Results of fitting a multichannel, monopolar, analog cochlear implant

Cochlear implants have been shown to restore a significant level of auditory sensitivity to the severely hearing impaired.

By Geary A. McCandless, PhD, Korine Dankowski, and Michael F. Dorman, PhD

During the past 15 years, remarkable progress has been made in the development and use of cochlear implants. Few, if any, treatment procedures or devices, including hearing instruments, have had such a positive impact on the severely hearing impaired. Whereas deafness previously relegated one to a life of silence or at best minimal and poorly distinguished sound, cochlear implants restore a significant level of auditory sensitivity and, for many patients, provide considerable auditory-only recognition of speech. Characteristically, implant users display wide differences in auditory function ranging from basic sound awareness to understanding conversational speech for the better functioning subjects. Even those with poor open-set discrimination ability score very high in understanding when coupled with lipreading. Test scores for sentences are usually better than 85% correct.

Whereas early design objectives of single channel devices were to provide awareness of sound and hopefully prosodic cues to enhance speech understanding, current multichannel devices are intended to provide speech formant cues and/or frequency information to permit open-set speech understanding in many patients. At present, of several thousand multichannel implant subjects, many hundreds can carry on face-to-face conversations with minimal effort. Some are even able to converse adequately on the telephone without using special codes or signals.

One indication of benefit of cochlear implants is the time per day of regular use. For multichannel device implantees, the average use per day is 12 to 14 hours.

There have been at least four multichannel implant types used in the United States with several others used to a limited degree in other countries.

Paradoxically, despite availability of implantable devices and outstanding success, relatively few of the over 100,000 potential candidates actively seek implantation. As word of effectiveness and safety of the devices spread, no doubt this trend will change.

Multichannel, multi-intracochlear electrode systems available in the United States produce generally good results in terms of speech recognition. There are, however, some functional differences between devices which can be demonstrated by tests in and out of noise, or by phoneme recognition tests and by tests of hearing environmental sounds. Differences among devices are to be expected, since some use a feature extraction coding scheme with pulsatile sequential stimuli and others use simultaneous analog signals directed via filters to various parts of the cochlea. The reasons for the differences between devices are not yet understood and are just now being studied.13

Due to the small numbers and recency of implant devices, relatively few hearing professionals have direct or extensive contact with implanted patients. There still exists the notion that auditory implants provide only gross awareness of sound. This is no longer true. When working with implant patients, one is soon impressed by the diversity of environmental sounds they are able to hear and the implant's contribution to speech communication.

It is difficult in written form to accurately describe the efficacy of cochlear implants. Results of various clinical tests do, however, quantify performance levels. These serve as a baseline to plot improvement and as a method by which to compare results among patients, devices or instrument settings.

One multichannel device in current use is the Symbion Implant. Among the characteristics of this implant is the use of a percutaneous connector with no implanted electronics. It employs monopolar analog coding and simultaneous band passed stimulation of four intracochlear electrodes for discrimination and scaling of pitch. The most apical electrode is located about 20-24 mm from the round window and electrodes are spaced 4 mm apart. Each electrode is driven by an analog signal corresponding to the input. The center frequencies of the filters for channels 1-4 (the most apical receiving the lowest frequencies) are 1, 1.5, 2 and 4 kHz. Fig. 1 is a schematic diagram of this device. Following amplification of the incoming signal, it is separated by band pass filters (BPF) changed from voltage-to-current (V/C) then passes directly through the skin to the cochlear electrodes.

Over 130 subjects now have been implanted with this device. The following are test results from 50 users who have worn the device for one year or longer.

---

Fig. 1. Schematic diagram of the Symbion multichannel, monopolar, analog cochlear implant system.

Geary A. McCandless, PhD, is professor and head of audiology in the Dept. of Communication Disorders and Div. of Otologyngology, University of Utah, Salt Lake City, UT. Korine Dankowski, is clinical research analyst at Symbion, Inc., Salt Lake City, UT. Michael F. Dorman, PhD, is professor at Arizona State University, Tempe, AZ.
sic or recognize numerous environmental sounds attests to the value of the cochlear implant in the lives of the severely impaired. □

References

Address further inquiries to: Geoffrey A. McCandless, PhD, Dep't. of Communication Disorders, 1201 Social-Behavioral Science Bldg., University of Utah, Salt Lake City, UT 84112.

CHRONOLOGY from page 38

Address further inquiries to: C.T. Campos, MA, Xomed Inc. 6743 South Dr. N., Jacksonville, FL 32216.

DRUGS from page 42

gardening dizziness, tinnitus and related symptoms.
5. Keep accurate records and include them in the client's file and/or hospital chart.
6. 15 dB at any test frequency should be regarded as criteria for change.

Follow-up monitoring protocol:
1. Testing should be continued until ototoxic drug therapy has been discontinued.
2. Testing should be conducted at periods of one week, one month and three months after drug therapy ceases. Further testing should be done as needed.
3. Infants and toddlers may require regular evaluations until they are three or four years of age.
4. A management program should be made available when necessary.

Knowledge of the properties and side effects of the drugs used or considered for use by clients is essential if the potential for ototoxicity can be accurately assessed. Hearing health care professionals should realize that the pharmacist can be a valuable resource as a member of the health care team. □

References

Address further inquiries to: Mary Ellen Brandelli, EDI, Central Michigan University, Speech-Language Clinic, Moore Hall, Room 441, Mount Pleasant, MI 48859.

Watch for the HEARING IN- years calendar of conventions, meetings and seminars for the hearing health industry coming out in December.
Their ages were 19 to 78 years. All had four functioning electrodes and were free from neurological disorders. The presumed etiologies of deafness included: unknown (n=23), congenital or progressive hearing loss (n=7), meningitis (n=7), ototoxic drugs (n=5), Menieres disease (n=4), trauma (n=3) and otosclerosis (n=1). Five patients were deafened at age 10 years or younger. Length of deafness before implantation ranged from 11 to 49 years.

Tests of performance were from the revised Minimal Auditory Capabilities Battery. The tests included the Spondee Recognition test, the Monosyllabic Word test and the Everyday CID Sentence tests with and without lipreading. Presentation level was 50 dB HL, a level corresponding to average conversational speech.

Fig. 2 shows the mean pre-implant audiogram, the implant-aided sound field audiogram and the average aided audiogram for these subjects using conventional hearing instruments. The implant-aided audiogram averages 30-35 dB in the speech frequencies compared to over 60 dB with hearing instruments. These results show that implant users can hear sound at conversational levels (50 dB HL), whereas with hearing instruments, they cannot hear speech since aided thresholds exceed 60 dB HL.

Results of the various speech tests with the implant are shown in Fig. 3. The positive effects of the implant, when viewed in light of total deafness and when compared with results with conventional hearing instruments (scores for any test typically being 0%), are impressive. They indicate that with this device and with tests presented auditory only, nearly all subjects have some open-set speech recognition for some tests and that single words can be recognized by many patients. Most impressive are results with lipreading which show that using the implant, plus visual cues (lipreading), the median score for CID sentences was 99%.

Special note should be made regarding the apparent wide range of scores for various subjects; some subjects do rather poorly while others perform well. These wide functional differences seem to remain over time despite constant improvement for individual subjects. Reasons for this disparity are not yet fully understood. Why should one subject with a fully functioning device perform differently than another with similar length of deafness and etiology? Length of deafness prior to implantation does seem to influence function. This strongly suggests that implantation is most effective if performed shortly after deafness occurs. Although there is no valid method of assessing amount of residual nerve fibers, it is felt that this may be the most significant single variable resulting in the large functional difference among patients. Determining potential nerve function is essential if function with an implant is to be predicted. At present, tests of residual nerve function are not part of the criteria for selection of subjects. On the more positive side, however, is the finding that subjects with multichannel implants with apparent limited nerve fibers and having poor test scores, auditory only, yield significant augmentation of lipreading using this device. Implants are not a substitute for conventional hearing instruments. Rather, hearing professionals should inform clinical patients of this option when a hearing instrument is no longer effective.

In summary, probably no procedure or device introduced in the past 50 years has the potential as does the multichannel cochlear implant to restore post auditory sensitivity and to provide coherent, usable auditory information to those with severe hearing impairment. Despite the frequent frustrations of adapting to new and strange sounds and in maintaining instrumentation, virtually all implantees would elect to have the implant when asked if they would have it done again. Conversing almost casually with an implant patient or watching a user once more enjoy music.