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Implanting outside the Guidelines: A Case Study

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Abstract

An 81-year-old female was referred for cochlear implantation due to difficulty communicating in her daily activities despite the use of appropriate amplification. The poorer ear was unable to tolerate amplification for the past 15 years. The open-set sentence-recognition test score in quiet in her "good" ear was 85 percent correct, indicating that the patient was not a traditional cochlear implant candidate. However, the sentence-recognition score in noise at +10 dB signal-to-noise ratio was 0 percent, demonstrating a significant breakdown in the patient's speech understanding in more difficult listening situations. This speech-in-noise score appeared to correlate with the patient's reported communication difficulties as well as with the communicative breakdowns that were observed clinically. The patient underwent cochlear implantation in the better ear. Cochlear implantation in this nontraditional patient provided objective and subjective benefit over hearing aid use.

Key Words: Cochlear implantation, postlingually deafened adults, signal-to-noise ratio, speech perception testing

Abbreviations: CID = Central Institute for the Deaf; CNC = consonant/nucleus/consonant monosyllabic words; HINT = Hearing-in-Noise Test; PTA = average of the pure-tone threshold hearing levels at 500, 1000, and 2000 Hz; SNHL = sensorineural hearing loss; SNR = signal-to-noise ratio

Sumario

Una mujer de 81 años de edad fue referida para implante coclear debido a sus dificultades para comunicarse en sus actividades diarias, a pesar del uso de amplificación apropiada. El oído peor había sido incapaz de tolerar la amplificación durante los últimos 15 años. El puntaje de la prueba de reconocimiento de palabras de lista abierta en silencio en su oído "bueno" fue de un 85%, indicando que le paciente no era una candidata tradicional

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para un implante coclear. Sin embargo, los puntajes de reconocimiento de frases en ruido, a una tasa señal/ruido de ±10 dB fueron de 0%, demostrando un colapso en la comprensión del lenguaje por parte de la paciente en situaciones auditivas más difíciles. Este puntaje de lenguaje en ruido pareció correlacionar con las dificultades reportadas por la paciente, así como con el colapso comunicativo que se observó clínicamente. La paciente fue sometida a una implantación coclear en el mejor oído. El implante coclear en esta paciente no tradicional aportó un beneficio objetivo y subjetivo sobre el uso de auxiliares auditivos.

Palabras Clave: Implante coclear, adultos ensordecidos post-lingüísticos; tasa señal/ruido, pruebas de percepción del lenguaje

Abreviaturas: CID = Instituto Central del Sordo; CNC = palabras monosilábicas consonante/núcleo/consonante; HINT = Prueba de Audición en Ruido; PTA = Promedio del umbral auditivo a tonos puros en 500, 1000 y 2000 Hz; SNHL = hipoacusia sensorineural; SNR = relación señal/ruido

Cochlear implantation devices have been approved by the federal Food and Drug Administration (FDA) for use in a specific patient population based on clinical trials. The implantation criteria for adults for the three cochlear implantation devices currently approved in the United States vary slightly. Advanced Bionics Corporation and Med-El Corporation guidelines indicate a bilateral severe to profound sensorineural hearing loss (SNHL) defined as a pure-tone average (PTA) of 70 dB HL or greater for the frequencies 500, 1000, and 2000 Hz. Both companies also require that patients receive limited benefit from amplification. For Advanced Bionics Corporation, limited benefit from amplification is defined as a score of 50 percent or less on an open-set sentence recognition task, such as the Hearing-in-Noise Test (HINT), in quiet. For Med-El Corporation, a score of 40 percent or less on the HINT sentences in quiet is required for candidacy. Cochlear Americas recommends that patients have a moderate to profound SNHL with a best-aided open-set sentence test score of 50 percent or less in the ear to be implanted and 60 percent or less in the nonimplant ear.

In the case described here, the patient did not meet the above criteria for cochlear implantation because she performed too well with her hearing aid. The purposes of this case report are to describe how additional testing, subjective impressions, and clinical judgment resulted in a decision to proceed with a cochlear implant and to report the performance obtained by the patient.

CASE REPORT

History Prior to Implantation

The patient was first seen at Mayo Clinic Florida in 1989 when she was 68 years old. The patient presented as a married, retired public health nurse with a history of Ménière's disease in the right ear since the 1960s. In 1980, the patient was fit with binaural hearing aids due to a bilateral progressive SNHL, worse in the right ear.

At the time of her initial visit to this clinic, the patient was using an in-the-canal style hearing aid only in her left ear. She had discontinued hearing aid use in the right ear three years earlier due to poor sound quality and lack of benefit. Audiometric testing showed a mild sloping to profound SNHL with a word-recognition score of 88 percent in the left ear and a moderate SNHL with a word-recognition score of 68 percent in the right ear. Amplification for the right ear was discussed, but it is unclear whether she pursued amplification with a local audiologist.

The patient returned to this clinic four years later in 1993, seeking medical and audiological management for a suspected decrease in hearing and speech understanding, particularly in background noise. Audiometric testing revealed a 10–25 dB

decrease in hearing thresholds in the right ear with no measurable word understanding. The left ear remained unchanged. From 1993 through 1998, the left ear remained stable, but the right ear slowly deteriorated to a severe to profound SNHL with recurring word-recognition scores of 0 percent. The patient was unable to tolerate a hearing aid in the right ear due to loudness discomfort and poor speech understanding. Magnetic resonance imaging (MRI) performed in 1995 was negative for cerebellopontine angle tumors or internal auditory canal lesions. From 1998 to 2001, the right ear exhibited slight additional decreases in hearing thresholds, 0 percent word-recognition scores, and no benefit from amplification. With the right ear established as an unaidable ear, the remainder of this case study will focus on the better-hearing, aidable left ear.

In mid-1998 the patient awoke with a sudden decrease in hearing in her left ear and mild unsteadiness. Audiometric testing revealed a moderate to profound sloping SNHL (PTA = 60 dB HL) in her left ear with a word-recognition score of 16 percent. The patient was placed on high-dose prednisone, with a seven-day course and a six-day taper. However, the steroid treatments provoked fluctuations in her blood sugar level, causing difficulty in managing her diabetes. A second MRI was performed and again was negative for pathological enhancement. Within 10 days, the patient experienced a sudden improvement in hearing in her left ear. The word-recognition score in the left ear increased from 16 percent to 64 percent. However, by the following month, the patient experienced another decline in her hearing, and a cochlear implant evaluation was considered. Audiometric retesting revealed a moderate to profound SNHL (PTA = 58 dB HL), with a word-recognition score of 26 percent in the left ear. With appropriate amplification in the left ear, HINT scores were 93 percent in quiet and 0 percent at +10 dB signal-to-noise ratio (SNR). Because the open-set sentence test score in quiet was significantly better than the FDA-approved criteria for cochlear implantation, a cochlear implant was not recommended at that time.

In January 1999, the patient reported frequent fluctuations in her hearing in the left ear, ranging from the ability to converse over the telephone to the inability to understand familiar melodies in church. She began using assistive listening devices both at home and in church. The patient was again placed on steroids in April 1999 while her primary care physician managed her blood sugar levels with insulin. From January to May 1999, word-recognition scores for the left ear fluctuated between 20 and 56 percent. By May 1999, the hearing in the left ear had deteriorated to a bilateral severe to profound SNHL. Subsequent audiograms from June 1999 to September 2001 revealed mild decreases in hearing in the left ear and similar fluctuations in word-recognition scores. Table 1 summarizes hearing test results for the left ear over the period from 1998 to 2001.

By 2001, the patient reported minimal benefit from the hearing aid in her left ear, and she and her husband had resorted to written communication due to increasing difficulty. In the clinic, the patient visibly struggled to follow a simple conversation

Table 1. Audiometric Summary for the Left Ear Prior to Cochlear Implantation

Test	August 1998	March 1999	May 1999	May 2000	March 2001	September 2001
Pure-Tone Average	58 dB	60 dB	83 dB	92 dB	88 dB	88 dB
CID Words	26%	56%	20%	52%	60%	24%
CNC Words			66%		36%	40%
HINT in Quiet	93%	96%	88%		62%	85%
HINT @ +10 dB Signal-to-Noise Ratio	0%					0%

Note: Consonant/nucleus/consonant (CNC) words and Hearing-in-Noise Test (HINT) sentence tests were in best aided condition in sound field at 70 dBA. Central Institute for the Deaf (CID) words were administered under headphones.

in quiet. The patient watched the speaker's face intently and mouthed each word as she understood it. She repeated aloud what she thought she heard and asked for confirmation. Given the clear communication difficulties, a second cochlear implant evaluation was scheduled.

The patient underwent audiologic and vestibular testing as part of the cochlear implant evaluation. Unaided audiometric testing revealed a bilateral severe to profound SNHL (Figure 1). Aided threshold and speech-perception testing was conducted in sound field for the left ear with appropriate amplification. Aided warble-tone thresholds were obtained in the mild-to-moderate hearing loss range and are shown in Figure 2. All speech materials used were recorded and presented at 70 dBA. HINT sentence lists were randomly presented with a practice list given prior to each test condition. In quiet, the HINT sentence score was 85 percent correct, and the consonant/nucleus/consonant (CNC) word score was 40 percent correct. The HINT score, similar to the previous test result, was better than expected given the difficulty she had following typical conversation. At +10 dB SNR, the HINT sentence score was 0 percent correct. Although cochlear implantation is indicated when the open-set sentence score is 50 percent or less in quiet, this patient was considered a viable candidate for cochlear implantation because of the communication difficulties observed clinically and reported by both the patient and her husband.

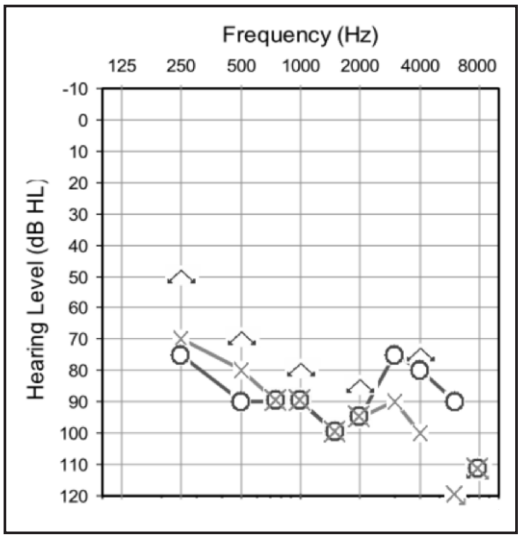

Figure 1. Pre-implant pure-tone audiogram.

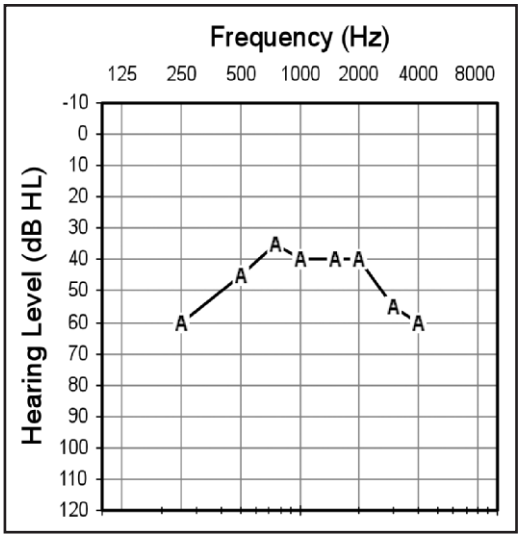

Figure 2. Pre-implant aided soundfield audiogram for the left ear.

Vestibular function also was assessed as part of the cochlear implant evaluation in September 2001. Results indicated symmetrical caloric responses and normal posturography. Given symmetrical vestibular function and the greater auditory deprivation in the right ear, the left ear was selected for implantation, as the best possible outcome with a cochlear implant would most likely be with the ear with the shorter duration of deafness. The patient was cautioned that speech understanding may not improve, or may worsen, with cochlear implantation. Nevertheless, the patient was eager to proceed.

Cochlear Implantation

In September 2001, the patient underwent cochlear implantation in the left ear. The device implanted was the Advanced Bionics Clarion HiFocus II with positioner. The patient was 81 years old at the time of her surgery. A full electrode array insertion was obtained without incident, and initial stimulation took place three weeks postsurgery. The patient initially was fit with the Platinum Sound Processor and then later with a CII BTE sound processor. She was given maps using Multiple Pulsatile Sampler, Continuous Interleaved Sampling, and Simultaneous Analog Stimulation (SAS) strategies. The patient had an immediate preference for the SAS encoder strategy. By one month postactivation, soundfield thresholds to the warble-tone stimuli were measured in the slight-to-mild hearing loss range. These thresholds are shown in Figure 3.

The patient's progress with the cochlear implant has been followed since November 2001 and is summarized in Table 2 and Figure 4. Soundfield hearing thresholds have remained relatively stable, while speech understanding in quiet and in noise has improved. Compared to the preoperative speech-understanding scores, the most significant improvement seen has been in the speech-in-noise score. At five years postactivation, the HINT sentence scores have improved 15 percent in quiet and 76 percent in noise at +10 dB SNR compared to the preoperative test scores. Moreover, a HINT sentence score of 56 percent was obtained at +5 dB SNR. The CNC word-recognition test score was 40 percent prior to implantation. All subsequent scores were significantly higher at the 0.05 level (Thornton and Raffin, 1978), with the exception of the five-

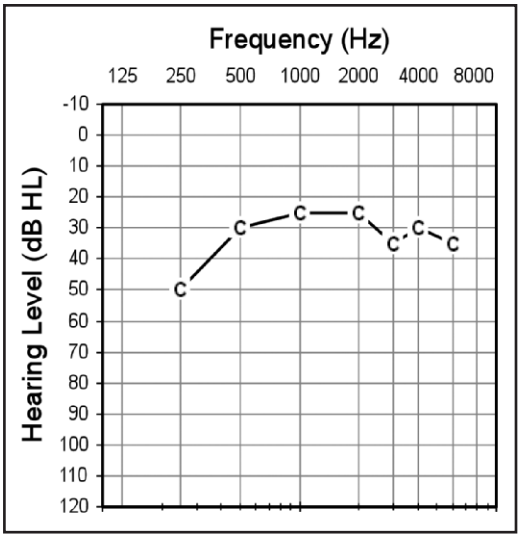

Figure 3. Soundfield thresholds with the cochlear implant at one month postactivation.

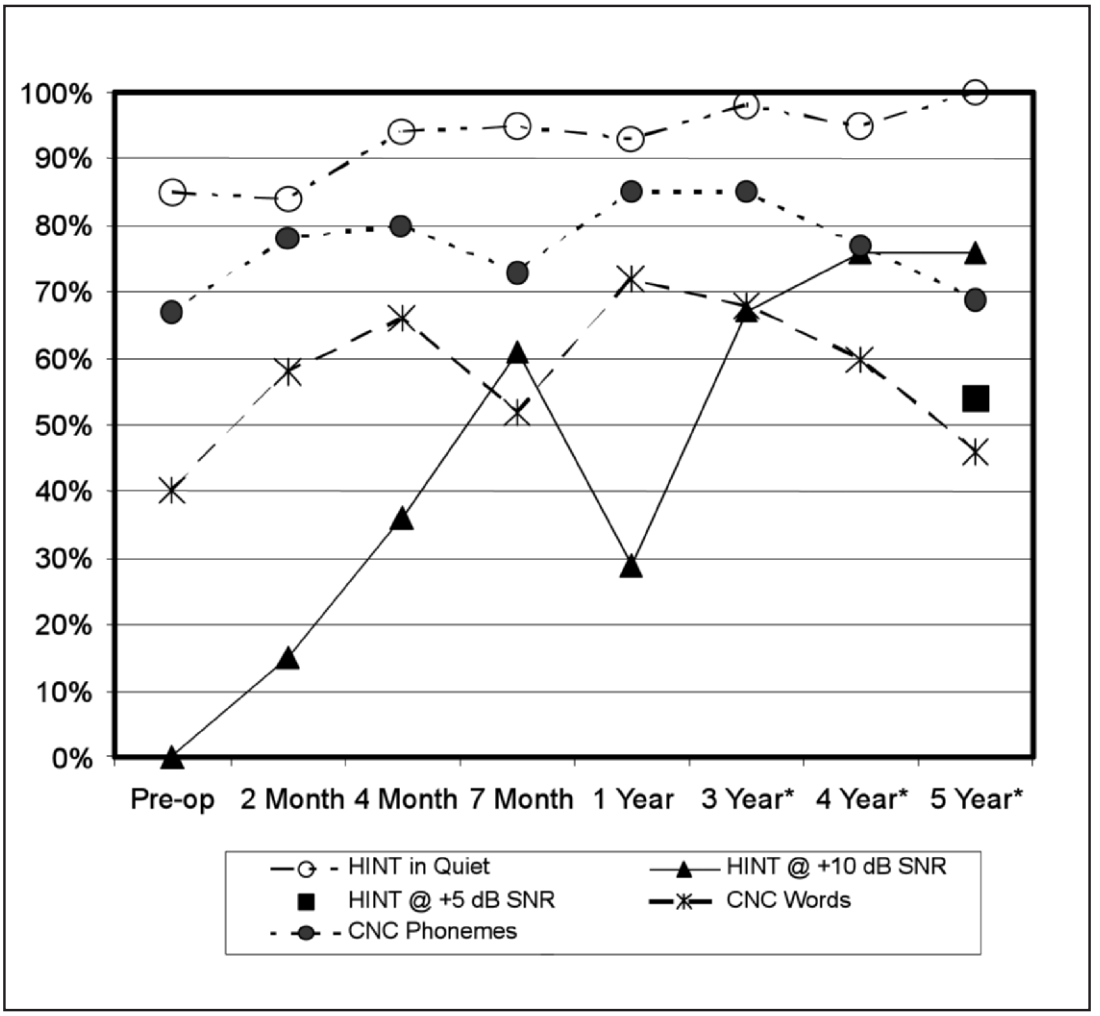

Figure 4. Percent correct performance for the patient preoperatively and at seven intervals after receiving the cochlear implant in the left ear. Scores are shown for the Hearing-in-Noise Test (HINT) in quiet and at +10 dB signal-to-noise ratio (SNR), consonant/nucleus/consonant (CNC) words, and CNC phonemes. Also shown is performance for the HINT at +5 dB SNR at the five-year return visit.

Table 2. Speech Perception Performance, Pre- and Post-implant

Test	Pre-op	1 Month	2 Months	4 Months	7 Months	1 Year	2 Years*	3 Years*	4 Years*	5 Years*
Pure-Tone Average	88 dB	27 dB	23 dB	23 dB	25 dB	25 dB	25 dB	28 dB	35 dB	30 dB
Hearing-in-Noise Test (HINT) in Quiet	85%		84%	94%	95%	93%		98%	95%	100%
HINT @ +10 dB SNR	0%		15%	36%	61%	29%		67%	76%	76%
HINT @ +5 dB SNR										54%
Consonant/nucleus/consonant (CNC) Words	40%		58%	66%	52%	72%		68%	60%	46%
CNC Phonemes	67%		78%	80%	73%	85%		85%	77%	69%

* Converted to HiResolution-S Strategy

year postoperative test score. The reason for this decrease in performance is unclear, especially in view of the excellent scores obtained in all other test conditions on that day. One possible explanation may be patient fatigue.

The patient and her husband have been extremely pleased with the results of the cochlear implant. Subjectively, the patient demonstrated improvement in her ease of communication. She appears less stressed and less tired and no longer mouths words to herself as she comprehends them. She and her husband have stopped writing to each other to communicate.

DISCUSSION AND CONCLUSIONS

This case described an audiometric and speech perception profile for an elderly adult who fell outside the recommended criteria for a cochlear implant yet gained appreciable benefit following cochlear implantation. Speech-perception testing in quiet failed to demonstrate the patient's daily communicative struggles. Retrospectively, the speech-in-noise test score more closely represented this patient's reported and observed communication difficulties. Walden and Walden (2004) and Killion and Gudmundsen (2005) have reported that speech-in-noise testing was a good predictor of patient satisfaction with hearing aids. Perhaps the use of speech-in-noise testing with cochlear implant patients may also be more reflective of satisfaction with amplification, albeit of a different type.

The difference between the speech-in-quiet score (85%) and the speech-in-noise score (0%) clearly indicated a breakdown in the patient's performance in more difficult listening situations. Though the reason for the deterioration of the speech perception in noise was uncertain, it was substantial. One possible explanation for this breakdown is end organ damage. Yet, in view of her age, the possibility of central presbycusis, or other central anomalies, could not be ruled out. Nonetheless, cochlear implantation was considered due to apparent communication struggles, good family support, and high patient motivation. The patient decided to undergo cochlear implantation in her only aidable ear in consultation with the cochlear implant team. Within one month of implantation, she reported an appreciable improvement in her everyday communication and environmental awareness. Soundfield thresholds showed a 10–30 dB improvement in the left ear with the cochlear implant compared to the hearing aid. Furthermore, the patient continued to obtain benefit over time as demonstrated by postoperative speech-

perception testing, as shown in Figure 4. Whereas only a modest improvement was seen in the speech-in-quiet condition, a substantial improvement was demonstrated in the speech-in-noise condition.

Improvement with speech recognition in noise with a cochlear implant has been reported in the literature. Hamzavi and colleagues (2001) report that improvements in speech recognition in noise were significantly greater in postlingually deafened cochlear implant users than with severe to profoundly hearing-impaired patients fitted with hearing aids. In their study, the Hochmaier, Schultz, and Moser sentence test was administered in quiet and at SNRs of +15 dB, +10 dB, +5 dB, and 0 dB. At three years postimplantation, the mean sentence-recognition scores at all SNR levels were higher for the cochlear implant users compared to the hearing aid users. Specifically, the mean sentence-recognition score at +10 dB SNR was 45 percent correct for the cochlear implant users compared to 16 percent correct for the hearing aid users. Other studies have reported open-set sentence recognition in noise with cochlear implants. Firszt and colleagues (2004) report a mean sentence-recognition score of 48 percent correct on HINT sentences at +8 dB SNR for their study patients with at least three months' experience with their cochlear implants. Fetterman and Domico (2002) found a mean performance of 73 percent at +10 dB SNR on the CUNY sentences with a minimum of six months' experience. Although different open-set sentence tests were used in each individual study, all three studies report a mean open-set sentence understanding in noise (+8 to +10 dB SNR) of no less than 45 percent. These studies suggest that postlingually deafened adults, on average, may achieve some open-set speech recognition in noise with a cochlear implant. In this case study, the patient followed this trend of improved speech-in-noise understanding with cochlear implantation.

The recommended guidelines and test materials used to assess cochlear implant candidacy lacked the sensitivity to demonstrate the communication breakdowns that this patient experienced in her daily life. Although the patient visibly struggled for comprehension, she was able to assimilate the auditory cues with language well enough that her communicative breakdowns were not evidenced in quiet. The subjective and behavioral observations as well as her reported communication difficulties were key elements in the decision to proceed with cochlear implantation. Firszt and colleagues (2004) recommend evaluating speech perception at 60 or 50 dB SPL in quiet and at 60 dB SPL in noise to better assess how cochlear implant users function in everyday life. Retrospectively, the speech-in-noise score was the crucial measurement in demonstrating this patient's candidacy for a cochlear implant, and it served as the benchmark of her progress.

Clinicians who depend only on FDA guidelines may risk rejecting candidates who could benefit significantly from cochlear implantation. Speech-in-noise tests or materials representative of typical listening situations should be incorporated in the test battery to better assess a patient's communicative challenges. Formal hearing inventory questionnaires may also prove helpful in these cases. As cochlear implant technology continues to advance and criteria for implantation expand, options for cochlear implantation will most likely become more complex. Research and development of assessment tools that are sensitive to everyday communication challenges are needed to accurately capture and quantify candidates' receptive communication skills.

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