

ARTÍCULO ORIGINAL

AUDIOLOGICAL REHABILITATION AFTER REFRACTORY IDIOPATHIC SUDDEN SENSORINEURAL HEARING LOSS: A PROSPECTIVE OBSERVATIONAL STUDY

Rehabilitación auditiva tras hipoacusia súbita idiopática neurosensorial refractaria: estudio observacional prospectivo

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SUMMARY: Introduction and objective: Between 30 % and 50 % of patients with idiopathic sudden sensorineural hearing loss (ISSNHL) fail to achieve clinically significant hearing recovery following corticosteroid therapy, resulting in persistent residual hearing loss. Objectives: To evaluate the audiological impact of auditory rehabilitation in refractory ISSNHL, describe the rehabilitation strategies indicated and adopted, and analyse the proportion of patients who accept or decline rehabilitation. Method: Prospective observational study of patients with refractory ISSNHL (2015–2024). Rehabilitation modality was selected according to audiometric profile, speech discrimination ability, and shared clinical decision-making. Changes in pure tone average (PTA) and speech discrimination score (SDS) were analysed before and after rehabilitation. Results: Thirty-six patients were included; ten (27.8 %) accepted active rehabilitation: seven with hearing aids and three with cochlear implants. Functional improvement in thresholds and speech discrimination was observed in most patients. Greater gains were noted in the small cochlear implant subgroup (n = 3).

A majority of patients (63.9 %) did not access any form of rehabilitation. Discussion: These findings highlight the existence of a significant therapeutic gap between pharmacological treatment failure and the implementation of auditory rehabilitation in patients with refractory ISSNHL. Although only a minority of patients accessed active rehabilitation, meaningful functional improvements were observed across all modalities, with cochlear implantation yielding the greatest gains in a small subgroup of selected candidates ($n = 3$). Conclusions: Auditory rehabilitation provides meaningful functional improvement in refractory ISSNHL. Cochlear implantation appeared to offer the greatest benefit in a small subgroup of selected patients ($n = 3$). A high proportion of patients do not access rehabilitative strategies, highlighting a significant clinical gap that warrants structured counselling at the point of pharmacological treatment failure.

KEYWORDS: idiopathic sudden sensorineural hearing loss; auditory rehabilitation; hearing aids; cochlear implant; audiology; single-sided deafness

RESUMEN: Introducción y objetivo: Entre el 30 % y el 50 % de los pacientes con hipoacusia súbita idiopática neurosensorial (ISSNHL) no alcanzan una recuperación auditiva clínicamente significativa tras el tratamiento corticoideo, lo que resulta en una hipoacusia residual persistente. EL objetivo fue evaluar el impacto audiológico de la rehabilitación auditiva en la ISSNHL refractaria, describir las estrategias de rehabilitación indicadas y adoptadas, y analizar la proporción de pacientes que aceptan o rechazan la rehabilitación. Método: Estudio observacional prospectivo de pacientes con ISSNHL refractaria (2015–2024). La modalidad rehabilitadora se seleccionó según el perfil audiométrico, la discriminación del habla y la toma de decisiones compartida. Se analizaron los cambios en el promedio tonal puro (PTA) y la puntuación de discriminación del habla (SDS) antes y después de la rehabilitación. Resultados: Se incluyeron 36 pacientes; diez (27,8 %) aceptaron una rehabilitación activa: siete con audífonos y tres con implantes cocleares. Se observó mejoría funcional en umbrales y discriminación del habla en la mayoría de los pacientes, siendo mayor en el reducido subgrupo de receptores de implante coclear ($n = 3$). El 63,9 % de los pacientes no accedió a ninguna estrategia de rehabilitación. Discusión: Estos hallazgos evidencian la existencia de una brecha terapéutica significativa entre el fracaso del tratamiento farmacológico y la implementación de la rehabilitación auditiva en pacientes con ISSNHL refractaria. Aunque solo una minoría de pacientes accedió a una rehabilitación activa, se observaron mejorías funcionales relevantes en todas las modalidades, siendo la implantación coclear la que produjo mayores ganancias en un reducido subgrupo de candidatos seleccionados ($n = 3$). Conclusiones: La rehabilitación auditiva proporciona una mejoría funcional significativa en la ISSNHL refractaria. La implantación coclear pareció ofrecer el mayor beneficio en un reducido subgrupo de pacientes seleccionados ($n = 3$). La elevada proporción de pacientes que no accede a las estrategias rehabilitadoras pone de manifiesto una brecha clínica importante que requiere un asesoramiento estructurado en el momento del fracaso farmacológico.

PALABRAS CLAVE: hipoacusia súbita idiopática neurosensorial; rehabilitación auditiva; audífonos; implante coclear; audiolología; sordera unilateral

INTRODUCTION

Hearing loss affects over 1.5 billion people worldwide and represents one of the most prevalent sensory disabilities, with substantial consequences for communication, social integration, and quality of life [1]. Among its acute forms, sudden sensorineural

hearing loss (SSNHL) — defined as a loss greater than 30 dB HL across three or more consecutive frequencies developing within 72 hours — stands out as a genuine otological emergency requiring prompt evaluation and treatment [2, 3]. Its annual incidence is estimated at 2–20 cases per 100,000 inhabitants, with a peak between 40 and 55 years of age [2–4].

In more than two-thirds of cases, no underlying aetiology is identified, leading to the designation of idiopathic sudden sensorineural hearing loss (ISSNHL). The pathophysiology of ISSNHL remains incompletely understood, and several competing hypotheses have been proposed. Cochlear viral inflammation — particularly involving herpes family viruses — and vascular ischaemia affecting the labyrinthine artery were historically the most cited mechanisms. More recently, auto-immune-mediated cochlear injury has gained considerable traction, supported by the observed responsiveness to corticosteroids and by serological and histopathological evidence in some patients [2, 3, 5]. Rupture of intralabyrinthine membranes has also been proposed as a contributing mechanism in a subset of cases. The coexistence of these diverging hypotheses reflects the likely multifactorial nature of the condition and has direct implications for treatment strategies.

Current clinical guidelines (AAO-HNS) recommend corticosteroids — administered orally, intratympanically, or in combination — as the first-line treatment [2, 3, 7]. This recommendation is echoed by other national and international consensus statements [5, 6]. Despite appropriate management, 30–50 % of patients fail to achieve clinically meaningful hearing recovery and are left with persistent unilateral hearing loss [2, 3, 5]. This residual impairment is not trivial: even with a fully functioning contralateral ear, unilateral hearing loss compromises speech understanding in noisy environments and sound localisation ability — both key aspects of everyday auditory function [8,9]. When pharmacological treatment fails, auditory rehabilitation becomes the next therapeutic step.

Rehabilitation options for patients with refractory ISSNHL range from conventional hearing aids and Contralateral Routing of Signal (CROS) systems [10–12] to bone-anchored hearing devices [13, 14] and, in selected cases, cochlear implantation [17–19]. However, real-world uptake of these strategies is variable and often low, and the gap

between pharmacological failure and the implementation of rehabilitative measures has been insufficiently characterised in the literature [5, 15, 16]. Cochlear implantation in particular has recently emerged as a promising option for patients with profound residual hearing loss following ISSNHL, with accumulating evidence suggesting meaningful gains in speech discrimination and auditory access [17–20].

Prior systematic reviews have synthesised outcomes of cochlear implantation in single-sided deafness and ISSNHL [17, 19, 25], providing strong evidence for cochlear implant efficacy in selected patients. However, these reviews focus primarily on cochlear implantation and do not characterise the full spectrum of rehabilitation strategies applied in routine clinical practice, nor do they describe the substantial proportion of patients who do not access rehabilitation at all. The present study contributes real-world prospective data across all rehabilitation modalities — conventional hearing aids, bone conduction devices, and cochlear implants — within a single institutional cohort, with an explicit focus on rehabilitation uptake and the clinical gap between pharmacological failure and rehabilitative intervention.

The present study aimed to evaluate the audiological impact of auditory rehabilitation in patients with pharmacologically refractory ISSNHL treated at a tertiary referral centre over a ten-year period (2015–2024). Secondary objectives included describing the rehabilitation strategies indicated and actually adopted, and analysing the proportion of patients who accept or decline rehabilitation.

MATERIAL AND METHODS

STUDY DESIGN

This was a combined retrospective–prospective, single-centre observational study of patients diagnosed with pharmacologically refractory ISSNHL, treated between January 2015 and

December 2024. The cohort of refractory patients was identified retrospectively through review of clinical records covering the full study period; all consecutive patients diagnosed with ISSNHL and confirmed as pharmacologically refractory during this period were included, without additional selection. Once the study protocol was established, audiological assessment — comprising baseline and post-rehabilitation PTA and SDS — was performed prospectively, according to a predefined protocol, in patients who subsequently underwent active auditory rehabilitation (conventional hearing aid fitting or cochlear implantation); this prospective component allowed standardised, protocol-driven measurement of functional outcomes in the subset of patients undergoing active intervention. Treatment response was assessed according to the criteria of the American Academy of Otolaryngology–Head and Neck Surgery (AAO-HNS). Patients were classified as refractory if they did not achieve clinically meaningful hearing recovery following pharmacological treatment, defined as an improvement of less than 10 dB in pure tone average (PTA), and were managed according to the standard clinical protocol, which included at least three intratympanic corticosteroid injections [24].

INCLUSION AND EXCLUSION CRITERIA

Inclusion criteria were: diagnosis of idiopathic sudden sensorineural hearing loss, defined as a sensorineural hearing loss of ≥ 30 dB HL across at least three consecutive frequencies, developing within a period of less than 72 hours; treatment with corticosteroids, including at least three intratympanic injections; and absence of clinically significant hearing recovery following pharmacological treatment. Exclusion criteria were: sudden hearing loss secondary to identifiable causes; retrocochlear pathology identified on magnetic resonance imaging; and neurological or cognitive disorders precluding reliable audiological assessment. Once refractoriness was confirmed, the therapeutic strategies indicated and adopted were

recorded, including rehabilitation with conventional hearing aids, bone conduction devices, cochlear implant candidacy, therapeutic abstention, and patient refusal of rehabilitation. Therapeutic abstention was defined as the absence of any rehabilitation recommendation documented in the clinical record, whether due to the patient's medical comorbidities, advanced age, absence of perceived functional disability, or clinician judgement that the expected benefit did not justify intervention. This category was distinguished from active patient refusal, in which rehabilitation was formally offered and declined. Informed consent was obtained from all patients enrolled in the study.

REHABILITATION CANDIDACY PROTOCOL

Following confirmation of pharmacological refractoriness, rehabilitation candidacy was assessed according to a standardised institutional protocol. The selection of rehabilitation modality was guided by audiometric profile, speech discrimination ability, patient preference, and clinical judgement, as described below.

Conventional hearing aid fitting was the first-line rehabilitation strategy offered to patients with moderate-to-severe residual hearing loss (PTA 41–90 dB HL) and a Speech Discrimination Score (SDS) above 50 % in the affected ear. Candidacy was confirmed after a minimum of three months of documented audiological stability, verified by serial pure tone audiometry at the outpatient clinic. Suitability for hearing aid fitting was assessed by an audiologist, taking into account the degree and configuration of the residual audiogram, expected aided benefit, ear canal anatomy, and patient motivation. The type of hearing aid and fitting parameters were individually tailored.

Bone conduction devices — including bone-anchored hearing aids (BAHA) and BICROS systems — were considered in patients with severe-to-profound residual hearing loss (PTA > 70 dB HL) unlikely to derive sufficient benefit from conventional air-conduction amplification, particularly

those with poor speech discrimination despite adequate amplification. The decision between a CROS/BICROS system and a bone-anchored device was informed by the degree of residual cochlear reserve, contralateral hearing status, and patient preference regarding surgical versus non-surgical solutions. In the present cohort, one patient underwent a trial of a bone-anchored device, and one trialled a BICROS system; neither achieved satisfactory functional benefit and both were subsequently considered for alternative strategies.

Cochlear implant candidacy was evaluated after at least twelve months of audiological stability in patients with profound residual hearing loss ($PTA > 90$ dB HL) and absent or minimal speech discrimination ($SDS \leq 50$ % in free field with optimal hearing aid fitting), who had either failed a prior hearing aid trial or were not suitable candidates for conventional amplification. Evaluation followed the standard multidisciplinary institutional protocol, including audiological assessment, MRI and CT of the temporal bone, medical evaluation, and a dedicated counselling session addressing expected outcomes and patient expectations. Final modality selection resulted from shared decision-making between the clinical team and the patient.

AUDIOLOGICAL EVALUATION

Pure tone average (PTA) was used as an objective measure of hearing threshold, calculated as the arithmetic mean of hearing thresholds at 500, 1000, and 2000 Hz. To assess the audiological impact of rehabilitation, a standardised protocol was applied consisting of measurement of the absolute change in speech discrimination before and after intervention. Speech discrimination was determined using the SDS at 65 dB in free field, employing lists of bisyllabic words without background noise. The acoustic material consisted of standardised lists of commonly used bisyllabic words; only responses repeated verbatim by the patient were considered correct, expressed as a percentage. The contralateral

ear was masked when the difference between the speech recognition threshold of the evaluated ear and the bone conduction threshold of the opposite ear exceeded 40 dB. Pre-rehabilitation data were obtained from conventional pure tone audiometry, while post-rehabilitation thresholds were assessed in free field with the patient positioned one metre from the loudspeaker. Consequently, the comparison between baseline and post-rehabilitation PTA corresponds to two distinct assessment modalities — conventional ear-specific pure tone audiometry under headphones at baseline, and aided free-field functional evaluation thereafter — rather than a single, unchanged measurement technique. This approach was adopted deliberately, as the clinically relevant outcome in auditory rehabilitation is the functional hearing achieved in real-world listening conditions with the device in place, rather than isolated unaided cochlear sensitivity; PTA comparisons in this study should accordingly be interpreted as estimates of functional benefit rather than as a direct measure of threshold change under identical test conditions.

STATISTICAL ANALYSIS

Variables were analysed using descriptive statistics. Categorical variables were expressed as absolute frequencies and percentages, and quantitative variables as means and standard deviations or medians and interquartile ranges, as appropriate. Statistical significance was defined as $p < 0.05$. To compare audiological outcomes before and after rehabilitation, the Wilcoxon signed-rank test was applied, given the small sample sizes and non-parametric distribution of the data. All statistical analyses were performed using IBM SPSS Statistics.

RESULTS

PARTICIPANTS

Of a total of 87 patients treated for ISSNHL during the study period, 38 were classified as

pharmacologically refractory. Two of these 38 refractory patients declined to participate and did not provide informed consent, and were therefore subsequently excluded from the final analysis, leaving 36 patients for inclusion in the final analysis. To clarify the patient flow illustrated in Figure 1, three further categories should be explicitly distinguished within this cohort. Excluded patients (n = 2),

described above, declined to participate and did not provide informed consent. A patient pending evaluation (n = 1) refers to the individual who remained on the surgical waiting list for cochlear implantation, whose candidacy assessment had not yet been completed at the time of study closure. Patients lost to follow-up (n = 3) were those who could not be reached or further evaluated after their

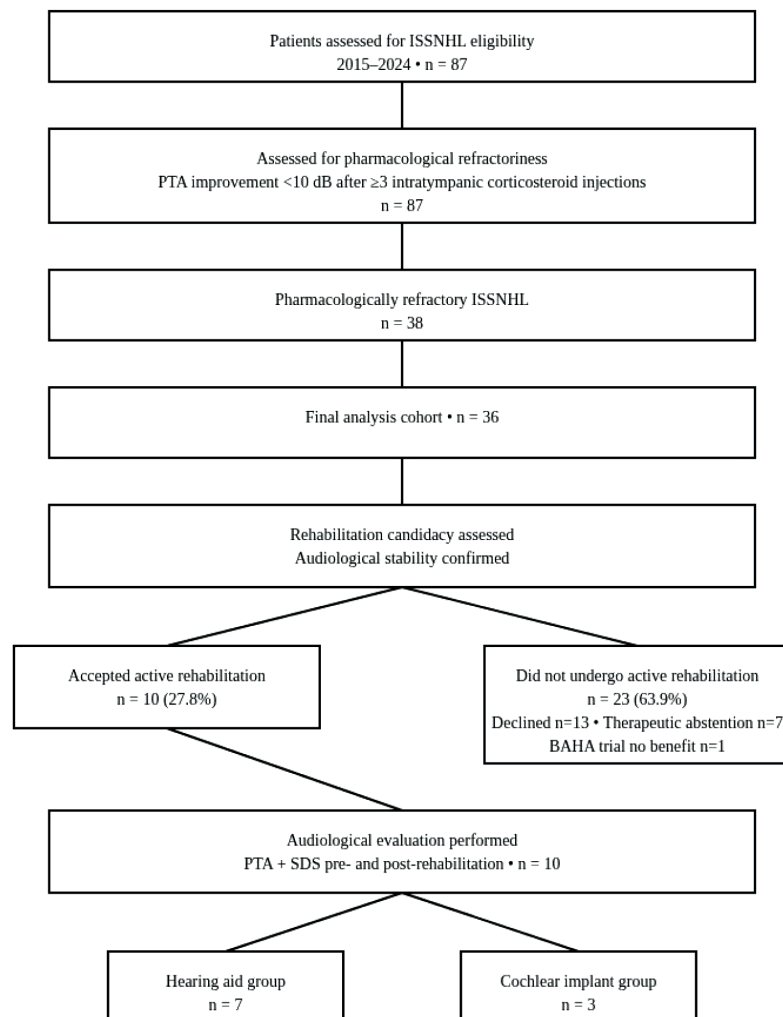


Figure 1. STROBE flow diagram of patient selection and rehabilitation allocation

refractoriness was confirmed, precluding ascertainment of their final rehabilitation outcome. Among the ten patients who underwent active auditory rehabilitation, the mean age was 67.2 ± 11.3 years (range: 42–79). Seven patients (70 %) were male and three (30 %) were female. The affected ear was the right ear in five patients (50 %) and the left ear in five patients (50 %). All ten rehabilitated patients reported associated ipsilateral tinnitus at baseline. Seven patients were rehabilitated with conventional hearing aids (mean age: 66.6 ± 12.5 years; five male, two female) and three with cochlear implants (mean age: 68.7 ± 8.3 years; two male, one female).

REHABILITATION STRATEGIES

Of the 36 patients in the final analysis cohort (excluded, pending-evaluation, and lost-to-follow-up categories are defined under Participants, above), in 23 patients (63.9 %), no active auditory rehabilitation strategy had been completed by the time of study closure [Figure 1]. This group comprised 13 patients (36.1 %) who actively declined the rehabilitation offered, 7 patients (19.4 %) in whom therapeutic abstention was adopted, 2 patients who underwent a device trial (bone-anchored device, $n = 1$; BICROS, $n = 1$) without achieving satisfactory functional benefit, and 1 patient who remained on the surgical waiting list, pending cochlear implantation, at the time of study closure (the patient pending evaluation referred to above). Ten patients (27.8 %) accepted an active auditory rehabilitation strategy. The remaining three patients (8.3 %) were lost to follow-up before rehabilitation could be completed or evaluated. Among the rehabilitated patients, seven (19.4 % of the total) were treated with conventional hearing aids and three (8.3 %) with cochlear implants. Functional audiological evaluation was performed exclusively in these ten patients (Table 1).

AUDIOLOGICAL OUTCOMES

In patients rehabilitated with conventional hearing aids, baseline hearing thresholds fell within

Table 1. Rehabilitation strategies applied to patients with refractory ISSNHL ($n = 36$)

Rehabilitation Strategy	n	%
Rehabilitated	10	27.8
Hearing Aid	7	19.4
Cochlear Implant	3	8.3
Not Rehabilitated	23	63.9
Declined	13	36.1
Therapeutic abstention	7	19.4
Surgical waiting list	1	2.8
Bone-anchored device trial without benefit	1	2.8
BICROS trial without benefit	1	2.8
Lost to follow-up	3	8.3

the moderate-to-severe to severe range, with PTA values between 50 and 87 dB HL (mean: 63.4 ± 12.8 dB HL). Following rehabilitation, functional PTA in free field improved to values between 20 and 68 dB HL (mean: 42.4 ± 14.6 dB HL), yielding a mean threshold improvement of 21.0 ± 5.1 dB HL. This improvement was statistically significant (Wilcoxon signed-rank test, $T = 0$, $n = 7$, $p < 0.05$). In patients rehabilitated with cochlear implants, baseline PTA was in the profound range (mean: 114.3 ± 9.8 dB HL). Following implantation, mean functional PTA decreased to 35.7 ± 5.1 dB HL (mean improvement: 78.7 ± 5.1 dB HL). Due to the small sample size, formal significance testing was not performed for this subgroup (Table 2).

Regarding speech discrimination, baseline SDS in the hearing aid group ranged from 15 % to 50 % (mean: 30.7 ± 11.7 %). Following hearing aid fitting, post-rehabilitation SDS ranged from 30 % to 100 % (mean: 72.9 ± 23.1 %), representing a mean gain of 42.1 ± 29.4 percentage points (Wilcoxon signed-rank test, $T = 0$, $n = 6$ [Patient 3 excluded: no change observed], $p < 0.05$). All three patients in the cochlear implant group had a baseline SDS of 0 %. Following implantation, SDS values increased to 50 %, 65 %, and 90 %, respectively (mean: 68.3 ± 20.2 %; mean gain: 68.3 ± 20.2 percentage points) (Table 3).

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Table 2. Hearing threshold outcomes in patients with active auditory rehabilitation (n = 10)

Pt	Rehabilitation	Baseline PTA (dB HL)	Post-rehab PTA (dB HL)	Improvement (dB HL)	Hearing loss grade (pre)
1	Hearing Aid	87.0	68.0	19.0	Severe
2	Hearing Aid	58.3	41.7	16.6	Moderate-to-severe
3	Hearing Aid	65.0	40.0	25.0	Moderate-to-severe
4	Hearing Aid	58.0	42.0	16.0	Moderate-to-severe
5	Hearing Aid	53.0	35.0	18.0	Moderate
6	Hearing Aid	72.5	50.0	22.5	Severe
7	Hearing Aid	50.0	20.0	30.0	Moderate
	<i>Mean ± SD</i>	<i>63.4 ± 12.8</i>	<i>42.4 ± 14.6</i>	<i>21.0 ± 5.1</i>	
8	Cochlear Implant	103.0	30.0	73.0	Profound
9	Cochlear Implant	120.0	40.0	80.0	Profound
10	Cochlear Implant	120.0	37.0	83.0	Profound
	<i>Mean ± SD</i>	<i>114.3 ± 9.8</i>	<i>35.7 ± 5.1</i>	<i>78.7 ± 5.1</i>	

Note: Threshold improvement = baseline PTA – post-rehabilitation functional PTA (ear-specific audiometry vs. free-field aided assessment — see Limitations). Positive values indicate reduction in hearing threshold. PTA: pure tone average (mean of 500, 1000, and 2000 Hz). Hearing Aid group: Wilcoxon signed-rank test $T = 0$, $n = 7$, $p < 0.05$. Cochlear Implant group: formal significance testing not performed ($n = 3$).

Table 3. Baseline versus post-rehabilitation speech discrimination outcomes (n = 10)

Pt	Rehabilitation	Baseline SDS (%)	Post-rehab SDS (%)	Improvement (pp)	Functional response
1	Hearing Aid	30	65	35	Good
2	Hearing Aid	50	70	20	Moderate
3	Hearing Aid	30	30	0	No response
4	Hearing Aid	30	70	40	Good
5	Hearing Aid	15	95	80	Excellent
6	Hearing Aid	20	100	80	Excellent
7	Hearing Aid	40	80	40	Good
	<i>Mean ± SD</i>	<i>30.7 ± 11.7</i>	<i>72.9 ± 23.1</i>	<i>42.1 ± 29.4</i>	
8	Cochlear Implant	0	90	90	Excellent
9	Cochlear Implant	0	65	65	Excellent
10	Cochlear Implant	0	50	50	Excellent
	<i>Mean ± SD</i>	<i>0.0 ± 0.0</i>	<i>68.3 ± 20.2</i>	<i>68.3 ± 20.2</i>	

Note: pp: percentage points. Functional response criteria: Excellent ≥ 50 pp; Good 30–49 pp; Moderate 10–29 pp; Minimal 1–9 pp; No response 0 pp. Patient 3 showed no SDS improvement and was excluded from statistical analysis. Hearing Aid group: Wilcoxon signed-rank test $T = 0$, $n = 6$, $p < 0.05$. Cochlear Implant group: formal significance testing not performed ($n = 3$).

DISCUSSION

Idiopathic sudden sensorineural hearing loss (ISSNHL) remains a significant clinical challenge, particularly in patients who fail to achieve functional hearing recovery after standard pharmacological treatment. Despite the widespread use of

corticosteroids as first-line therapy, a considerable proportion of patients experience only partial recovery or no improvement, and may substantially affect auditory performance, communication abilities, and overall quality of life [2, 8, 9].

In the present series, 63.9 % of patients with refractory ISSNHL did not access any form of active

auditory rehabilitation, either due to patient refusal or therapeutic abstention. This finding highlights an important issue frequently encountered in clinical practice: the existence of a therapeutic gap between the failure of pharmacological treatment and the implementation of rehabilitative strategies. Understanding the reasons for this low uptake is arguably the central clinical question raised by the present data. Several converging factors are likely to contribute. First, patients with unilateral hearing loss may underestimate their functional impairment, particularly in quiet listening environments, and may not perceive their disability as sufficiently severe to justify intervention. Second, negative expectations regarding hearing device benefit, concerns about stigma, and the financial burden of hearing aids — which are not publicly funded in many healthcare systems — are well-documented barriers to rehabilitation uptake [16]. Third, therapeutic abstention may reflect clinician-side factors, including uncertainty regarding device suitability for unilateral loss, lack of awareness of the growing evidence base for cochlear implantation in this population, or failure to systematically address rehabilitation during routine follow-up. Furthermore, in the Valencian Community, cochlear implantation for single-sided deafness is currently not included among the standard publicly funded indications at the regional level, which represents a structural barrier that limits access to this modality independently of patient suitability or clinical recommendation. Actively addressing these barriers — through structured counselling at the point of pharmacological treatment failure, referral pathways to rehabilitation services, and patient education — is likely to be more impactful than refinements in rehabilitation technique per se, and represents a priority area for future clinical improvement efforts.

Among the patients who accepted active auditory rehabilitation, representing 27.8 % of the cohort, clinically meaningful functional improvements were observed. Patients rehabilitated with

conventional hearing aids demonstrated improved functional hearing thresholds and increased speech discrimination scores. These findings are consistent with previous studies reporting that hearing amplification may provide measurable benefits in selected patients with residual unilateral hearing loss following ISSNHL, although the degree of improvement may vary depending on baseline hearing status and individual adaptation to the device [10–14].

The most pronounced functional gains were observed in patients rehabilitated with cochlear implants, representing 8.3 % of the study population. These patients initially presented with audiometric thresholds in the profound range and absent speech discrimination. Following cochlear implantation, they achieved functional free-field thresholds and substantial improvements in speech recognition. These results align with the growing body of evidence supporting cochlear implantation as an effective rehabilitative strategy in carefully selected patients with refractory unilateral ISSNHL, particularly in terms of restoring speech perception and improving functional auditory access [17–20, 22–26]. Beyond audiometric and speech-recognition gains, cochlear implantation has also been reported to restore aspects of binaural hearing and to improve tinnitus perception in patients with unilateral deafness — a particularly relevant consideration, as all rehabilitated patients in the present series reported baseline ipsilateral tinnitus [23]. These findings should nonetheless be interpreted with caution: they derive from a small subgroup of only three cochlear implant recipients, which precludes formal statistical comparison and constrains the generalisability of the observed benefit; confirmation in larger cohorts is warranted.

An important methodological aspect of the present study is the emphasis placed on functional audiological outcomes, particularly speech discrimination, as the primary indicator of rehabilitation benefit. In the context of unilateral hearing loss, improvements in speech understanding are

especially relevant because they directly impact everyday communication, listening effort, and social participation. Focusing on speech discrimination therefore provides a clinically meaningful measure of rehabilitation success beyond pure-tone audiometric thresholds [12, 21, 22].

Taken together, these findings highlight the clinical importance of actively considering auditory rehabilitation in patients with persistent hearing impairment after ISSNHL. Early counselling regarding rehabilitative options, including hearing aids and cochlear implantation, may help reduce the underuse of rehabilitation strategies and facilitate more timely access to hearing restoration. Furthermore, systematically addressing rehabilitation during routine follow-up may improve patient awareness and increase acceptance of these interventions.

Future research should aim to further clarify the factors that influence patient acceptance of auditory rehabilitation after ISSNHL, including audiological severity, patient expectations, and psychosocial determinants. Prospective studies with larger cohorts and standardised outcome measures are also needed to better define the long-term functional benefits of different rehabilitation modalities and their impact on quality of life.

LIMITATIONS

The present study has certain limitations inherent to its design that should be considered when interpreting the results. Regarding audiological measurement, pre- and post-rehabilitation thresholds were obtained using different assessment approaches: conventional ear-specific pure tone audiometry under headphones at baseline, and free-field evaluation with the device in situ after rehabilitation. Rather than representing a methodological inconsistency, this reflects standard clinical practice in auditory rehabilitation, where the meaningful outcome is functional aided hearing in real-world conditions, not isolated cochlear sensitivity. Threshold improvement values should

therefore be understood as estimates of functional benefit, which is precisely the parameter of clinical relevance in this context.

The number of rehabilitated patients ($n = 10$) is modest, as is expected in a condition with low prevalence, strict inclusion criteria, and — as this study itself demonstrates — a high rate of rehabilitation refusal. The cochlear implant subgroup in particular ($n = 3$) does not allow for formal inferential statistics or generalisation of outcomes; however, the granularity of individual patient data reported here provides clinically meaningful information that complements the existing literature. It should also be noted that, in the Valencian Community, cochlear implantation for single-sided deafness remains outside the standard publicly funded indications at the regional level, which further constrains patient access to this rehabilitation modality independently of clinical criteria or centre expertise. This regulatory context partly explains the low number of implanted patients in the present cohort and is likely to be a contributing factor to the therapeutic gap observed across the series. The single-centre design similarly reflects the rarity of the condition and the challenge of recruiting larger cohorts in routine clinical practice rather than a design limitation per se.

Finally, the absence of patient-reported outcome measures represents an area for improvement in future studies, as quality-of-life and subjective benefit data would enrich the interpretation of audiometric findings.

CONCLUSIONS

Auditory rehabilitation provides clinically meaningful functional improvement in patients with pharmacologically refractory ISSNHL. In this small subgroup, cochlear implantation appeared to offer the greatest audiological benefit among carefully selected patients with profound residual hearing loss and absent speech discrimination, although this observation is based on only three

patients and warrants confirmation in larger series. A high proportion of patients do not access rehabilitative strategies following pharmacological failure, underscoring the need for structured counselling and proactive rehabilitation referral at the point of treatment failure.

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