Application of the Auditory Nerve Test System (ANTS) in candidates for cochlear implantation – case series and literature review

Original Article

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Abstract

Objectives: To evaluate cochlear nerve function, an essential requirement for cochlear implantation (CI), using the Auditory Nerve Test System (ANTS).
Materials and Methods: We present the initial experience of our department through three clinical cases of CI candidates with risk factors for cochlear nerve dysfunction who underwent intraoperative assessment with ANTS, followed by an immediate decision regarding CI placement.
Results: In two cases, a robust electrical response was recorded with ANTS, suggesting functional integrity of the cochlear nerve, and CI implantation was performed with favourable clinical outcomes. In the remaining case, the absence of a neural response led to the decision not to implant a CI, considering the low likelihood of auditory benefit.
Conclusion: ANTS is an objective and reliable tool for intraoperative assessment of cochlear nerve functionality during cochlear implantation in selected cases.

Keywords: auditory nerve test system (ANTS); cochlear implants; cochlear nerve; auditory brain stem evoked response

Introduction

Functional evaluation of the auditory nerve is critical when selecting candidates for cochlear implantation (CI). While profound sensorineural hearing loss (SNHL) typically implies a cochlear lesion, certain circumstances require confirming whether the cochlear nerve retains sufficient physiological integrity for auditory perception.[1,2] In cases of auditory nerve malformation or hypoplasia, magnetic resonance imaging (MRI) alone cannot always confirm the presence of a functional nerve.[3]

The consensus guidelines recommend using electrically evoked auditory brainstem responses (eABRs) as a positive predictor of

post-CI sound perception, thereby increasing the likelihood of clinical benefits in selected cases.[4-6] Auditory rehabilitation via CI has become increasingly relevant for hearing loss associated with cerebellopontine angle (CPA) tumors, such as vestibular schwannomas (VSs). If the cochlear nerve remains anatomically intact following tumor resection, concurrent placement of CI is an option; consequently, intraoperative nerve monitoring is increasingly used to guide this surgical decision.[7,8]

Another common scenario is SNHL with prolonged auditory deprivation. The consensus regarding a specific time limit beyond which CI benefits become unlikely has not been yet achieved. The evidence indicates that measurable gains can be achieved even after decades of deafness, such as the ability to perceive monosyllabic words after 50 years of anacusis.[3] Overall, however, the literature reveals a negative correlation between the duration of deafness and auditory discrimination. The age of onset is a critical factor: the later the hearing loss occurs, the better the speech perception outcomes following CI.[9] Other specific conditions, such as auditory neuropathy with suspected postsynaptic damage (e.g., following meningitis, petrous bone trauma , or severe ototoxicity), also benefit from objective intraoperative assessments.[4,12]

While auditory brainstem responses (ABRs) are inadequate for evaluating profound SNHL, electrophysiological evaluation of the auditory pathway using electrical stimulation overcomes the limitations of acoustic stimuli in patients with profound deafness. eABRs are brainstem-level responses triggered by the electrical stimulation of the cochlea or cochlear nerve, which can be recorded using surface electrodes on the scalp. These potentials are analogous to acoustic ABRs, typically displaying waves II, III, and V within the first 10 ms post-stimulus, reflecting neural conduction along the central auditory pathway. Promontory stimulation can be applied for both the subjective promontory test and the objective recording of extracochlear eABRs. The promontory test is limited by its reliance on behavioral responses, whereas extracochlear eABR testing, despite being objective, is technically demanding and has a limited negative predictive value (NPV).[10,11]

In recent years, a specific technology has emerged for the intraoperative evaluation of the auditory nerve: the Auditory Nerve Test System (ANTS®), developed by MED-EL (Innsbruck, Austria). ANTS is an eABR stimulation and recording system that uses a disposable intracochlear electrode, designed to test the auditory nerve responses prior to the placement of the definitive CI.[1]

This article aims to describe a series of three clinical cases and review the existing literature on the use of the ANTS as a relevant complementary diagnostic tool in auditory nerve assessment.

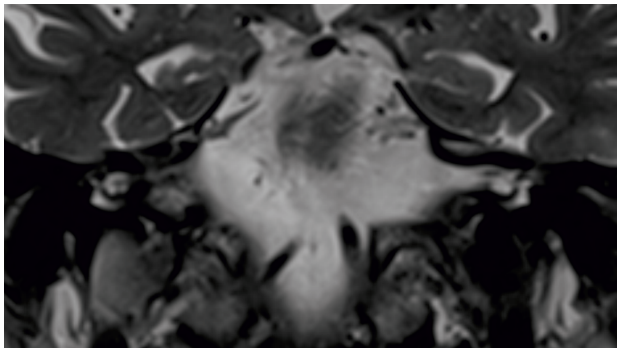
Clinical Cases

Case 1

A 72-year-old man presented with profound right-sided and severe-to-profound left-sided hearing loss secondary to complex neurosurgical procedures; the patient had no history of hearing loss prior to these procedures . Ten years previously, the patient had undergone microvascular decompression of the right trigeminal nerve via a retrosigmoid approach for trigeminal neuralgia caused by neurovascular conflict. Immediate postoperative complications included a hemorrhagic stroke causing a mass effect on the anterosuperior cerebellum, linked to acute profound hearing loss. Notably, 8 years later, the patient underwent microsurgical decompression of the left trigeminal nerve for the same indication. During the immediate postoperative period, the patient experienced new-onset moderate-to-severe left-sided hearing loss, with worsening speech discrimination in the subsequent months.

ABR testing showed a bilateral absence of waveforms. Imaging revealed a possible discontinuity of the right cochlear nerve and lesion of the left cochlear nerve (Figure 1). Considering the potential for left-sided auditory rehabilitation—as this ear had a

Figure 1
Pre-CI evaluation MRI. Discontinuity of the right cochlear nerve and thinning of the left cochlear nerve are observed, with greater severity on the right.



shorter duration of deafness and higher likelihood of nerve stimulation—the patient was scheduled for ANTS evaluation. The intraoperative decision to proceed with the placement of CI was contingent on the test results. Following a transmastoid approach with posterior tympanotomy and round window exposure for the placement of CI, the ANTS test electrode was inserted into the left cochlea. A positive response was obtained: a clear wave V was recorded at both the apical and basal contacts (indicating responses across various cochlear regions at

Figure 2
Table and graphical representation of ANTS responses. Intraoperative recording

Recording	Position	Amplitude (µA)	Wave V
1	Apical	0	No
2	Apical	500	Yes
3	Apical	750	Yes
4	Basal	750	Yes
5	Basal	850	Yes
6	Basal	500	Yes
7	Basal	750	Yes
8	Basal	850	Yes
9	Basal	300	No
10	Basal	300	No

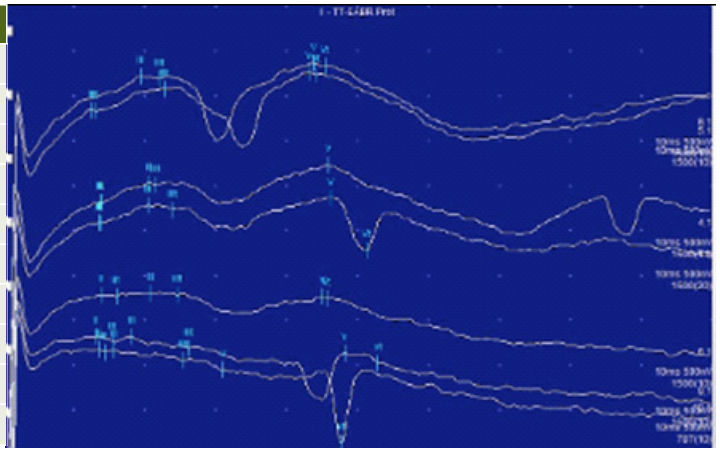
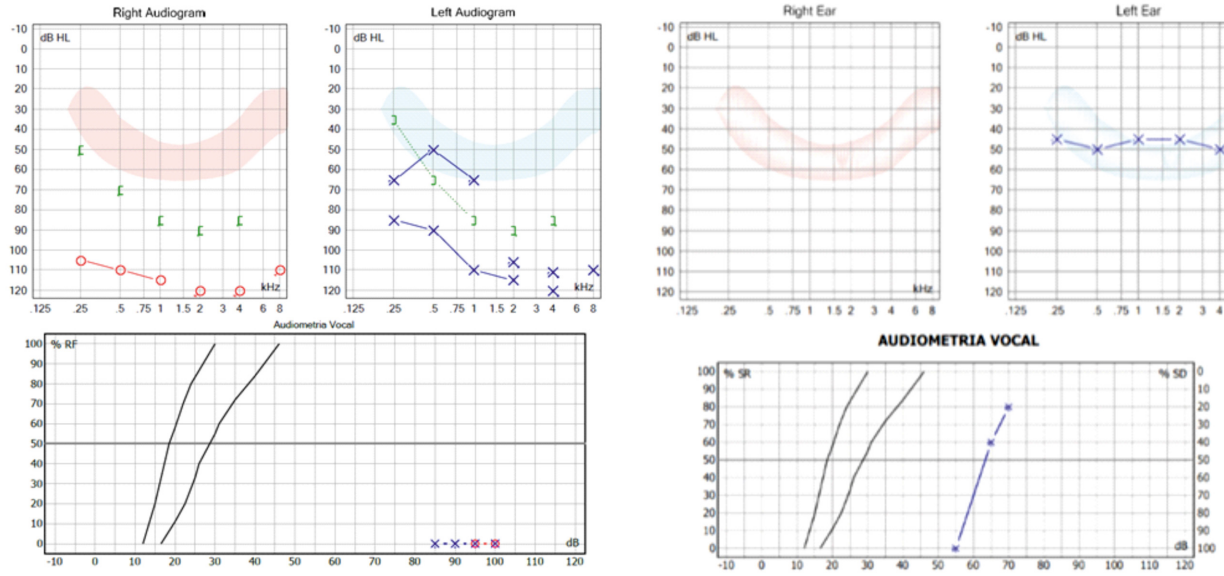


Figure 3
Audiometric assessment before (left) and 6 months following CI (right).



stimulation levels above 500 μA; Figure 2). CI placement was then conducted. Notably, 6 months following CI activation, the patient demonstrated satisfactory outcomes (Figure 3). Significant audiometric gain was achieved, which positively impacted the patient's quality of life. The positive ANTS result was confirmed by successful rehabilitation.

Case 2

A 70-year-old man presented with acute-onset profound right-sided sensorineural hearing loss following retrosigmoid excision of a right cerebellopontine angle meningioma (Figures 4 and 5). Right-sided ABR testing performed 1 year postoperatively showed an absence of identifiable waveforms. Based on the operative report and postoperative MRI, reliable anatomical preservation of the right cochlear nerve could not be confirmed.

The patient sought a solution for right-sided hearing loss, and was highly motivated for unilateral auditory rehabilitation due to significant difficulties in social and occupational settings. Signal re-routing options, such as contralateral routing of signals (CROS) hearing aids or a bone conduction implant, were proposed; however, the patient chose direct stimulation of the affected ear. The patient was counseled that the anatomical presence of the nerve did not guarantee functional preservation. Therefore, intraoperative neural function assessment using the ANTS was offered as an adjunctive tool for surgical decision-making.

Intraoperatively, no wave V could be elicited, even at the maximum stimulation levels of the device (Figure 6). Based on these outcomes, the overall clinical picture of the patient, and etiology of the hearing loss, the decision was made not to proceed with CI placement. This avoided unnecessary prolonging of the surgery and implanting a device that was unlikely to provide auditory benefit.

Figure 4
MRI of the cerebellopontine angle meningioma (left). MRI following meningioma excision (right).

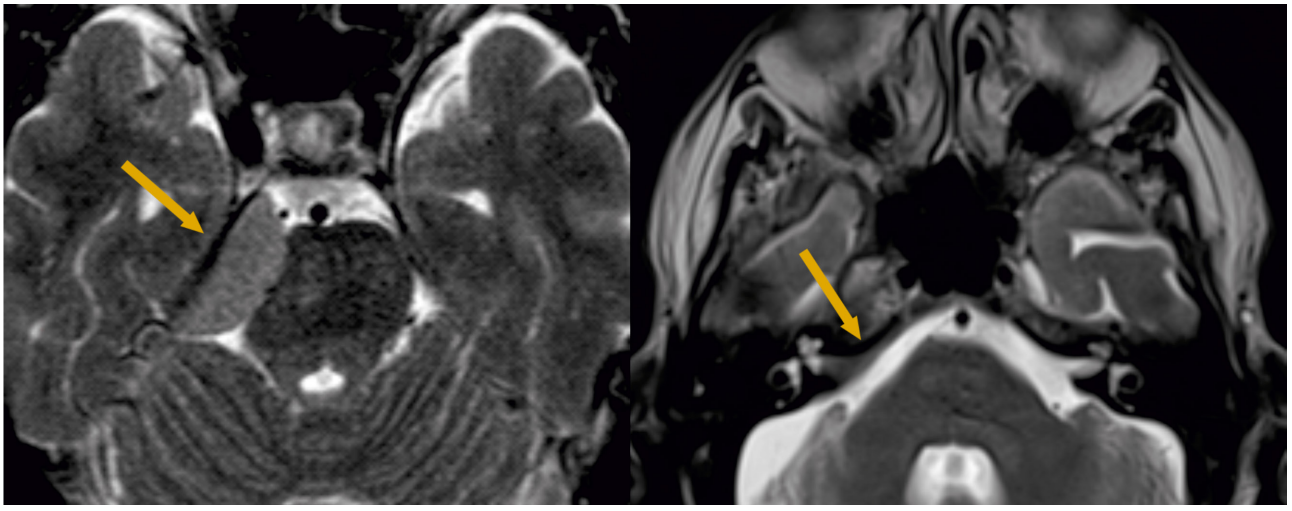


Figure 5
Audiometric evaluation prior to CI placement

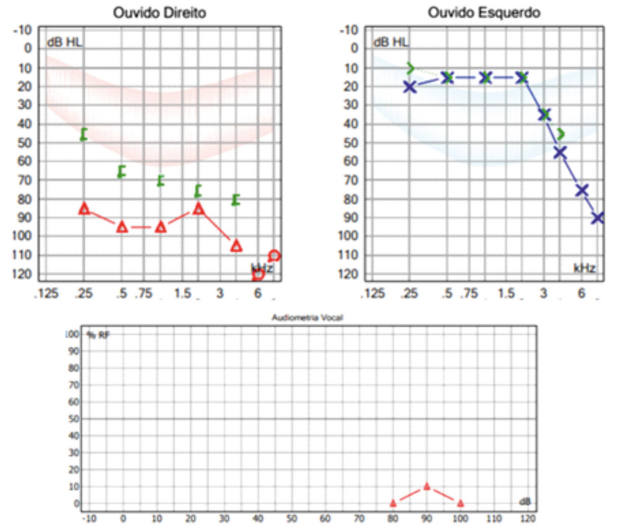


Figure 6
Graphical representation of ANTS responses. Intraoperative recording. Note the absence of a waveform where wave V is expected

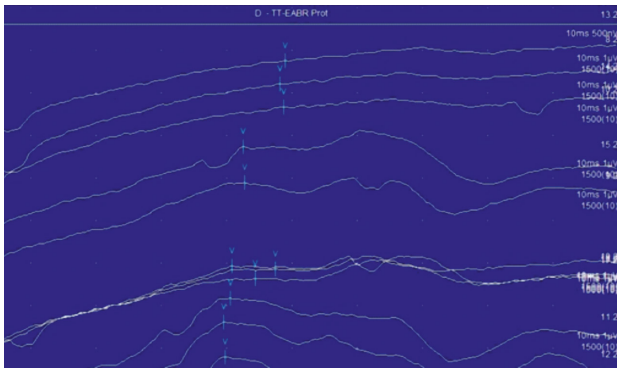
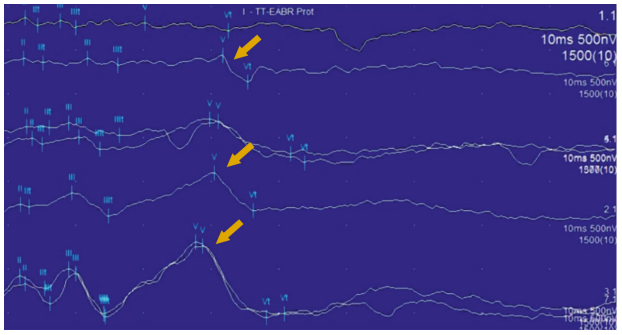


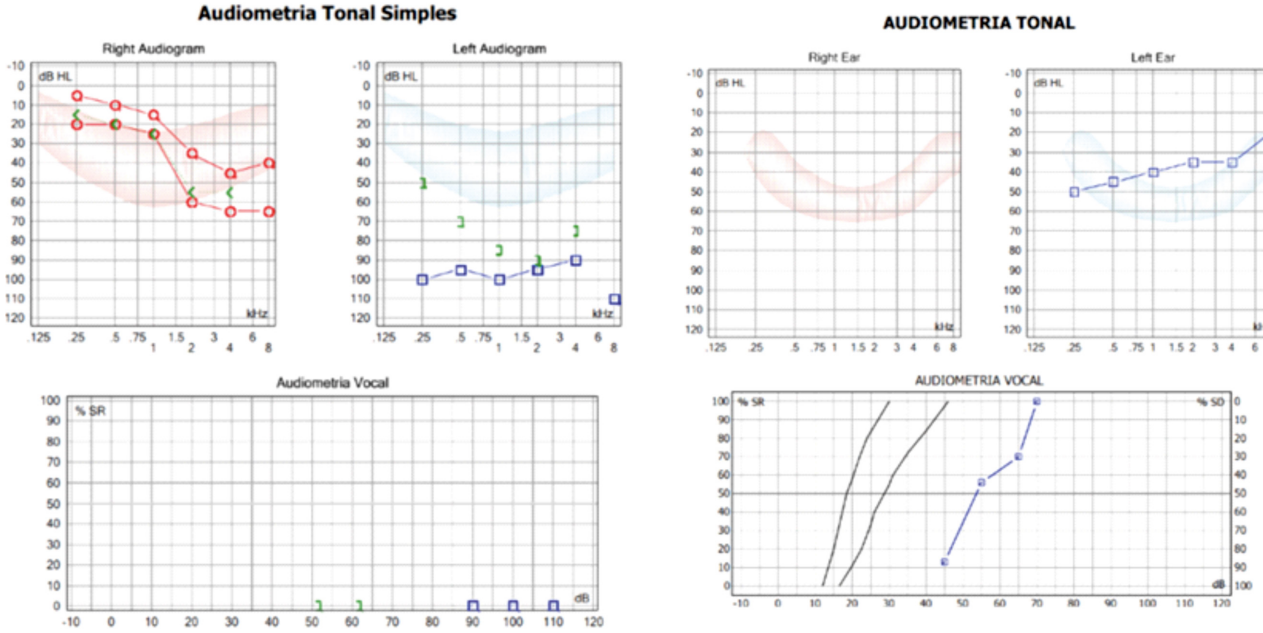
Figure 7
Graphical representation of ANTS responses. Intraoperative recording



Case 3

A 69-year-old man presented with a 45-year history of sudden-onset profound sensorineural hearing loss in the left ear. Due to the preservation of serviceable hearing in the right ear, the patient had not actively pursued auditory rehabilitation for the affected side. Cranial MRI and CT imaging excluded retrocochlear pathology and significant anatomical abnormalities, and a trial with a CROS hearing aid provided no benefit. Consequently, cochlear implantation of the left ear was considered. ABRs were absent on the left side. To determine whether the auditory nerve remained functional after 45 years of severe sensorineural hearing loss, the patient underwent intraoperative left-ear ANTS testing. Wave V was successfully identified (Figure 7), leading to CI placement.
The patient had an uneventful recovery. At the 1-year follow-up, the patient demonstrated consistent CI use and objective hearing gains (Figure 8).

Figure 8
Audiometric assessment before (left) and 1 year post-CI (right).



Discussion

Since the early decades of CI, assessing the ability of the cochlear nerve to conduct electrical stimuli has been recognized as essential for guiding implantation decisions and estimating potential functional outcomes. ABRs remain the cornerstone of electrophysiological assessment; however, in cases of profound SNHL, the absence of waveforms may reflect either severe cochlear dysfunction or neural impairment, thereby limiting the test's discriminative value.[5] To overcome this, techniques evolved toward electrical stimulation with objective auditory pathway recordings (eABRs), initially via extracochlear stimulation (promontory, round window) and more recently, via intracochlear methods.[5]

Promontory testing, described by House and Brackmann, involves transtympanic electrical stimulation coupled with the behavioral assessment of auditory sensation, pioneering the concept of a cochlear "bypass" by directly depolarizing spiral ganglion neurons.[4] Despite its simplicity, the test is inherently subjective—relying on patient cooperation and risking confusion with facial nerve paresthesias—and is prone to false negatives, which are exacerbated by suboptimal electrode placement, limited electrical diffusion, sedation, anxiety, or high electrical thresholds.[4,12]

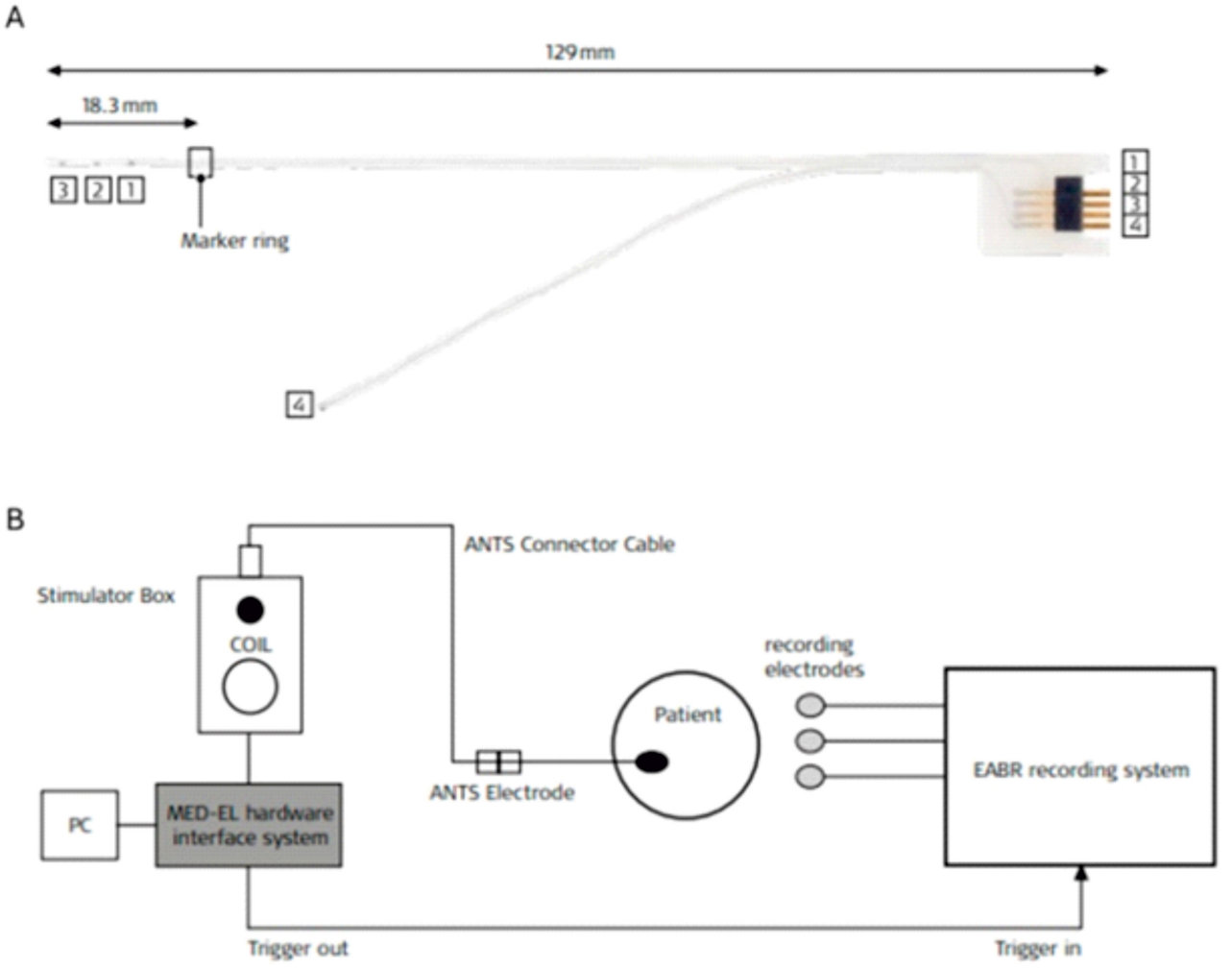
To obtain more objective responses, extracochlear eABRs, such as the *PromStim*, were developed. These include stimulating the promontory or round window niche and recording via surface electrodes, allowing for an objective reading of the wave III/V complex. Studies have shown that a reproducible electrical wave V is a useful indicator of neural function and generally correlates with a good positive predictive value (PPV) for post-CI auditory perception. However, the NPV is restricted: the absence of an extracochlear wave V does not entirely exclude CI benefit.[7-9] Susceptibility to stimulus artifacts and the geometry of the electric field in the middle ear are the major factors contributing to this limitation. Depending on the patient characteristics, sedation or general anesthesia may also be required.[5] Electrical stimulus artifacts can obscure the tracing components if alternating polarity, balanced bipolar stimulation, and synchronized artifact rejection are not employed. Furthermore, the electric field geometry in the middle ear (the exact position and angle of the electrode on the promontory or round window, contact pressure, and otic capsule thickness) influences the number of fibers effectively stimulated and signal-to-noise ratio.[7-9]

The introduction of intracochlear test electrodes brought the assessments closer to actual CI stimulation conditions. The ANTS uses a disposable intracochlear electrode with three active contacts and an extracochlear reference to stimulate cochlear nerve endings and record ABRs prior to inserting the permanent CI array (Figure 9).[3,13,14]

In comparative studies, the eABRs elicited by an intracochlear test electrode and by the CI itself exhibit nearly identical morphology and latencies, with only minor differences attributable to the insertion depth and stimulus geometry.[13,3] In VS surgery, the intraoperative use of an intracochlear electrode demonstrated an overall diagnostic accuracy of approximately 93% for predicting the auditory perception with a CI following tumor resection.[1] In a subsequent analysis, the PPV of intracochlear eABR approached 100%, whereas the NPV was moderate (approximately 55%). Specifically, the presence of wave V correlated strongly with CI success; however, the absence of a response did not always preclude some degree of sound perception.[2]

The three cases in this series align with these findings. In the first case, involving a history of bilateral neurosurgery with structural compromise of the auditory nerve, the presence of wave V using the ANTS at both apical and basal contacts supported the decision to proceed with CI placement, yielding functional outcomes consistent with the expected performance following a

Figure 9
Schematic of the ANTS components: (A) The ANTS system electrode array with contacts 1–4: apical electrode (3), middle electrode (2), basal electrode (1), and reference electrode (4). (B) eABR stimulation and recording setup: PC – Laptop with MedEl programming software (©MED-EL, Innsbruck, Austria).



positive test.[1-3] In the second case, the absence of intracochlear eABRs led to the decision not to proceed with implantation, a decision consistent with the high risk of retrocochlear damage in this setting. However, given that the reported NPV for the ANTS is moderate in some series, the decision required a careful risk-benefit assessment and thorough preoperative discussion with the patient. In this case, the presence of unilateral profound deafness was a significant factor in the decision-making process.[1,2] In the third case, which involved unilateral profound deafness of a duration of 45 years with anticipated synaptic degeneration and auditory nerve atrophy, the ANTS demonstrated neural function, prompting CI placement. This outcome is consistent with literature reports revealing that prolonged deprivation does not inherently imply a lack of neural viability, particularly when the intracochlear eABR is robust.[3,6]

Hallin & Schart-Morén (2025)[15] reported on the use of intraoperative intracochlear eABR testing (ANTS) in adults with long-standing deafness, a condition associated with nerve fiber atrophy and synaptic degeneration that can compromise the outcomes of CI. Despite limited auditory benefit in terms of speech discrimination, all patients with implants

with a positive ANTS demonstrated basic sound perception, confirming that the nerve remained responsive.[11,12] Concordant results have been reported in other series, including scenarios of prolonged auditory deprivation and in pediatric populations, reinforcing the utility of the ANTS as an intraoperative neural viability test.[3,16-18]

The interpretation of intracochlear eABRs requires technical standardization. Anesthesia and the degree of muscle relaxation can reduce amplitudes and affect latencies; furthermore, electrode positioning (insertion depth, proper placement in the scala tympani, and perilymph contact), contact impedance, and electrical background noise in the operating room all influence the clarity of wave V.[3,5,13] The strategies to mitigate artifacts include bipolar and balanced stimuli, alternating polarity, synchronized artifact rejection, proper placement of recording electrodes, and replication to confirm reproducibility.[5,7–9] Inadvertent facial nerve stimulation from the electrical stimuli used in eABR testing is possible, particularly in cases requiring higher stimulus intensities to elicit a response. Morphology, latency variation, and the amplitude growth function (abrupt vs. gradual) with increasing intensity as well as consistency across contacts, help distinguish auditory activation from non-auditory artifacts.[4-5,7]

Considering the prognostic value of the ANTS, a negative result reduces the likelihood of clinical benefit but does not eliminate it. Specifically, following the resection of a VS or meningioma, a negative test most often aligns with a lack of clinical benefit. Conversely, in cases of prolonged auditory deprivation, subthreshold responses may occur that fail to meet the wave V criterion but still allow for some auditory perception with appropriate programming.[2,3,6] According to the International Consensus Statement on Intraoperative Testing for Cochlear Implantation Surgery, integrating intraoperative eABR into the decision-making process is recommended, rather than relying on it in isolation. It is necessary to evaluate the etiology of hearing loss, imaging studies determining nerve caliber in the internal auditory canal, duration of deprivation, patient age, and rehabilitation goals.[19]

In continuous monitoring settings, combining ANTS with the measurement of cochlear nerve action potentials (CNAPs) or dorsal cochlear nucleus action potentials (DNAPs) has been described as a complementary approach for functional nerve monitoring throughout surgery. These protocols document the preservation or loss of responses during critical dissection stages, thereby increasing the precision of intraoperative decision-making.[10,12,17,20] Regarding the relationship between eABR metrics and clinical outcomes, the studies indicate a correlation between eABR thresholds and post-implantation performance, particularly in sound detection. However, predicting speech discrimination remains highly variable and multifactorial (e.g., age, duration of deprivation, central plasticity).[3,6] This distinction aligns with the nature of intracochlear eABR—a test that primarily assesses the conduction of an electrical stimulus and subsequent viability of the auditory pathway up to the brainstem, making it less specific as a quantitative predictor of speech perception.

From an operational standpoint, ANTS integrates seamlessly into the standard CI surgical workflow without requiring the actual implant for testing, thereby avoiding the need to use an implant for monitoring purposes.[3,13]

In light of the recent international consensus recommendations on intraoperative monitoring during CI surgery, intracochlear eABR results obtained with systems such as ANTS should be interpreted within the broader context of auditory pathway assessment. A reproducible wave V carries a high PPV for achieving auditory perception post-implantation. Conversely, the absence of a response should not be viewed as an absolute contraindication for implantation, given its moderate NPV and the potential for false negatives, particularly in cases of prolonged auditory deprivation or reduced

neural excitability. Therefore, eABR results should be integrated with other available intraoperative tests, such as electrode impedance measurements and electrically evoked compound action potential/neural response telemetry (ECAP/NRT) and interpreted alongside the patient's clinical and imaging data.[19]

The drawbacks of this study include the small number of cases, etiological heterogeneity, and variable follow-up duration, which preclude the local estimates of sensitivity, specificity, and predictive values. Multicenter prospective studies with standardized recording protocols and analysis of clinical covariates (age, etiology, duration of deafness) and technical covariates (insertion depth, stimulus parameters) will be useful to refine NPV estimates. Other studies have noted similar technical limitations.[1–3,5,7–10,13,16,17,19]

Conclusion

In scenarios where cochlear nerve integrity is uncertain during CI surgery, ANTS provides an objective intraoperative measure that integrates seamlessly into the surgical workflow. In two of the three cases presented, the presence of an ANTS wave V supported the decision to proceed with implantation, and subsequent clinical outcomes were consistent with preserved neural viability.

In the single case where a response was absent, the surgical decision relied on a comprehensive evaluation of the clinical picture, leading to the decision not to proceed with CI. The high PPV of ANTS indicates a strong probability of auditory nerve integrity. Conversely, due to its moderate NPV, a negative result does not entirely exclude the potential benefit of a CI. Ultimately, surgical decision-making must incorporate not only the results of ANTS, but also the etiology, imaging findings, duration of deafness, laterality, and patient expectations.

Conflicts of Interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

Data Confidentiality

The authors declare having followed the protocols in use at their working center regarding patients' data publication.

Protection of humans and animals

The authors declare that the procedures were followed according to the regulations established by the Clinical Research and Ethics Committee and to the 2013 Helsinki Declaration of the World Medical Association.

Privacy policy, informed consent and Ethics Committee Authorization

The authors declare that they have written consent for the use of photographs of patients in this article.

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Availability of scientific data

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Declaration of Generative AI and AI-Assisted Technologies in the Writing Process

The authors did not use generative AI or AI-assisted technologies in the preparation of this manuscript and assume full responsibility for the content of the publication.

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