surgery and to evaluate medically the CI patient, both pre- and post-implantation. The medical examination, historical information, laboratory reports, and audiological findings are used to determine, with the team, the surgical approach and ear to be implanted.

The rehabilitation medicine physician evaluates the candidate's neurological status, with particular emphasis on coordination and compensation for vestibular end-organ deprivation, seen

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commonly in profound sensorineural deafness. Examination and inquiry regarding familial/genetic factors is valuable in determining etiology and potential benefits. Metabolic and cardiovascular status are also evaluated as necessary to predict, as far as possible, tolerance of surgery, healing, and foreign body response.

The aural rehabilitationist is an audiologist or speech-language pathologist with special training in the psychosocial aspects of deafness and communication training procedures. Their role is to determine the patient's level of communicative functioning pre- and post-implant, and to teach use of the new auditory code in conjunction with visual input. There must be an awareness of the psychosocial and behavioral problems presented by the patient as well. Information is shared with the deafness counselor and clinical psychologist in order to help the patient deal with attitudes and feelings, and, most importantly, to ensure that the patient has realistic expectations of what the CI will provide. Evaluations are performed to assess speechreading skills (Jeffers & Barley, 1971; Davis & Silverman, 1978; Plant & Macrae, 1981), speech perception (Erber & Alencewicz, 1976; Owens, Kessler, Telleen, & Schubert, 1981; Trammell, Farrar, Francis, Owens, Schepard, Witlen, & Faist, 1980), and overall psychosocial functioning (Kagan, 1966; Giolas, Owens, Lamb, & Shubery, 1979; Cattell, Eber, and Tatsuoka, 1982; McCarthy & Alpiner, 1983). The latter important psychosocial functioning measures are not routinely collected by other CI teams. Once the level of functioning is determined, appropriate hierarchical therapeutic goals are instituted in order to improve deficits and move the patient toward optimum communicative adjustment.

The speech-language pathologist makes the determination of voice and articulation disorders, and provides remediation to correct abnormal conditions. The speech of adventitiously profoundly deaf persons who derive no benefit from hearing aids deteriorates gradually due to the absence of critical auditory (i.e., acoustic) cues necessary to monitor production (Zimmermann & Rettaliata, 1981; Cowie, Douglas-Cowie, & Kerr, 1982; Kirk & Edgerton, 1983). Speech changes associated with postlingual profound deafness may include misarticulations, aberrant vocal quality, inappropriate intensity levels, and inappropriate pitch and stress patterns (Leder, Spitzer, Milner, Flevaris-Phillips, Richardson, & Kirchner, 1986). Considerations must be expanded to include language disorders when dealing with congenitally impaired adults or any category of children, in whom implantation is a very limited investigative area at the present.

The clinical psychologist deals with the psychological trauma concomitant with profound adventitious deafness (Ramsdell, 1960; Rousey, 1971). In addition, counseling is often needed for appropriate adjustment to be made after receiving a CI (Miller, Duvall, & Berliner, 1978). Psychological tests are administered to ascertain if there are any inappropriate behaviors present severe enough to rule out candidacy for a CI, and to determine individual patient intervention strategies. As standardly used, psychological tests are for purposes of excluding inappropriate subjects. A component of our clinical research is to determine the relative contribution of psychological factors, such as rate of processing (Spitzer, 1986), to the ultimate successful performance of an implantee. The resultant profile is reviewed with all team members in order to meet best the patient's psychological needs.

The program coordinator recieves referrals and prepares correspondence with patients, coordinates patient and staff schedules, makes travel arrangements for the patient and family, orders all CI devices and accessories, and is responsible for daily and projected budgetary requirements.

The most difficult decision for the CI team is a recommendation for or against cochlear implantation. If the decision is to implant, the team must work together to provide the profoundly deaf CI patient optimum pre- and post-implant aural rehabilitation, which is essential for successful management (Edgerton, 1985; Flevaris-Phillips, Leder, Spitzer, & Richardson, 1985). If the decision is not to implant, individualized selection of the most appropriate, alternative state-of-the-art rehabilitative means (such as the use of vibrotactile devices) is instituted.

Criteria for Use of the Cochlear Implant

There is no universally accepted set of criteria for CI selection. Some CI teams have implanted patients with an aidable contralateral ear (Berliner, Luxford, & House, 1985), while others have varying criteria for temporal bone anatomy or brainstem auditory evoked potential results. Our following standardized set of criteria is necessary

for CI selection.

(1) Adults between the ages of 18 and 70 years who acquired normal speech and language prior to becoming profoundly deaf;
(2) Profound sensorineural hearing loss bilaterally, i.e., > 90 dB Hearing Level (American National Standards Institute, 1970) as measured under headphones;
(3) Severe impairment of speech discrimination and recognition performance, both under headphones and while wearing powerful hearing aids, poorer than the mean performance (± 2 standard deviations) of implant users (Thielemeir, Brimacombe, & Eisenberg, 1982);
(4) Absence of responses to brainstem auditory evoked potentials at the maximum output of the equipment (thus ruling out non-organic hearing loss or overlay);
(5) Medical examination which attempts to determine the etiology of deafness, suggestive of at least some residual cochlear nerve function, and whether the patient can tolerate a surgical procedure that requires general anesthesia (Simmons, 1985);
(6) Normal temporal bone radiologic findings, i.e., observation of the presence of the cochlear turns without significant bony obliteration or malgenesis;
(7) Psychological examination demonstrating no organic brain impairment, psychosis, mental retardation, learning disability, unremitting unrealistic expectations, or personality traits that would markedly decrease the probability of completing the program;
(8) Consensus by the CI team that the patient understands the possible benefits and limitations of the implant and will cooperate in the entire pre- and post-surgical rehabilitative protocol. Involvement in the program requires a long-term, i.e., two to three year, committment by the implantee for return visits.

Cochlear Implant Evaluation Protocol

Table 1 delineates the recommended comprehensive evaluation battery used to determine an individual's candidacy for cochlear implantation (Flevaris-Phillips, et al., 1985). All cochlear implant candidates are assessed on four major evaluative categories in order to obtain a profile of medical status, audiological functioning, communicative proficiency, and psychosocial adjustment.

Evaluation of CI candidacy begins with the medical examination. Etiology is determined, when possible, in order to provide insight into the nature of the hearing loss and resultant medical sequelae, i.e., aural fullness, tinnitis, and vestibular problems. A general/internal medicine physical examination is performed to determine the patient's general health and if the patient can tolerate surgery. Tomograms ascertain the patency of the cochlea turns and rule out obliterative disease. The fluorescent antibody absorption test identifies luetic deafness. If positive results are found, appropriate medical treatment is provided, and the patient is re-examined at a later date to note any audiologic changes. Other tests are performed specific to the presenting condition of the patient.

Ophthamologic and optometric examinations are performed in order to determine if the patient has any visual pathology and, if so, is fitted with correct eyeglass prescriptions. Since one of the most important benefits of the CI is as an aid to speechreading (Gantz, Tyler, Preece, McCabe, Lowder, & Otto, 1985), it is important for the patient to have optimum corrected vision in order to be able to integrate inputs from vision and the new electrical auditory signals.

The audiological examination is crucial to the determination of CI selection. The audiologist uses standard pure-tone audiometry, tests for vestibular function and brainstem transmission, and speech perception tests (Erber & Alencewicz, 1976; Trammel et al., 1980; Owens, et al., 1981) to obtain a clear picture of the patient's overall auditory capabilities. Only when a diagnosis of profound bilateral sensorineural deafness is made can the patient be considered a candidate for cochlear implantation.

Communicative and psychosocial evaluations are carried out by the aural rehabilitationist in conjunction with the audiologist and speech-language pathologist. Pre-CI speechreading tests (Jeffers & Barley, 1966; Davis & Silverman, 1978; Plant & Macrae, 1981) determine the patient's baseline skills, and the latter scores are used later to document improvement post-CI. If audiological findings indicate that there may be some residual hearing, it is imperative for trials to be conducted with an auditory trainer and powerful hearing aids to exhaust traditional methods. Vibrotactile devices are introduced to determine if they are of any benefit, and to observe

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Table 1

Comprehensive Evaluation Protocol for the Prospective Cochlear Implant Candidate

Medical, Ophthamologic/ Optometric, Audiologic Examinations	Communicative Evaluations	Psychosocial Evaluations	Recommendations/ Team-Patient Decisions
	Auditory Assistive		**Individual/Family**
Medical	**Devices**	**Individual**	**Rehabilitation**
Etiology	Hearing Aids	Psychological	**Proceed With Implant**
General Physical	Auditory trainer	Social Adjustment	
Examination			Medical
Chest X-Ray, EKG,	**Non-Auditory**	**Family**	Ophthamalogy
Laboratory/Blood	**Assistive Devices**		Audiology
Work-up		Psychological	Cochlear Implant
Tomogram	Vibrotactile	Social Adjustment	Communication
Fluorescent Anti-	Aid		Strategies
body Absorption			Speech Pathology
Test	**Speechreading**		Psychology
Other Tests as			
Needed	Videotapes		**Alternative Non-**
	Live-Voice		**Implant Decisions**
Opthamalogic/			
Optometric	**Communicative Skills**		Medical
	and Strategies		Ophthamalogy
Non-Contact Tonometry			Audiology
Slit-Lamp Examination	Speechreading		Hearing Aids
Ophthalmoscopy	Communicative Acts		Tactile Device
Refraction			Communication
	Articulation and		Strategies
Audiologic	**Voice**		Speech Pathology
Unaided			Psychology
Aided	Vocal Pathology		
Psychoacoustic			
Electronystamography	Intensity		
Brainstem Auditory	Prosody		
Evoked Potentials	Duration		
Speech Perception	Stress		
Tests	Intonation		

how the patient adapts to novel input, information that may provide insight into later CI use. Based on psychosocial test performance (Kagan, 1966; Cattel, et al., 1982; Giolas, et al., 1979; McCarthy & Alpiner, 1983), counseling is initiated to aid the patient regarding coping appropriately with profound deafness and use of the CI or alternative devices. Any voice and articulation abnormalities are identified by the speech-language pathologist, and remediation plans are incorporated into the patient's overall communicative rehabilitation plan. When all communicative deficiencies are determined, an individual rehabilitation plan is instituted to improve the patient's communicative strategies.

It should be noted that a unique aspect of the present evaluation protocol is administration of an intensive short-course of aural rehabilitation.

A baseline is obtained from which later comparisons can be made in order to document the CI candidate's amenability to treatment and prognosis for improvement.

A psychological evaluation is performed by the clinical psychologist using standard assessment instruments (Reitan, 1958; Matthews & Klove, 1964; Dahlstrom, Welsh, & Dahlstrom, 1972; Kaplan, Reitan, & Davidson, 1974; Russell, 1975; Wechsler, 1981; Kaplan, Goodglass, & Weintraub, 1983), which have been specifically selected for their lack of contamination by auditory requirements. Findings are shared with the CI team, the patient, and family so that psychological needs are understood and do not become a hindrance to implementing the communicative rehabilitation plan and optimum use of the CI. Concurrently, evaluation of some of the psychosocial and psychological measures may yield insights to allow discrimination among prospective candidates, with the expectation that these data will allow streamlining of the CI protocol.

After information from all four areas has been collected, analyzed, and synthesized, recommendations are made to the prospective CI candidate and family regarding the feasibility of cochlear implantation, or alternative state-of-the-art hearing, visual, and/or tactile aids. At that juncture, the rehabilitation plan is presented, relevant referrals to other professionals, if needed, are made, and a timetable provided listing future key dates and activities.

Summary

A CI is not the beginning and end for profoundly hearing-impaired or totally deaf persons. Not only must specific criteria for its use be met, but an integrated and holistic diagnostic and therapeutic approach must be used to gain optimum communicative benefit from the device. Only a team approach can comprehensively evaluate the CI candidate's pre-CI communicative strategies and skills, and then design and implement individual rehabilitative goals.

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