JOURNAL OF THE ROYAL SOCIETY OF NEW ZEALAND
2025, VOL. 55, NO. 3, 520–529
https://doi.org/10.1080/03036758.2024.2376057

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RESEARCH ARTICLE

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Next day cochlear implant switch-on: the New Zealand experience

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ABSTRACT

The objective of this study was to review the practice of next-day cochlear implant activation, or switch-on, after surgery for adult cochlear recipients in northern New Zealand. A retrospective observational study compared next-day and three-week post-surgical outcomes related to early complications, electrode impedance values, speech perception outcomes and the number of patient appointments and speech processor MAPs to the point of stabilisation. Over a five-year period, 167 consecutively implanted recipients were included in this review. Results indicate that less time from surgery to switch-on had no impact on the incidence of wound or fitting complications, and resulted in lower initial impedance measures, fewer hours of follow-up visits and fewer MAPs during the subsequent nine months. Speech perception outcomes did not differ between the early and later switch-on groups. General satisfaction with next-day switch-on practices has resulted in consistent use of this protocol with high patient and clinician satisfaction and improved clinical efficiencies.

ARTICLE HISTORY
Received 2 February 2024
Accepted 24 June 2024

HANDLING EDITOR
Grant Searchfield

KEYWORDS
Cochlear implant; early device activation; clinical management; electrode impedance; patient satisfaction; speech perception

Introduction

The evolution of cochlear implant (CI) technologies and candidacy indications has generated increases in the number and characteristics of recipients, necessitating more efficient and convenient clinical management strategies for busy clinics and diverse patient preferences. Historically, this specialised patient care has been modelled in stages: referral, evaluation, surgery, device activation and ongoing device programming and rehabilitation. Observation of trends in current practices suggests that these stages are now being collapsed or combined to afford a reduction in clinic visits, enable more patient choice, and potentially, create clinic capacity for increased CI utilisation. For example, Patro et al. (2022) reported offering evaluation and surgery in a one-day patient visit. In this case, telemedicine afforded counselling and communication via phone and Internet, making the first in-person visit possible on the day of surgery.

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Supplemental data for this article can be accessed online at https://doi.org/10.1080/03036758.2024.2376057.

Traditional CI recipient follow-up programming and assessment intervals within the first year post-implant, typically 3-month intervals until 12 months, are also being scrutinised for reduction. Berg et al. (2023) reported evidence indicating the 3 – or 6-month interval follow-up visits could be eliminated without consequence, provided validated methods of determining stimulation levels were used during device activation. Reductions in the number of patient visits translate into cost savings and efficiencies for patients and centres and could enable significant increases in clinic capacity and adult CI utilisation rates.

The interval between surgery and device activation, or switch-on, has varied among centres. When surgical procedures were more invasive, recovery time from surgery and anesthesia dictated an extended time of 3–4 weeks before device switch-on. Earlier switch-on may reduce the incidence of post-surgical complications by affording the opportunity for clinicians to examine the incision in the early stages of healing. Recent publications on early activation summarising the benefits, risks and/or complications have concluded that shorter intervals are safe and feasible (Alshalan et al. 2023; Parker et al. 2023; Soncini et al. 2024). At the Northern Cochlear Implant Programme in Auckland, New Zealand, next-day switch-on practices have been the standard practice since 2017. The purpose of this report is to describe a retrospective review of the New Zealand experience with next-day switch-on protocols, summarising the benefits and challenges from the perspective of patients and clinicians. This study was developed as an audit of outcomes and practices and was approved by the research committee of The Northern Cochlear Implant Programme.

Methods

Over 1000 individuals have received care from the Northern Cochlear Implant Programme, which serves a geographic region of about 600 km around Auckland. From 2007 to 2018, the programme was delivered through the University of Auckland Audiology Division. Since 2018, The Hearing House (https://www.hearinghouse.co.nz) has provided adult audiological evaluations and cochlear implant rehabilitation services, with surgery occurring at local private and public hospitals. This study is a retrospective chart review of adult cases conducted over a five-year period between 2014 and 2019 comparing aspects of next-day versus delayed switch-on practices. These include the incidence of complications, changes in electrical impedance measures over time, the number of post-implant patient visits and speech processor MAPs, and speech perception scores. Data were collected from patient charts and compiled on an Excel spreadsheet for analysis. All consecutively implanted CI recipients during that timeframe were included in this review. The population included 99 male and 68 female participants; 165 received their first CI and 2 were undergoing second ear surgery. Patient age ranged between 19 and 89 years with a mean age of 59 years. The mean age of individuals participating in the day after surgery switch-on was 59 years, and the mean age of patients with delayed switch-on was 58 years. Patient management, while individualised, did not vary for the two groups beyond the timing and practices of the switch-on, as described.

In general, surgery was undertaken on the designated ear using standard mastoidectomy with a posterior tympanotomy approach and the use of dissolvable stitches, surgical

glue and sterostrip tape for wound closure. The routine practice was to keep patients overnight at the hospital and have a wound check prior to discharge the following day when bandages were removed and surgical tape was replaced. Patients then came to the cochlear implant centre for device activation and orientation to the technology, either the next day (early group) or in about three weeks (late group).

Switch-on practices differed slightly between the early and late groups. For both groups, the first speech processor programmes, or MAPs, were based on the results of intra-cochlear evoked compound action potential (eCAP) testing collected during surgery. These are neural responses to the electrical stimulation delivered and recorded by the internal device collected through the commercial software, Neural Response Telemetry (Nucleus® NRT) (Gantz et al. 1994; Brown et al. 1998). Population means from the programming software and the extrapolated configuration of NRT responses amongst the active electrodes create the first-fit MAP for both groups. The late group participated in additional behavioural measurements to fine-tune the first MAP; the early group did not. Initial MAP parameters were set to a 720 Hz or 900 Hz rate with a pulse width between 25 and 37. Four progressively louder maps were created, and patients were encouraged to use these as their comfort permitted until the next visit. For the early group, the goal of the first week of CI use was familiarisation with sound, or 'sound enrichment', with limited pressure or expectations for the patient beyond regular device use and acclimation to comfortable sound. Subsequent appointments for the early group included a typical fitting paradigm of using behavioural measures of loudness scaling and setting dynamic range, similar to the switch-on process for the late group. During the five-year period, 167 patients received one of the Cochlear® 500 series electrode array internal devices and were fitted with a Cochlear® N7 processor (Cochlear™ Limited Sydney, Australia).

Results

Next-day switch-on occurred for 92 recipients (early group), and 69 recipients (late group) had switch-on at three weeks post-surgery. Six patients were not included in either group because their switch-on was delayed due to post-surgical vertigo (3/6) or issues with magnet retention related to skin flap thickness (3/6). Two recipients were removed from the analysis of the late switch-on group because of differences in speech testing as a result of English as a second language.

Complications: device retention, wound healing problems and post-surgical recovery

The primary concerns with early switch-on include interference with achieving device retention, wound healing and managing immediate post-operative fatigue and illness. The speech processor must fit securely behind the pinna and the receiver-stimulator coil must adhere to the internal magnet for proper stimulation; it is essential to maintain the cleanliness of the fresh incision and the integrity of the skin flap over the internal receiver to promote good wound healing. CI recipients often report tenderness and numbness around the incision site after surgery so care must be taken to minimise irritation of the wound. The individual's body mass index (BMI) and the amount of wound

Table 1. Complications at initial switch-on or within the first month of CI surgery and mean number of visit hours and MAPs in first 9 months post switch-on.

	Coil retention issues	Incision integrity issues	Post-surgical recovery issue (dizzy/unwell)	Mean number of audiology and rehabilitation hours in the first 9 months post switch-on	Mean number of MAPs generated in the first 9 months post switch-on
Day after surgery switch on group ($N = 92$)		1		8.5652 (SD 2.8191)	16.2065 (SD 5.7871)
Three week switch on group ($N = 69$)		2		14.1214 (SD 2.9597)	19.1324 (SD 7.1309)
One week switch on group ($N = 6$) (Excluded from analysis)	3		3		

swelling affect the needed strength of the magnet for adequate retention. Post-operative fatigue and balance problems are not uncommon for many surgical procedures due to anesthesia intolerance and the general stress of surgery. Additionally, balance issues and dizziness are known risk factors for CI surgery. The six patients who were excluded from this review and switched on at one-week post-op were unable to tolerate or accommodate a secure fit of the external hardware due to a lack of consistent coupling of the device, or, due to post-operative balance recovery issues that made them too unwell to tolerate the fitting. Table 1 shows the number of complications during the first month post-surgery for both groups, as well as those excluded from analysis. Coil retention issues were those situations when the speech processor could not be securely fit, despite trying stronger magnets or alternative coupling options. Incision integrity issues were those requiring return for medical intervention beyond the first post-op check; these cases were managed through short-term oral antibiotics.

Electrode impedance levels

Cochlear implants are designed to replicate the function of the cochlea and enable access to a reasonable dynamic range of loudness so the recipient can hear soft, medium and loud aspects of speech. Loudness growth depends on the relationship between neural stimulability, electrode impedance levels and the level of electrical stimulation that can be applied to each electrode to remain in electrical compliance. These, in turn, affect speech coding settings of pulse width and stimulation rate and can further impact battery use and overall satisfaction with sound quality. Impedance is the inverse of resistance to current flow and plays a fundamental and dynamic role in device programming. Figure 1 compares overall impedance values for the two groups at the time of switch-on.

For each recipient, impedance values were recorded and mean group values, by electrode, were calculated across the 22 active electrode sites. Any electrodes that measured as open circuits were removed from analysis. Across the electrode arrays, the early switch-on group demonstrated significantly lower values compared to the last switch-on group. The mean impedance value averaged across the electrode array for the 1-day switch on group was 5.7143, SD = 2.05772; for the 3-week switch on group the mean was 13.7763, SD = 1.72710. *P* values generated using a two-sample *T*-test were $P < .001$. Impedance values

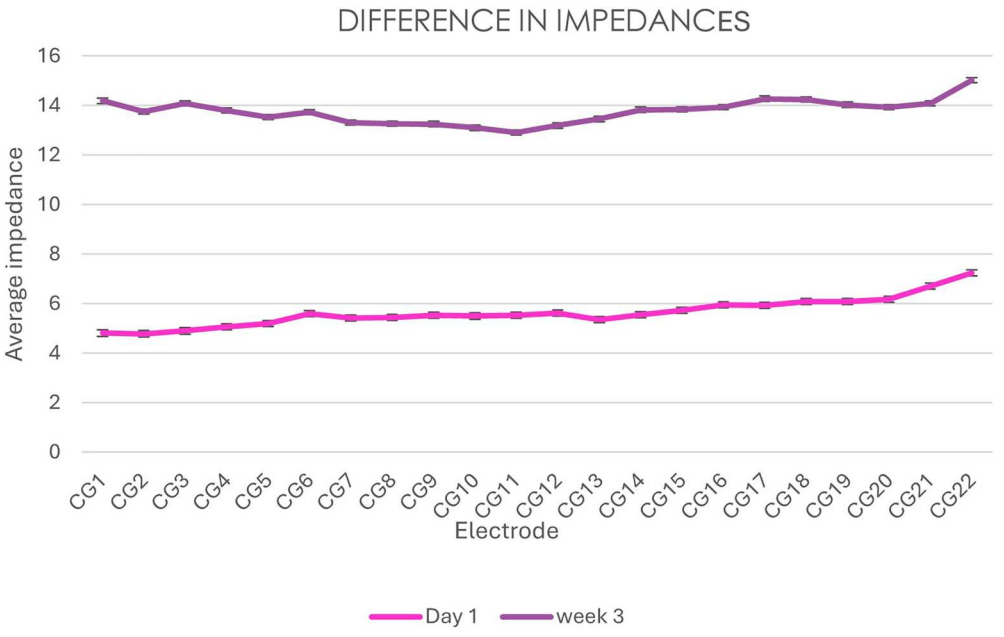

Figure 1. Average impedance results at the time of switch-on for CI recipients at one day ($n = 92$) versus 3 weeks ($n = 67$) post-surgery. The mean impedance value averaged across the electrode array for the 1-day switch on group was 5.7143, SD = 2.05772; for the 3-week switch on group the mean was 13.7763, SD = 1.72710. *P*-values generated using a two-sample *T*-test were $P < .001$.

are known to decrease and stabilise over time with continued use for most recipients, regardless of the interval between surgery and initial switch-on (Hughes et al. 2001).

Number of patient visits and MAPs

Adaptation to electrical stimulation varies among CI recipients, and this impacts the number of speech processor programmes, or MAPs, that each patient progresses through before achieving stabilisation. Typically, CI recipients progress to higher levels of stimulation over the first few weeks of device use until comfortable listening levels plateau. The mean number of hours of patient appointments and the mean number of MAPs during the first 9 months post-implantation are shown in Table 1. The number of hours of audiology appointments varied between the two groups with the next day switch-on group at about 8 and a half hours and the 3-week switch-on group averaging about 14 h. Next-day switch-on patients had between 16 and 18 new MAPs during the first 9 months and the 3-week switch-on group averaged a slightly higher number of MAPs in the same time period, 18–20.

Speech perception outcomes

Speech perception testing was completed at various post-switch intervals for all CI recipients; not every person was tested at each of the 3-month intervals due to the typical clinical variability of follow-up visits and as such statistical analysis (*Z*-test for

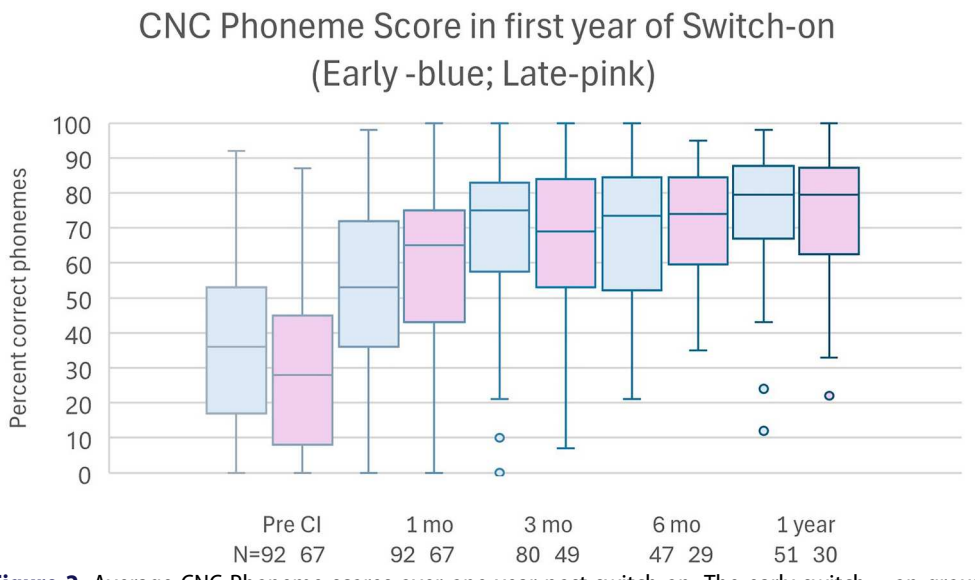

Figure 2. Average CNC Phoneme scores over one year post switch on. The early switch – on group (blue) pre CI and 1-month post switch-on included 92 CI recipients. The late switch-on group (pink) pre-CI and 1 month post switch-on included 67 CI recipients. The mean phoneme score at 1 month post switch-on for the 1-day switch-on group was 57.43, SD = 21.15; for the 3-week switch on group the mean was 63.56, SD = 23.00. Two-sided *P*-values generated using the *Z*-test for proportions were *P* = .240. The *N* is shown for each interval and group. Statistical analysis was not possible at later test intervals due to unequal number of CI recipients, but mean scores and standard deviation bars are indicated.

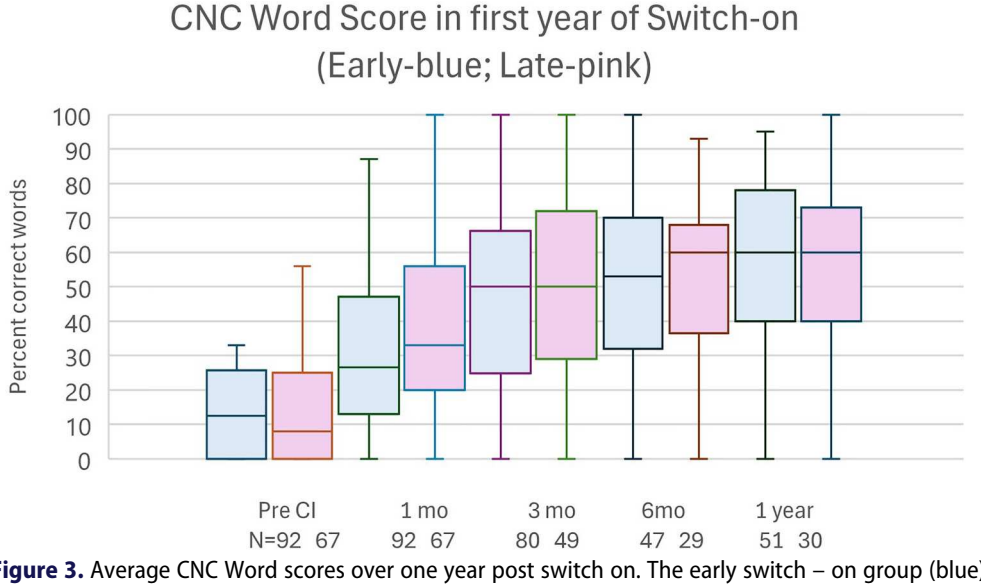

Figure 3. Average CNC Word scores over one year post switch on. The early switch – on group (blue) pre CI and 1-month post switch-on included 92 CI recipients. The late switch-on group (pink) pre-CI and 1 month post switch-on included 67 CI recipients. The mean word score at 1 month post switch-on for the 1-day switch-on group was 34.77, SD = 22.01; for the 3-week switch on group the mean was 44.00, SD = 25.08. Two-sided *P*-values generated using the *Z*-test for proportions were *P* = .240. The *N* is shown for each interval and group. Statistical analysis was not possible at later test intervals due to unequal number of CI recipients, but mean scores and standard deviation bars are indicated.

proportions) was carried out on the one-month post switch on data only. Recorded sound field tests using CNC words (Peterson and Lehiste 1962) were presented at 55 dB SPL in the CI-only condition. Figure 2 includes CNC phoneme results for all patients tested at various time intervals during the first year post-surgery and Figure 3 includes CNC word results for all patients at various time intervals during the first year post surgery. For the three-month follow-up, the results represent the mean CNC word and phoneme scores for 80 of the early switch-on group and 49 of the later switch-on group. The 12-month scores represent 51 individuals from the early switch-on group and 30 individuals from the late switch-on group. A small difference in word recognition was evident at the 1-month post switch on visit, but the groups converged at later test intervals. The average change in CNC word scores at 1-year post-implant was about 57% and the average phoneme score was about 76% for both the early and later switch-on groups (Figures 2 and 3).

Discussion

Complications: device retention, wound healing problems and post-surgical recovery

Next-day post-surgery placement of the speech processor and good coil retention is possible with the smaller surgical incisions currently used by CI surgeons. Coil retention was problematic for three early switch-on patients who were later switched on at one week; typically, this issue was overcome by the temporary use of a stronger magnet. Multiple magnet strengths are available to secure the transmitting coil and the clinician or the patient can easily decrease the magnet strength over time, as needed. When necessary, strategies to protect the incision and support retention of the external coil included placing the speech processor on the opposite ear using a long cable that runs along the back neckline. This is especially useful when the patient no longer wears a contralateral hearing aid. For recipients who continue to wear a hearing aid on the opposite ear, this may be practiced for a shorter period so there is opportunity for the CI recipient to experience bimodal listening, as well as CI-only practice; it soon becomes unnecessary. Additionally, some individuals like to wear a cap that can be strategically placed to support the transmitting coil. Similarly, a headband is often an acceptable short-term solution for others.

The importance of safe wound integrity and healing cannot be understated. In the initial stage of implementing the next-day switch-on protocol, a procedure was put in place for audiologists to photograph the wound and send it to the surgeon to ensure the wound status was acceptable. Over time, audiologists gained increased comfort with identifying issues and sought guidance from the surgeon only when the wound was not healing as expected. When the wound was particularly sensitive, a short-term option offered by the manufacturer and frequently used was the CochlearTM Headworn Adaptor. This ear-specific device couples the speech processor and the transmitting coil into a single unit, taking pressure off the pinnae.

The finding that fewer complications occurred in the first month for early switch-on patients may have been due to the more immediate inspection of the wound. Patients with the delayed switch-on may have retained the bandage cover longer, creating an

environment for infection. Additionally, since they may have been less likely to feel pain due to numbness, they may not have been aware of early signs of infection. Recipients may also have been less inclined to follow up with local healthcare providers to address healing problems, waiting instead for their upcoming switch-on date and allowing problems to escalate. From the surgeon's perspective, the more immediate knowledge of a patient's outcome is gratifying. One surgeon said:

> Day after surgery so puts the patient on the front foot in terms of habilitation. There doesn't seem to have been a problem with pain or infection, especially with keeping the processor off the incision. I am almost disappointed if a patient doesn't have an appointment for next-day switch-on.

It is worth noting that two CI recipients, one in the early switch-on group and one in the late switch-on group required CI revision within the first six months of device use due to staph infection; this outcome was unrelated to the early or late switch-on condition.

The experience of dizziness after surgery can be perceived as imbalance, lightheadedness, or true vertigo. Fina et al. (2003) found that patients with certain pre-implant characteristics have a higher probability of experiencing disturbing vestibular symptoms after cochlear implantation. These are often related to their medical and hearing history and aetiology. In these cases, clinicians can prepare the patient during pre-operative counselling and plan for a delayed switch-on. More recently, pre-operative vestibular assessment has been added to the CI work-up at many centres, which provides important additional information to the surgeon about the better ear to choose if vestibular issues have some probability of occurring (El-Karaksy et al., 2019).

Number of patient visits and MAPs

The difference in patient visit hours and number of MAPs may seem inconsequential when viewed on an individual basis, but, as CI clinicians know, each appointment involves focused attention from both the CI recipient and the audiologist to improve sound quality and discuss technology needs and progress with rehabilitation goals. When less time is spent on device programming, more time can be focused on these other needs. Earlier acclimatisation to sound reduces the electrical signal orientation period and clients report the adjustment phase to the unnatural sound quality occurs more quickly. In the context of a clinic with over 600 adult CI recipients, the combined savings of time by reducing the number of appointments adds up to create additional capacity for more evaluations or other clinic functions.

For the patients, fewer appointments may mean less time off work and a reduced financial burden on families. One recipient reported the following: 'I decided to not get an implant five years ago because I am the only person working in my family and I couldn't take the time off work.' In this CI centre, demographic data is collected on patients as part of their qualification for public funding of a cochlear implant. Of the 92 patients who had next-day switch-on, 54 were employed and the average travel time of this group was 190 km from the centre, with the furthest distance travelled being 690 km. Fewer visits for this group meant less time off work for clinical follow-up.

Additionally, CI recipients report the longer interval from surgery to switch-on is a time of great anticipation and worry. It can be particularly challenging for CI recipients who may have anxiety about being without any sound awareness for an extended period

of time and are uncertain about the amount of benefit their new sound source will provide. Anecdotal reports provided powerful insights. One CI recipient reported: 'When I got my second implant, I knew what I was facing with the operation, but fear does creep in until you know it is over and done with and you have sound in that ear.'

Speech perception outcomes

Speech perception outcomes are one aspect of patient benefits from a cochlear implant and have been the standard measuring metric to demonstrate improvement in communication function. Quality of life measures indicate more intangible benefits and are increasingly recognised as a more meaningful reflection of CI benefits (McRackan et al. 2022). The average improvement in speech perception performance for both the early and later switch-on groups was similar at the one-year post-implant follow-up and compared to other contemporary reported results of adult CI recipients who have consistent device use (Schvartz-Leyzac et al. 2019; Zhan et al. 2023).

Conclusions

In summary, early CI switch-on has been a successful change in clinical protocols and has proven safe and efficient, providing benefits to both the clinic and the patients. Exclusions to this approach include patients who have known vestibular issues or high BMI that precludes immediate processor fitting. This model has also been used with the paediatric population at this centre, and anecdotally, we have observed similar findings and outcomes. Successful implementation of the early switch-on model in this programme exemplifies the on-going need for clinics and clinicians to be flexible and agile, resulting in better service to a diverse clientele and strategically accommodating greater capacity for CI uptake.

Author contributions

CS developed the study concept, participated in data collection and patient testing and approved the final version of this paper. HT prepared this paper.

Acknowledgments

We gratefully thank all cochlear implant programme kiritaki (patients) and the clinical and administrative staff of The Hearing House for supporting this study.

Disclosure statement

No potential conflict of interest was reported by the author(s).

References

Alshalan A, et al. 2023. Early activation after cochlear implantation: a systematic review. European Archives of Oto-Rhino-Laryngology. 280:3489–3502. doi:10.1007/s00405-023-07965-3.

Berg KA, Holder JT, Gifford R. 2023. Development of an optimized protocol for cochlear implant care to increase cochlear implant. 44 (8)E635 - E64 ISSN: 1537-4505.

Brown CJ, Abbas PJ, Gantz B. 1998. Preliminary experience with neural response telemetry in the nucleus CI24M cochlear implant. Am J Otol. 19:320–327.

El-Karaksy A, Kouzo H, Attallah M, Talaat M. 2019. Vestibular function assessment in cochlear implant patients. Egypt J Otolaryngol. 35(1):63–74.

Fina M, Skinner M, Goebel JA, Piccirillo JF, Neely JG. 2003. Vestibular dysfunction after cochlear implantation. Otology & Neurotology. 24(2):234–242. doi:10.1097/00129492-200303000-00018.

Gantz BJ, Brown CJ, Abbas PJ. 1994. Intraoperative measures of electrically evoked auditory nerve compound action potential. Am J Otol. 15(2):137–144.

Hughes ML, Vander Werff KR, Brown CJ, Abbas PJ, Kelsay DM, Teagle HF, Lowder MW. 2001. A longitudinal study of electrode impedance, the electrically evoked compound action potential, and behavioral measures in nucleus 24 cochlear implant users. Ear and Hearing. 22(6):471–486. doi:10.1097/00003446-200112000-00004.

McRackan TR, Hand BN, Chidarala S, Dubno JR. 2022. Understanding patient expectations before implantation using the cochlear implant quality of life-expectations instrument. JAMA Otolaryngology–Head & Neck Surgery. 148(9):870–878. doi:10.1001/jamaoto.2022.2292.

Parker R, Muzaffar J, Ayas M, Brassington W. 2023. Early activation of cochlear implants: a systematic review and narrative synthesis. Cochlear Implants International. 1–12. doi:10.1080/14670100.2023.2290777.

Patro A, Haynes DS, Perkins EL. 2022. Same-day patient consultation and cochlear implantation: patient experiences and barriers to implementation. Otology & Neurotology. 43(8):e820–e823. doi:10.1097/MAO.0000000000003627.

Peterson GE, Lehiste I. 1962. Revised CNC lists for auditory tests. Journal of Speech and Hearing Disorders. 27:62–70. doi:10.1044/jshd.2701.62.

Schvartz-Leyzac KC, Conrad CA, Zwolan TA. 2019. Datalogging statistics and speech recognition during the first year of use in adult cochlear implant recipients. Otology & Neurotology. 40(7):e686–e693. doi:10.1097/MAO.0000000000002248.

Soncini A, Franzini S, Di Marco F, et al. 2024. Early fitting in cochlear implant surgery: preliminary results. European Archives of Oto-Rhino-Laryngology. 281:61–66. doi:10.1007/s00405-023-08076-9.

Zhan KY, Walia A, Durakovic N, Wick CC, Buchman CA, Shew MA, Herzog JA. 2023. One-year hearing preservation and speech outcomes comparing slim modiolar and lateral wall arrays. Otolaryngology-Head and Neck Surgery. 169(2):340–347. doi:10.1002/ohn.273.