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Simultaneous Translabyrinthine Vestibular Schwannoma Removal and Cochlear Implantation: Assessment of Wireless Connection Speech Test

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ABSTRACT

Objective: Simultaneous vestibular schwannoma (VS) removal via the translabyrinthine approach (TLA) and cochlear implantation (CI) allows for overlapping surgical fields, improving postoperative hearing outcomes, and minimizing complications associated with multiple surgical interventions. However, the effectiveness of this surgical approach remains a topic of debate. To address this, we aim to evaluate surgical outcomes using an objective wireless connection speech test to ensure accurate auditory performance.

Methods: We describe six patients with simultaneous TLA and CI surgery from 2020 to 2024. All patients presented with single-sided deafness or asymmetric hearing loss due to vestibular schwannomas classified as Koos grade I or II, confined to the internal auditory canal. Preoperative and postoperative hearing outcomes were assessed through pure-tone audiometry thresholds, word recognition scores, Visual Analog Scale (VAS), and Abbreviated Profile of Hearing Aid Benefit survey (APHAB). Magnetic resonance imaging (MRI) confirmed that tumors were either completely or nearly completely excised. Postoperative hearing outcomes were also evaluated through Sound Field (unplugging) tests, occlusion plugging tests, and the iPad speech test—a wireless transmission of recorded sound directly to the CI's speech processor.

Results: The pure-tone audiometry thresholds and word recognition scores improved from preoperative to postoperative assessments ($p = 0.0002$ and $p = 0.03$, respectively). Of the five patients who performed the postoperative iPad speech test, monosyllabic and disyllabic scores were consistently lower than the outcomes from the plugged and unplugged tests. Notably, two patients reported no measurable iPad-based speech recognition despite measurable performance on the plugged test. Additionally, APHAB scores showed significant improvement across all patients.

Conclusion: Simultaneous TLA and CI emerges as an effective procedure for restoring hearing in patients with small vestibular schwannomas, allowing the recovery of binaural hearing.

Level of Evidence: 4

1 | Introduction

Vestibular schwannoma (VS), also known as acoustic neuroma, arises from Schwann cells on the vestibular nerve. VS typically leads to unilateral symptoms, including progressive hearing loss, tinnitus, and balance issues. Most commonly, patients with VS experience unilateral hearing loss [1]. Although treatment options such as stereotactic radiation and surgery are available, they are unable to fully restore hearing [2]. Because of the disease itself or during the treatment process, many patients eventually lose hearing in one ear, which becomes a factor that deteriorates their quality of life.

Cochlear implantation (CI) is recognized as the most effective method to restore binaural hearing in patients with single-sided deafness (SSD) [3]. Many studies have reported that using a cochlear implant to restore binaural hearing helps improve quality of life and cognitive abilities [2]. CI has been demonstrated to enhance speech perception and sound localization significantly [4]. The primary criteria for CI candidacy include the anatomical and functional preservation of the cochlear nerve, as well as the cochlea's ability to accommodate an electrode array [5]. Challenges such as cochlear ossification and vascular or inflammatory compromise [6] can complicate the surgical process and worsen expected hearing outcomes. Therefore, performing CI in patients with VS remains controversial due to the challenge of preserving the anatomical and functional preservation of the cochlear nerve during tumor resection. For instance, although the nerve may be anatomically preserved intraoperatively, its electrophysiological function can be compromised, thereby limiting the effectiveness of postoperative cochlear stimulation and hearing outcomes. An additional consideration is the magnetic resonance imaging (MRI) for tumor surveillance and cochlear implant electrode array assessment, as the implant's magnetic component can compromise the image resolution. However, with advancements in the evaluation of cochlear implant auditory performance in single-sided deafness—such as the wireless connection speech test which transmits signals directly to the cochlear implant's speech processor and enables isolated hearing assessment of the implanted ear—along with adjustments in the positioning of the CI magnet and accumulated experience in surgical techniques, many of these concerns have been significantly mitigated. As a result, simultaneous surgeries are now being performed much more frequently than before [7].

Simultaneous translabyrinthine VS removal and CI is a convenient and efficient approach for tumor resection while aiming to restore hearing. The translabyrinthine approach (TLA) is a viable option for patients with no residual hearing or severe hearing loss, as it ablates the labyrinth and thus results in the loss of any remaining auditory function. It is a safe and effective approach with low complication rates, such as a low risk of facial nerve paralysis. The approach provides extensive access to the internal auditory canal, allowing full exposure to the auditory nerve and tumor. It offers a direct approach to the cerebellopontine angle, requiring minimum cerebellum retraction [8]. Using the same surgical posture and field exposure for both procedures also minimizes the risks associated with multiple anesthesia exposures, contamination, additional incisions, and bone drilling, thus reducing overall recovery time.

A key concern with the simultaneous removal of the tumor and CI is the effectiveness of hearing restoration in cases of single-sided deafness. While there is ongoing debate as to whether patients with SSD perceive sound through the implanted ear or have the impression of hearing from the normal or residual hearing in the contralateral ear, the objective of CI in this patient population is to improve sound localization and speech perception in noisy environments. To isolate and accurately assess speech localization and perception from the implanted ear, the authors developed and reported a wireless connection test that transmits speech signals directly to the cochlear implant [9].

In this study, we assess six cases of simultaneous translabyrinthine vestibular schwannoma removal and cochlear implantation. Authors used the "iPad speech test"—a reported speech test using a wireless connection in single-sided cochlear implant users—followed by standard audiological exams and surveys, including average pure-tone audiometry, word recognition score percentages, Visual Analog Scale, and Abbreviated Profile of Hearing Aid Benefit survey. These cases raise important considerations on audiological performance and future implications.

2 | Materials and Methods

2.1 | Patients

Six patients diagnosed with small (< 2 cm) vestibular schwannomas (VS) underwent the translabyrinthine approach (TLA) surgery with simultaneous cochlear implantation between May 2020 and June 2024.

The surgical approach was selected based on tumor characteristics, including its location and size within the internal auditory canal (Koos grade I or II), as well as patient-related factors such as age and preoperative hearing status. This study was approved by the institutional review board of Severance Hospital (project number: 4-2023-1367). The requirement for informed consent was waived due to the retrospective nature of the study.

2.2 | Surgical Procedure

All surgeries were performed by a senior surgeon (I.S.M). Initially, a postauricular incision was made, followed by a complete mastoidectomy. Posterior tympanotomy was then performed extensively to fully expose the round window membrane, and a cochleostomy was conducted for electrode insertion [10].

The bone overlying the sigmoid sinus and tegmen was removed. After retracting the sigmoid sinus, a labyrinthectomy was carried out to identify the internal auditory canal (IAC) [11]. The dura of the posterior fossa and IAC was opened, and the tumor was resected with facial and cochlear nerve preservation.

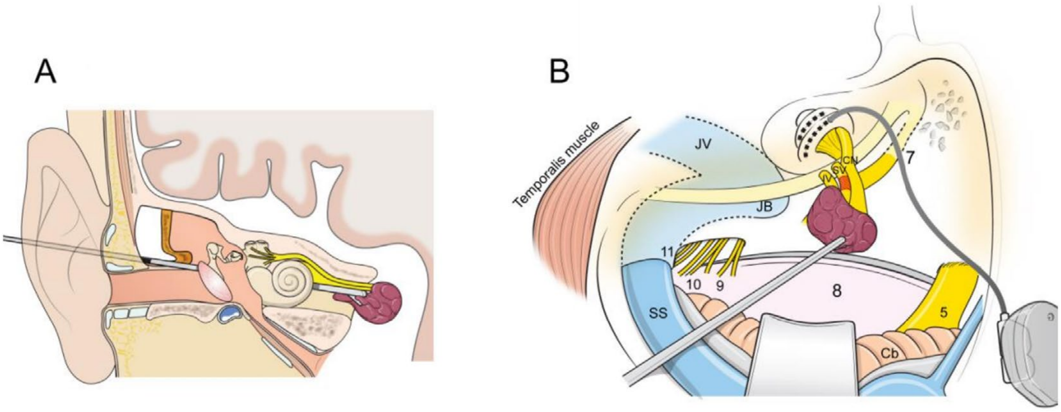
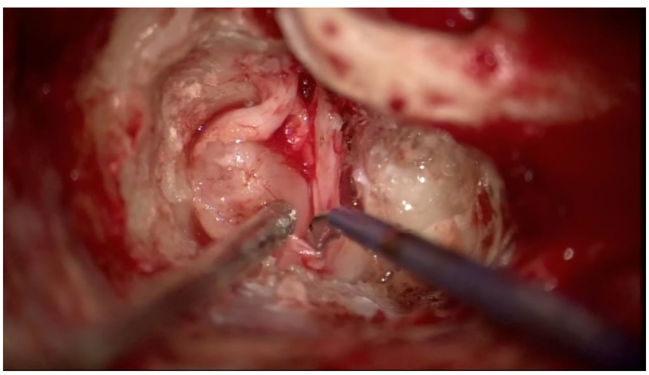


FIGURE 1 | Surgical approach of simultaneous translabyrinthine vestibular schwannoma removal and cochlear implantation. (Panel A) A small vestibular schwannoma tumor was resected using the translabyrinthine approach (TLA), which involved removing the labyrinth and drilling through the mastoid and posterior temporal bone, while preserving the facial nerve (cranial nerve VII) and vestibulocochlear nerve (cranial nerve VII). (Panel B) The TLA approach offers a direct approach to the cerebellopontine angle and full exposure to surrounding cranial nerves and tumor, especially the cochlear nerve that allows for successful cochlear implantation. Cb = cerebellum; CN = cochlear nerve; IV = inferior vestibular; JB = jugular bulb; JV = jugular vein; SS = sigmoid sinus; SV = superior vestibular.



VIDEO 1 | Simultaneous translabyrinthine vestibular schwannoma removal and cochlear implantation. Caption: Surgical operation of simultaneous translabyrinthine vestibular schwannoma removal and cochlear implantation. CI = cochlear implant; CN = cranial nerve; EAC = external auditory canal; LSCC = lateral semicircular canal; N = nerve; VS = vestibular schwannoma. Video content can be viewed at https://onlinelibrary.wiley.com/doi/10.1002/lio2.70197.

Following tumor removal, the surgeon verified the anatomical integrity of the cochlear nerve. The internal auditory canal was packed with a temporalis muscle graft and fibrin glue to prevent cerebrospinal fluid leakage.

Since the mastoid bone has already been drilled, the surgeon created a pocket in the temporal bone for the internal component of the cochlear implant. The internal device was positioned 9 cm from the external auditory canal to optimize MRI visibility, and the electrode array was inserted directly through the cochleostomy site (Figure 1 and Video 1).

2.3 | Hearing Assessment

For both preoperative and postoperative assessments, pure-tone audiometry (PTA) was conducted in a soundproof booth, and the word recognition score (%) was measured at the most comfortable level using the adapted Korean Hahm's list. For each WRS and PTA test, the healthy contralateral ear that did not receive the CI was plugged. In addition to these tests, each patient was evaluated through the Sound field (unplugging) test, occlusion plugging test, and the iPad speech test at either 6 or 8 months postoperatively, based on patient availability. Functional testing of the cochlear implant device was completed at either 5 or 7 months postoperatively. Hearing in noise test (HINT) was not performed as this study primarily focused on isolating and evaluating the affected ear's performance independently and minimizing masking-related issues associated with HINT.

To assess cochlear implant (CI) performance in patients with single-sided deafness (SSD), the authors reported outcomes of a wireless connection test, referred to as the iPad speech test, based on a previously developed Korean-language iPad speech test software [9]. Standardized monosyllabic words and sentences were pre-recorded on an iPad and transmitted via Bluetooth directly to the CI speech processor. The iPad speech test utilized the same word and sentence stimuli as the conventional auditory speech evaluation, based on the validated Seoul National University Hospital (SNUH) Speech Perception Test. Once the wireless connection was established, the audiologist determined the most comfortable listening level. This method enabled direct stimulation of the cochlear nerve through the implant by bypassing both the external microphone and middle ear, while fully excluding input to the contralateral normal-hearing ear (Figure 2). Compared to traditional methods such as the "unplugging test," which uses speaker-based delivery in a sound-isolated booth, or the "plugged and muffed" approach, which occludes the hearing ear with earplugs and headphones [12], the iPad speech test eliminates the potential for residual acoustic input to the normal ear.

Participants also performed Visual Analog Scale (VAS) and Abbreviated Profile of Hearing Aid Benefit (APHAB) surveys

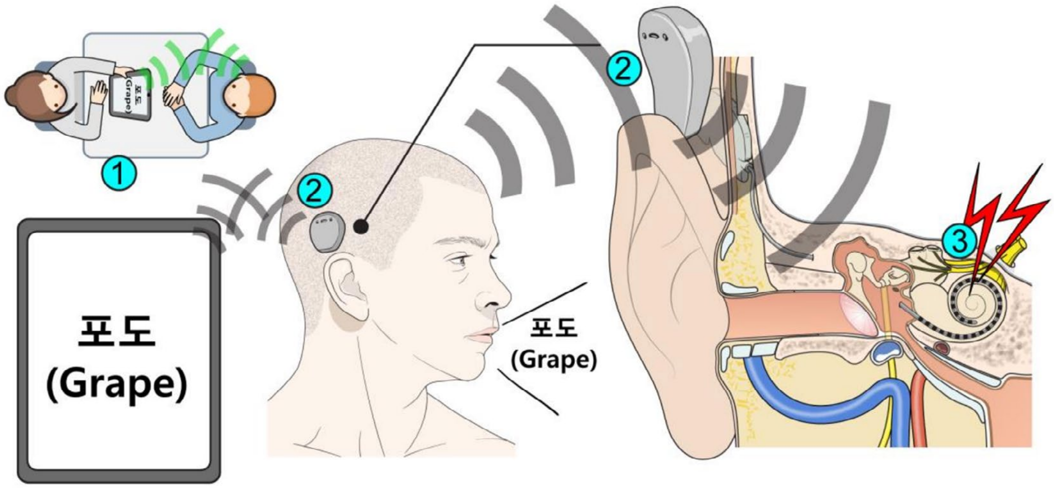


FIGURE 2 | iPad speech test. (1) An audiologist selects a pre-recorded sound (one syllable, two syllables, or sentence) on the iPad. (2) The recorded stimulus is transmitted directly to the cochlear implant's speech processor through wireless Bluetooth technology. (3) Stimuli directly activate the cochlear nerve and bypass the middle ear structures.

to assess subjective symptomatic outcomes. VAS for hearing loss assesses patients' self-reported attitude toward hearing loss on the side where the surgery will be performed. Patients are asked to mark a point on a 100 mm horizontal line anchored by word descriptors that represent their perception of their current state. On a scale from 0 to 10, they mark a point on a 10-point line with 0 as normal hearing and 10 as cannot hear at all [13].

The APHAB questionnaire is an abbreviated version of the Profile of Hearing Aid Benefit, which is a commonly used questionnaire to assess an individual's self-perception of their hearing ability and benefit of hearing aids [14]. The 24-questions are divided into four subscales—ease of communication (EC), background noise (BN), reverberation (RB), and aversiveness of noise (AV)—reporting the level of difficulty patients experience while communicating in various everyday situations [15]. Each item is a statement, such as "When I am having a quiet conversation with a friend, I have difficulty understanding" or "Traffic noises are too loud." The patient decides how often the statement is true from seven choices: Always (99%), Almost always (87%), Generally (75%), Half the time (50%), Occasionally (25%), Seldom (12%), and Never (1%) [16]. In both surveys, a lower value indicates a better result.

2.4 | Tumor Surveillance

Preoperative and immediate postoperative gadolinium-enhanced magnetic resonance imaging (MRI) was taken to evaluate the extent of tumor removal and successful CI insertion.

2.5 | Statistical Analysis

All statistical analyses were performed using R software (version 4.1.2), and p values <0.05 were considered significant. Mean and standard error were used for descriptive statistics. The single paired t-test was conducted to compare preoperative and postoperative hearing thresholds (dB HL) as it demonstrated normal distribution on the Shapiro–Wilk normality test. However, for WRS (%) and comparison of unplugged vs. plugged vs. iPad speech tests, the Wilcoxon Signed-Rank Test demonstrated a non-parametric distribution of the sample.

3 | Results

A total of six patients underwent simultaneous TLA and CI. The mean patient age was 61.0 years old ± 4.30. Tumors were confined to the IAC and Koos grade I or II in all patients, with a mean of 8.0 ± 1.31 mm (Tables 1 and S1).

For each patient, the pure-tone audiometry (PTA) thresholds and word recognition scores (WRS) demonstrated significant improvement from the preoperative to postoperative assessments (Table 2; $p = 0.0002$ and $p = 0.03$, respectively).

The efficacy of three assessment methods for cochlear implant (CI) performance in single-sided deafness (SSD) was compared: unplugging, plugging, and the iPad test. Out of a six patients cohort, five patients completed the iPad speech test; one was lost to follow-up. iPad-based monosyllabic and disyllabic word recognition scores were consistently lower than those obtained in both plugged and unplugged postoperative test outcomes. Of these five patients, two patients reported no measurable speech recognition despite having a significant measurable response for the plugged testing.

In the VAS, all patients reported "10" pre-operative, representing "cannot hear at all" in the ear with the VS tumor. Post-operatively, all patients reported improved subjective hearing outcomes with scores less than 10 (Table 3). For the APHAB survey, patients reported 54.8 ± 7.0, 73.4 ± 5.0, 95.2 ± 1.07, 92.8 ± 2.48 for pre-operative BN, RV, AV, EC, respectively, and 40.2 ± 5.2, 35.6 ± 8.07, 29.4 ± 9.78, 22.8 ± 1.63 post-operative BN, RV, AV, EC respectively (Table 3). Thus, all hearing outcomes in all the assessments reported improvements pre-operative to post-operative.

TABLE 1 | Summary of preoperative and postoperative surgical outcomes of simultaneous translabyrinthine vestibular schwannoma removal and cochlear implantation.

	General condition		Tumor condition		Preoperative hearing test (lesion site)		Postoperative hearing test (lesion site)										
									Unplugged test (%)			Plugged test (%)			iPad test (%)		
Patient no.	Sex	Age (years)	Site	Tumor size (mm)	PTA threshold (dB HL)	WRS (%)	PTA threshold (dB HL)	WRS (%)	1 syllable	2 syllables	Sentence	1 syllable	2 syllables	Sentence	1 syllable	2 syllables	Sentence
1	F	53	Right	7 × 4	100	0	34	58	90	80	94	90	80	96	0	0	0
2	F	70	Left	8 × 7	100	2	28	79	85	100	100	55	65	86	35	50	75
3	F	45	Right	12 × 7	100	0	50	24	100	100	100	64	60	80	0	0	0
4	M	64	Left	11 × 5	59	76	25	81	90	80	94	90	90	96	0	40	86
5	F	61	Right	7 × 2	85	48	24	88	40	50	78	NA	NA	NA	NA	NA	NA
6	F	73	Right	3 × 3	80	4	32	78	90	100	100	40	50	82	25	30	70

Abbreviations: CI: cochlear implant, NA: not available, PTA: pure tone average, WRS: Word Recognition Score.

TABLE 2 | Comparison of preoperative and postoperative hearing outcomes.

	Preoperative hearing test	Postoperative hearing test	*p*
Hearing threshold (dB HL)[a]	87.3 ± 6.69	32.2 ± 3.90	0.0002**
WRS (%)[b]	21.7 ± 13.3	68.0 ± 9.71	0.03

***p*-value less than 0.01.
[a]One sample *t*-test.
[b]Wilcoxon Signed-Rank Test.

4 | Discussion

For patients with severe unilateral hearing loss and small vestibular schwannoma (< 2 cm), simultaneous translabyrinthine approach (TLA) and cochlear implantation (CI) can offer successful tumor resection and hearing restoration. Our study findings are consistent with a 2021 study of 41 cases, which also highlights statistically significant improved PTA and sentence recognition scores [3]. To our knowledge, this study contributes to the limited number of reported cases (< 150) [7], offering valuable insights into the growing body of evidence supporting the efficacy of this procedure. All cases demonstrated improved hearing outcomes across all assessments, with no major postoperative complications such as cerebrospinal fluid leak, meningitis, wound infections, facial palsy, or seizures.

4.1 | Selection of Surgery Choice

The choice of TLA surgery is motivated by its ability to provide greater exposure to anatomical landmarks such as the internal auditory canal (IAC) and excellent visibility of the facial nerve. This allows for anatomical conservation and offers the most direct, widest view of the tumor with less retraction of the cerebellum or temporal lobe. The approach provides extensive access to the internal auditory canal, allowing full exposure to the auditory nerve and tumor [11]. Performing both procedures simultaneously offers many advantages. Using the same surgical posture and field exposure minimizes the risks associated with multiple anesthesia exposures, contamination, additional incisions, and bone drilling, thus reducing overall recovery time and surgical costs [3].

Additionally, recent studies indicate that cochlear implantation—especially in patients with contralateral normal hearing—improves sound localization and speech perception in noisy environments [2], significantly enhancing the quality of life and reducing the risk of cochlear ossification. The limitations of simultaneous TLA and CI are consistent with those reported in separate TLA or CI surgeries, most notably cerebrospinal fluid (CSF) leakage. This can be mitigated by packing the Eustachian tube and middle ear with temporalis muscle, fat, or fibrin glue. Due to the small surgical areas involved in otological surgeries, the operation also requires experience and familiarity, with careful attention to bleeding control and nerve exposure.

TABLE 3 | Pre-operative and post-operative outcomes in visual analog scale (VAS) and abbreviated profile of hearing aid benefit (APHAB).

Patient	VAS in hearing loss Pre-operative	VAS in hearing loss Post-operative	BN Pre-operative	RV Pre-operative	AV Pre-operative	EC Pre-operative	BN Post-operative	RV Post-operative	AV Post-operative	EC Post-operative
1	10	8	46	66	96	96	46	58	67	63
2	10	4	60	78	96	96	40	27	19	17
3	10	4	44	64	91	83	52	41	12	8
4	10	5	44	68	96	94	42	42	29	23
5	10	1	80	91	97	95	21	10	20	3

Note: APHAB subscales: BN, background noise; RV, reverberation; AV, aversiveness; EC: ease of communication.

4.2 | Surveillance

An additional advantage of this simultaneous approach is the optimization of MRI visibility. Positioning the cochlear implant more vertically and posteriorly with an angle of 160° from the nasion to the external auditory canal and internal magnet facilitates better imaging for tumor follow-up and cochlear implant monitoring [17]. Our study confirmed cochlear nerve integrity anatomically through postoperative MRI and functionally using iPad-based testing. Intraoperative functional testing—such as electrically evoked auditory brainstem response (eABR), auditory response telemetry (ART), and the Auditory Nerve Test System (ANTS; MED-EL, Innsbruck, Austria)—can provide real-time electrophysiological confirmation of implant function and auditory nerve integrity. For instance, ANTS enables real-time assessment of eABR without requiring cochlear implant insertion and has demonstrated a strong correlation with postoperative auditory perception, especially in tumor-related cochlear implantation cases [18, 19]. However, most patients enrolled in this study underwent surgery before ANTS were offered and therefore were only used in a small subset of patients. To maintain consistency across the cohort, intraoperative data were excluded from the analysis. This limitation should be addressed in future studies by incorporating standardized intraoperative functional testing across all patients.

We also did not use cochlear nerve action potential (CNAP) monitoring intraoperatively [20]. Studies have reported that CNAP can provide a near-real-time assessment of cochlear nerve function, which could provide a more comprehensive evaluation of cochlear nerve integrity pre- and post-operation. However, its clinical effectiveness as a predictor of cochlear implant auditory performance remains uncertain, as electrophysiological function may be impaired by vascular mechanisms such as coagulation or spasm of the internal auditory artery, despite anatomical preservation of the cochlear nerve [21]. In addition, for countries where CNAP is not approved (including South Korea), iPad testing offers a practical and accessible alternative for evaluations of CI in patients with SSD.

4.3 | Hearing Assessment

For both preoperative and postoperative assessments, pure-tone audiometry (PTA) and the word recognition score (%) were measured. In addition to these tests, we performed three postoperative tests: unplugging, plugging, and the iPad test at around 6 months postoperatively, with functional cochlear implant device testing at 5 or 7 months.

In evaluating the effectiveness of cochlear implantation in patients with single-sided deafness (SSD), the Hearing in Noise Test (HINT) is a widely accepted and validated method for measuring speech perception in the presence of background noise. Improved performance on HINT, indicated by a reduced signal-to-noise ratio, highlights auditory benefits that can be seen in SSD patients with CI compared to patients with SSD. However, in SSD populations, accurately isolating the cochlear implant ear poses a challenge due to the normal-hearing or residual-hearing contralateral ear. Techniques such as contralateral masking or the “plugged and muffed” method are often employed to minimize this influence, but they are prone to over- or under-masking, require specialized equipment, a controlled sound environment, costly and resource-intensive [9]. However, in the context of evaluating the implanted ear in isolation, particularly in SSD cases, the iPad test is more accurate as it not only isolates the CI side more effectively, but also reflects improvements in speech discrimination. For instance, unplugging testing, which uses speakers in a sound-isolated room, may be inaccurate due to potential sound leakage and environmental interference [12]. The plugging test, where the normal hearing ear is occluded with earplugs and headphones, simulates single-sided hearing loss but is limited by residual hearing and incomplete isolation of the hearing ear. In contrast, the iPad test, which employs wireless transmission of recorded stimuli directly to the CI's speech processor, provides complete isolation of the hearing ear, offering a more precise and controlled assessment of CI performance in SSD. Therefore, the choice of this wireless connection test was used to investigate speech discrimination improvement using the iPad-based isolated ear testing.

To our knowledge, this study is the first to employ an iPad speech test in this surgical approach, a reported more objective hearing assessment in SSD over traditional techniques, such as the “plugged and muffed” approach. This testing completely excludes the normal hearing ear and provides a more accurate assessment of CI performance [9] and consistent with reported findings of iPad speech test in independent cochlear implant patients [22]. It also offers advantages such as lower testing costs, increased accessibility to a wider market, and reduced financial burden on patients.

Out of a six patientsi cohort, five patients completed the iPad speech test; one was lost to follow-up. Although preoperative iPad speech testing was not feasible due to the requirement of an implanted cochlear device, postoperative results revealed that three patients (Patients 2, 4, and 6) achieved moderate to high scores in sentence recognition on the iPad speech test (70%–86%), despite low preoperative word recognition scores (≤4%). This finding suggests a potential benefit in improved speech perception from the surgery, as further supported by statistically significant improvements in preoperative to postoperative PTA thresholds and WRS. In addition, iPad-based monosyllabic and disyllabic word recognition scores were consistently lower than those obtained in both plugged and unplugged postoperative test outcomes. For instance, of these five patients, the two remaining patients reported no measurable speech recognition despite having a significant measurable response for the plugged testing.

This discrepancy—where two patients reported significant measurable results during the plugged test but failed to recognize speech during iPad testing—raises important questions about the reliability of the plugged test as a predictor of CI performance. This indicates that patients may continue to rely more on their healthy ear with normal or residual hearing than on the implanted ear during plugged tests. As a result, this inconsistency suggests an overestimation of cochlear implant performance in the plugged test and underscores the potential of the iPad speech test as a more accurate and objective tool for evaluating CI function in patients with single-sided deafness (SSD). Further investigation is warranted to assess the predictive validity of the plugged test in this context. In addition, a validated iPad-based monosyllabic speech perception test exists for the Japanese and English languages, but no such validated version is currently available in Korean [9]. Future studies should focus on increasing the sample size of iPad speech testing and validating a Korean iPad speech test to expand its clinical applicability and standardization [9].

Lastly, this surgical approach demonstrated improved symptomatic outcomes based on patients' subjective reports. Reductions in VAS and APHAB scores indicate the potential for improving objective hearing outcomes and, most importantly, quality of life [23]. These results align with the findings in patients undergoing independent cochlear implants [24]. Specifically, patients have reported better results in everyday listening situations—such as conversations with family and friends or sounds of traffic and sirens—and relief from psychosocial consequences of their condition [25], increasing patient satisfaction with the surgery [26]. Thus, our study highlights the novelty of this approach as the first to incorporate iPad-based speech testing in simultaneous vestibular schwannoma resection and cochlear implantation surgeries. It contributes to the growing body of reported surgical cases (< 150) [7], offering a safer and more efficient method for hearing restoration and tumor removal.

5 | Conclusion

Simultaneous CI and translabyrinthine VS removal is a viable option for hearing rehabilitation in specific conditions. If the integrity and function of the cochlear nerve are preserved and can be clearly evaluated during surgery; the position of the CI's internal device can be adjusted to allow for effective postoperative MRI surveillance; and the wireless speech test can accurately assess hearing in the operated ear, this approach may become a more widely accepted treatment method in the future.

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Conflicts of Interest

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.