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Prognosis of Acute Low-Tone Hearing Loss without Vertigo: A Scoping Review

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Abstract

Objective—Despite its relatively high prevalence, our understanding of the natural clinical course of acute low-tone hearing loss (ALHL) without vertigo remains incomplete. The purpose of this study is to summarize the findings of studies that evaluated recovery from hearing loss (HL), recurrence and/or fluctuation of HL, and progression to Meniere's Disease (MD) of patients presenting with ALHL without vertigo.

Methods—A scoping review of the English literature was performed. On May 14, 2020 and July 6, 2022, MEDLINE, Embase, and Scopus were searched to identify articles related to the prognosis of ALHL. To be included, articles had to present outcomes that were clearly distinguishable for patients with ALHL without vertigo. Two reviewers evaluated articles for inclusion and extracted data. Disagreements were adjudicated by a third reviewer.

Results—Forty-one studies were included. There was extensive heterogeneity between studies in regards to defining ALHL, treatment methods, and time of follow up. Most of the cohorts (39 out of 40) reported partial or complete recovery of hearing in the majority (>50%) of patients, although reports of recurrence were relatively common. Progression to MD was infrequently reported. Shorter time from onset of symptoms to treatment predicted better hearing outcomes in 6 of 8 studies.

Conclusion—The literature suggests that although the majority of patients with ALHL experience hearing improvement, recurrence and/or fluctuation are common and progression to

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Level of Evidence: NA

MD occurs in a minority of patients. Additional trials utilizing standardized inclusion and outcome criteria are needed to determine the ideal treatment for ALHL.

Lay Summary:

This scoping review found that the majority of patients with acute low-tone hearing loss without vertigo experience hearing improvement. Recurrence and/or fluctuation are common and progression to Meniere's disease occurs in a small proportion of patients.

Keywords

low-tone; hearing loss; Meniere's disease; fluctuation; recurrence; treatment

INTRODUCTION

Acute low-tone hearing loss (ALHL) was first recognized as a distinct form of sudden sensorineural hearing loss in 1982[1]. It is commonly defined as sudden sensorineural hearing loss (SSHL) confined to the lower frequencies without accompanying vertigo[2, 3]. Reports from epidemiologic studies have found that ALHL accounts for roughly 1 in 5 cases of SSHL[4]. Despite its relatively high prevalence, our understanding of the natural clinical course of ALHL remains incomplete.

There is a large body of literature from institutions in East Asia reporting the clinical outcomes of patients presenting with ALHL. However, these studies mostly consist of retrospective or prospective case series of patients adhering to specific treatment regimens, thereby presenting an incomplete view of the overall clinical course of ALHL. An epidemiologic study found that most patients with ALHL go on to experience complete or partial recovery of their hearing loss (HL)[5].

It has also been hypothesized that ALHL may represent an early manifestation of Meniere's disease (MD), given that a subset of patients with ALHL progress to having MD[6–8]. Indeed, laboratory-based studies have demonstrated an association between ALHL, endolymphatic hydrops, and MD, as characterized by positive glycerol test results[8, 9], abnormal electrocochleography[8, 10, 11], demonstration of cochlear/vestibular hydrops as well as saccular enlargement on magnetic resonance imaging[2, 12, 13], and temporal bone studies[14, 15]. Furthermore, a subset of patients who recover from ALHL go on to experience fluctuating or recurrent low-tone HL[6, 7, 16–18] and other auditory manifestations of MD without vestibular symptoms[8]. Given the limited sample size of these studies, however, it is unclear what proportion of patients with ALHL actually go on to experience full-blown MD or an intermediate disease state with recurrent ALHL.

No studies have attempted to condense all the available evidence regarding the clinical progression of ALHL. A previous meta-analysis of three retrospective chart reviews compared the odds of achieving hearing recovery in patients with ALHL treated with steroids versus diuretics[19]. Zhu et al found no difference in outcomes between those treated with steroids versus diuretics. Notably, this meta-analysis did not incorporate the findings of numerous retrospective and prospective studies because they lacked comparison treatment

groups. The meta-analysis also did not evaluate rates of ALHL recurrence or progression to MD. As such, a comprehensive evaluation of the world literature is needed to better understand the natural history of ALHL, prognosis, and treatment outcomes.

A scoping review was therefore conducted to determine the extent of available evidence and gaps in the English literature related to ALHL. The primary goal of this review was to identify and characterize the clinical outcomes (recovery from HL, recurrence and/or fluctuation of HL, and progression to MD) of patients presenting with ALHL. The secondary goal was to summarize the clinical factors that have been reported to be associated with favorable hearing outcomes.

METHODS

This scoping review was reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis Scoping Review (PRISMA-ScR) guidelines[20].

Scoping Literature Search

The literature search was composed by a medical librarian (author S.J.K.) and utilized subject headings and keywords to represent the concepts of ALHL and prognosis. The databases MEDLINE (via PubMed), Embase (via Elsevier), and Scopus (via Elsevier) were searched from inception to May 14, 2020, with an additional search conducted on July 6, 2022. Non-human studies were removed. Reproducible search strategies are available in Supplemental Digital Content 1. Per PRISMA guidelines, the protocol described above was registered with the international prospective register of systematic reviews (PROSPERO) and is available for review[21] (PROSPERO CRD42020189829).

All studies were imported into the online screening platform Covidence (Cochrane). Study selection is depicted in Figure 1 (See Supplemental Digital Content 2 for PRISMA-ScR checklist). All study abstracts were screened independently by two reviewers. Abstracts which passed initial screening then underwent full-text review by two independent reviewers. Studies were included or excluded based on the criteria below. Conflicts in both abstract screening and full-text review were adjudicated by a third reviewer.

Inclusion/Exclusion Criteria

Studies were included if they met both of the following inclusion criteria:

1. Patients with either unilateral or bilateral ALHL, as defined by the study authors, without concurrent vertigo.
2. The study reported any outcomes related to recovery from ALHL, recurrence and/or fluctuation of HL, or progression to MD in patients with ALHL without vertigo. If articles included patients with other types of HL or patients with vertigo, then outcomes had to be clearly distinguishable for patients with ALHL without vertigo.

Studies were excluded if they met either of the following criteria:

1. The focus of the study was on pediatric presentations of ALHL.

2. The primary population of interest was ALHL presenting with concurrent vertigo.

Cohorts with retrocochlear disease, history of otologic surgery, acoustic trauma, barotrauma, acute or chronic otitis media, or history of MD were excluded. Non-English articles, case reports (i.e., single patient studies), editorials, letters, comments, practice guidelines, consensus development conferences, and book chapters were also excluded.

Data Extraction

The following data of interest were collected when available: study characteristics, patient characteristics, and patient outcomes. Study characteristics included study design, country of origin, study-specific audiometric definition of ALHL, and follow-up period. Patient characteristics included demographics, laterality and severity of HL, presence of tinnitus, medical comorbidities, vestibular evaluation, and interventions received. Patient outcomes were defined by the study and included recovery from HL, recurrence and/or fluctuation of HL, and progression to MD. Data were extracted independently by 2 reviewers and discrepancies were resolved via discussion. Studies that had no treatment comparison groups relative to the outcomes of interest were treated as case series during the data extraction period

Extraction and Categorization of Outcome Data

For each given outcome of interest (recovery from HL, recurrence or fluctuation of ALHL, and progression to MD), results were reported across all applicable studies. For recovery from ALHL, studies often presented outcomes in four categories (“Complete Recovery”, “Partial Recovery”, “No Change”, and “Progression”), with varying definitions for each category.

Although studies often presented outcomes in four recovery categories (as described above), other studies simply dichotomized recovery (e.g., “Any Recovery” vs. “No Recovery”). Therefore, we reported the dichotomous outcomes when needed (“Improvement” vs. “No Improvement”). Four-category outcomes were also converted to dichotomous outcomes in the following manner: Complete and Partial Recovery were considered Improvement while No Change and Progression were considered No Improvement. The findings of studies which reported quantitative rather than categorical hearing outcomes were reported separately.

Recurrence of ALHL, fluctuation of ALHL, and progression to MD were characterized dichotomously (“Yes” or “No”). The range of follow-up periods for these outcomes was also reported. Only 1 out of 12 studies[13] evaluating recurrence provided audiometric criteria for defining recurrence while 7 out of 7 studies[8, 17, 18, 22–25] evaluating fluctuation provided audiometric criteria for defining fluctuation. Therefore, the outcomes of recurrence and fluctuation may have reflected the same event: worsening HL after initial HL recovery. In accordance with this possibility, a separate outcome “Recurrence or Fluctuation of low-tone hearing loss” was created by aggregating outcomes of either recurrence or fluctuation across all studies.

All outcomes of interest were stratified by the following treatment modalities: Systemic Steroids alone, Diuretics alone, Steroid and Diuretic, No Steroid or Diuretic, and Treatment Unspecified or Unclear. Cohorts in which “most” patients received a specific intervention or for which treatment regimens “generally comprised” of specific interventions were categorized into the Treatment Unspecified or Unclear group. The findings of cohorts treated with intratympanic (IT) steroids for the treatment of ALHL were reported separately.

Clinical factors and their potential association with hearing outcomes were also extracted. These factors were stratified by studies which evaluated associations without adjustment for potential confounders, studies which evaluated associations with adjustment for potential confounders, and epidemiologic studies. Epidemiologic studies were tabulated separately due to their large sample sizes, and thus, greatly increased chance of detecting significant associations.

RESULTS

A total of 2,831 studies were identified by the literature searches. Among these, 1,257 duplicates were removed and 1,574 articles were screened by title and abstract. A total of 305 full-text studies were reviewed for eligibility. One additional study[17] was identified within the references of one of the full-texts and manually added to the full-text review. Among all full-texts reviewed, 41 studies[3–8, 10, 13, 16, 17, 22–52] were determined to meet the study inclusion and exclusion criteria and these studies subsequently underwent data extraction (Figure 1).

Overview of Included Studies

Of 41 studies, 30 evaluated outcomes without comparison of interventions, 11 compared outcomes by interventions, and 1 was an epidemiologic study. Of studies that compared interventions for ALHL, only one[51] was a randomized controlled trial. All other studies were observational studies. A majority (34 out of 41 studies) originated from East Asia. Four studies originated from institutions in Europe with no studies originating from North America. Most studies (31 out of 41) were published in the 2000s or 2010s. The earliest included study was published in 1986[34]. Published studies consistently demonstrated a female preponderance, and the age ranged from 14 to 77 years with the vast majority of studies reporting a mean age of onset in the 4th decade of life. All included studies are summarized in Table 1.

Definition of Low-Tone Hearing Loss

Among all included studies, 21 different audiometric criteria were used to define ALHL (see Table 1). The most commonly used criterion (7 out of 41 studies) was the 2011 Acute Profound Deafness Research Committee of the Japanese Ministry of Health, Labor, and Welfare Definition of ALHL: the sum of thresholds at 125, 250, and 500 Hz must be 70 dB or greater and the sum of thresholds at 2, 4, and 8 kHz must be 60 dB or less.

Reported Treatment Modalities

Among the included papers, 13 studies reported hearing outcomes following administration of systemic steroids alone, 4 studies following diuretics alone, 10 studies following a combination of systemic steroid and diuretics, 8 studies following intratympanic steroids, and 15 with other or unspecified treatments. Descriptions of all study cohorts in included papers are displayed by treatment type in Supplemental Digital Contents 3–8.

Outcomes

A total of 32 studies evaluated recovery from HL, with reported mean or median follow-up time ranging from one week[3, 28] to 3.3 years[39]. Among these 32 studies, 15 studies reported outcomes in four recovery categories and 30 studies reported outcomes that could be dichotomized. Among these 30 studies, there were 40 distinct patient cohorts. A cohort was defined as a group of patients receiving the same treatment within a study. The overwhelming majority of study cohorts (39/40) reported a greater than 50% rate of hearing improvement (i.e., >50% of patients in each cohort achieved some form of hearing improvement) within a diverse range of follow up times. This was true whether or not an intervention was provided and regardless of the treatment rendered. The rate of complete hearing recovery was most frequently reported to occur in the 40–80% range for 14 out of 22 cohorts, regardless of treatment status. A summary of these studies and their outcomes can be found in Supplemental Digital Contents 3–8. In addition to categorical outcomes, recovery from HL was also reported using a variety of quantitative metrics in 13 studies (Supplemental Digital Content 9).

A total of 18 studies evaluated recurrence or fluctuation of hearing loss following ALHL, with reported mean or median follow-up time ranging from 8 weeks[22, 24, 25] to 5.6 years[16, 33]. Though variable, the reported rates of fluctuation or recurrence were below 50% in all (21/21) cohorts. A total of 14 studies evaluated progression to MD with reported mean or median follow-up time ranging from 1 year[50] to 5.6 years[16, 33]. The progression to MD was consistently reported to occur in fewer than 40% of patients and was 20% or less in 10 out of 14 cohorts.

Clinical Factors Associated with Hearing Outcomes

Assessment of potential factors that may be associated with better hearing outcomes was examined. Overall, very few studies reported on potential factors that may influence hearing outcomes. Demographic factors such as age and sex were examined in 6 studies, time to onset of treatment in 8 studies, severity of initial HL in 9 studies, presence of tinnitus in 2 studies, and other comorbid conditions such diabetes and hypertension in 3 studies. The epidemiological study by Sato et al (2017) found that age, gender, time to onset of treatment, and severity of initial loss were significant predictors of hearing outcome. Increased time to onset of treatment was the most consistently reported risk factor for poorer hearing outcomes across all clinical studies that examined this relationship (Table 2).

DISCUSSION

This scoping review sought to understand the available evidence that characterizes the clinical outcomes of patients presenting with ALHL in an effort to shape future research inquiry and inform clinical practice. Due to heterogeneity in the populations of interest, outcome measures, and follow-up periods, a systematic review with meta-analysis of the current literature was deemed inappropriate.

General trends in the available data demonstrated that many ALHL patients experience partial or complete recovery of hearing although reports of recurrence were relatively common. Progression to MD was reported to occur in a minority of ALHL cases. Overall, the literature consistently reported that shorter time to onset of treatment predicted better hearing outcomes in those with ALHL. Among all studies that examine treatment effects in this review, Suzuki et al.[46] authored the only observational study to control for potential confounders while comparing different treatment modalities for ALHL. Their multivariate analysis showed that systemic steroid treatment was significantly associated with hearing recovery whereas diuretic treatment was not. The only randomized clinical trial[51] compared sequential diuretic and steroid treatment (i.e., steroids were only administered if the patient did not achieve complete recovery within 2 weeks on diuretics alone) versus simultaneous diuretic and steroid administration. The authors reported that sequential treatment was non-inferior to simultaneous treatment. However, nearly one-third of all patients in the sequential arm eventually required systemic steroid administration. The findings of these two studies would suggest that systemic steroid administration may be slightly more effective than diuretics in achieving hearing recovery in patients with ALHL. To definitively answer this question however, additional studies and trials comparing steroid and diuretic treatment with adjustment for potential confounders are required.

Despite the general observed trends in the literature, our scoping review has revealed several remaining knowledge gaps. First, there is a dearth of literature on ALHL from research institutions outside of East Asia. As such, it remains unknown whether the overall prevalence and prognosis of ALHL is the same for other and more diverse populations. The relative contribution of genetic, environmental, and social factors on disease presentation and treatment response is unknown and warrants further investigation in more populations. Epidemiologic surveys from research institutions outside of East Asia would help improve our understanding of the overall global disease burden of ALHL, which may spur needed advances in its identification and treatment. Second, more studies are needed to assess how ALHL compares to other forms of SSHL regarding hearing recovery, recurrence of HL, and the effect of treatment on recovery and recurrence. A handful of studies found that patients with ALHL had both a higher rate of hearing recovery[39] and HL recurrence[16, 33, 39, 44] than patients with sudden high-tone deafness, but more studies are needed to compare outcomes against other types of SSHL (pan-tonal loss, profound deafness). Third, a greater number of longitudinal studies (with follow-up beyond 5 years) are needed to more accurately determine the rates of recurrence/fluctuation and progression to MD for patients with ALHL. Concurrently, quality-of-life studies are needed to help characterize the disease burden of ALHL and identify potential strategies to mitigate these effects.

Moving forward, consensus is needed regarding a common set of audiometric criteria for the diagnosis of ALHL as well as the evaluation of hearing outcomes. Within our review, there was significant variability in how hearing outcomes were reported and the criteria used to define various outcome categories. The provision of raw audiometric data as digital supplementary material would aid in advancing our understanding of this disease entity across multiple populations. The duplication of previously published data or patient cohorts should also be disclosed and highlighted to reduce bias. Similarly, studies must have clear criteria for distinguishing recurrence from fluctuation of HL. Having uniform methods for characterizing outcomes and high-quality studies that account for confounders, would facilitate more robust systematic reviews and meta-analyses and allow research groups to better determine optimal interventions for ALHL[53–56]. The selection of a global standard would be a worthwhile goal and could be addressed through collaborative action by international professional organizations of otolaryngologists and audiologists. In addition to the methodological challenges encountered in the literature, there were additional limitations. First, non-English articles were excluded in this scoping review and our results may not reflect all the available literature on ALHL. Second, authors may have published more than once on the same patient cohort, creating the possibility for duplicate data.

Calls by the National Institutes of Health and other funders to promote standardization and transparency have increased in recent years and provides us even greater impetus to move our fields forward to create accessible raw data and utilize standard ‘common data elements’ in our research. Consistent reporting on patient characteristics and treatment protocols are a basic requirement to fill knowledge gaps, elucidate prognostic factors, and inform clinical decision making and patient counseling.

CONCLUSIONS

While the literature suggests that the majority of patients with ALHL appear to experience hearing improvement, recurrence and/or fluctuation are common. Progression to MD appears to occur infrequently. Shorter time from onset of symptoms to onset of treatment may be associated with better hearing outcomes. Additional studies and randomized controlled trials utilizing standardized criteria for diagnosis, study inclusion and hearing outcome are needed to determine the natural history and ideal treatment for ALHL.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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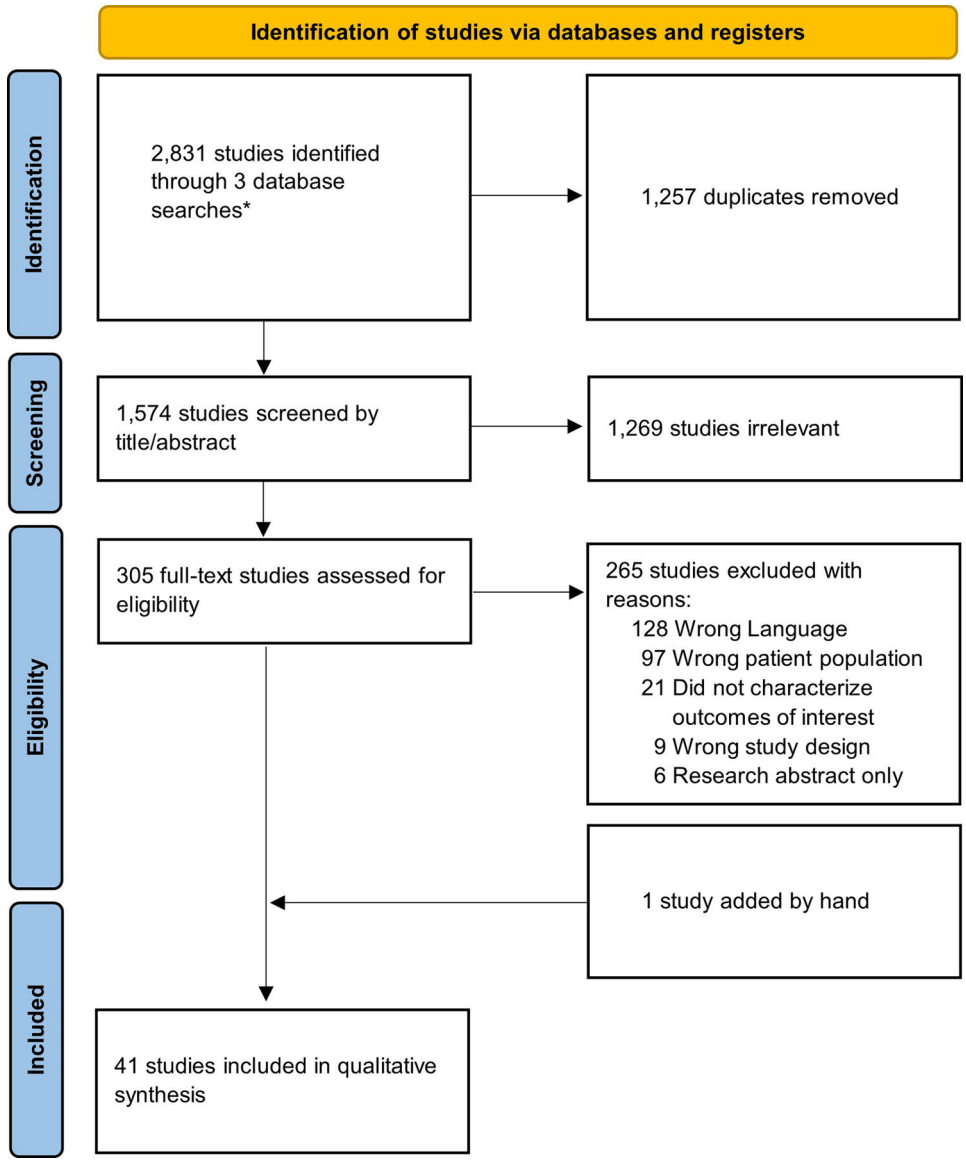

Figure 1:
Study inclusion flowchart.

Table 1:

Characteristics of Included Studies

Study	Design	Audiometric Definition of Low-Tone Loss	Number of Patients (M/F)	Mean Age (years)	Treatments	Outcomes Measured	Categorical Audiometric Outcome Measure (if available)	Follow-up Period
Alatas 2009	Case series	Hearing threshold > 30 dB HL at 3+ of the following frequencies: 0.125, 0.25, 0.5, 1.0, 1.5 kHz. Average hearing loss at three higher frequencies (4, 6, 8 kHz) is ≤ 10 dB.	14 (3M/11F)	Mean (SD): 43 (15.02)	IT dexamethasone + oral prednisolone	Hearing recovery and recurrence/ fluctuation	4 categories[a]	Varied: After conclusion of therapy or after complete recovery achieved.
Chang et al. 2016	Cohort study	2011 Japanese Ministry of Health and Welfare Definition[b]	47 (11M/36F)	Mean 43	Oral methylprednisone vs. oral methylprednisone + HCTZ	Progression to MD	NA	1 month for initial outcomes. Unclear when MD assessed.
Chen et. Al 2021	Case series[c]	The average hearing loss at .125, .25, and .5 kHz is ≥ 30 dB and sum at 2, 4, and 8 kHz is ≤ 60 dB	49 (13M/36F)	Mean 41.3	Oral prednisone + mannitol	Hearing recovery	NA	7 days
Choi et al. 2011	Case series	The average hearing loss at .125, .25, and .5 kHz is ≥ 30 dB, and the average hearing loss at 2, 4, and 8 kHz is ≤ 20 dB	61 (18M/43F)	Mean (SD) 43.2 (15.2)	Oral prednisolone, HCTZ, betahistine, gingko biloba, nicergoline	Hearing recovery and progression to MD	4 categories	3 months
Derinsu et al. 2006	Case series	Upsloping Audiogram	7 (1M/6F)	Mean 43.7	Steroids	Hearing recovery	≥ 10 dB improvement (yes/no) in 4-frequency PTA (0.5, 1, 2, and 4 kHz)	Unclear
Fuse et al. 2002	Cohort study	Sum of hearing thresholds at .125, .250, and .5 kHz is ≥ 100 dB and sum at 2, 4, and 8 kHz is ≤ 60 dB	19 (NA)	NA	Oral and IV prednisolone	Hearing recovery	4 categories	2 months
Fushiki et al. 2009	Case series[c]	Average threshold at .125, .25, .5 kHz is at least 10 dB worse than at 2, 4, and 8 kHz. Less than 10 dB difference in hearing threshold at 1 kHz in comparison with that of adjacent frequencies	82 (31M/51F)	Mean (SD): 41.6 (13.8)	Most received IV corticosteroids	Recurrence/ fluctuation and progression to MD	NA	Mean, range: 56, 6–196 months
Fushiki et al. 2010	Case series[c]	Average hearing threshold at .125, .25, .5 kHz is at least 10 dB worse than that at 2, 4, and 8 kHz, and there is less than 10 dB difference in the hearing threshold at 1 kHz compared to adjacent frequencies (500 Hz and 2 kHz).	35 (11M/24F)	Mean (SD): 37.8 (11.9)	Most received IV dexamethasone	Hearing recovery, recurrence/ fluctuation and progression to MD	Recovery (yes/no), not defined by the authors.	Mean, range: 48, 6–196 months Unclear when initial recovery from HL assessed
Hong et al. 2013	Case series[c]	Average hearing threshold at .125, .25, and .5 kHz at least 10 dB poorer than average hearing threshold at	28 (7M/21F)	Mean, range: 43, 18–61	Oral prednisolone	Recurrence/ fluctuation and	Hearing Improvement (yes/ no), defined as > 15	Mean, range: 510, 133–879 days

Study	Design	Audiometric Definition of Low-Tone Loss	Number of Patients (M/F)	Mean Age (years)	Treatments	Outcomes Measured	Categorical Audiometric Outcome Measure (if available)	Follow-up Period
		2, 4, 8 kHz. Pure tone threshold of 30 dB or higher at three low consecutive low frequencies.				progression to MD	dB gain, unclear at which frequencies.	
Huy and Sauvaget 2005	Case series[c]	Low-tone hearing loss characterized by audiogram shape	59 (NA)	NA	IV steroids + mannitol	Hearing recovery	Complete Recovery (yes/no), defined as final PTA (re: 0.5, 1, 2, and 4 kHz) in the affected ear < 25 dB.	30 days
Im et al. 2016	Case series	Average hearing threshold ≥ 30 dB at .125, .25, .5 kHz and ≤ 20 dB at 2, 4, and 8 kHz.	31 (13M/18F)	Mean (SD): 39.4 (13)	Generally, methylprednisolone + HCTZ	Hearing recovery	Hearing Recovery (yes/no), defined as PTA gain of 10 dB or more at .125, .25, and .5 kHz.	12 weeks
Imamura et al.1997	Case series	Average hearing thresholds at .125, .25, and .5 kHz is ≥ 30 dB, and the average hearing threshold at 2,4, and 8 kHz is ≤ 20 dB.	137 (36M/ 101F)	Mean 40.6	Vitamin B12 + ATP disodium + varying prednisone dosages	Hearing recovery, recurrence/ fluctuation	4 categories	>3 weeks
Inui et al. 2019	Case series	2011 Japanese Ministry of Health, Labor and Welfare for Acute Profound Deafness definition[b]	47 (11M/36F)	Mean, range: 43.3, 17–71	Hydrocortisone and/or betamethasone	Hearing recovery and recurrence/ fluctuation	Cure vs. No Cure. Cure defined as recovery of thresholds to ≤ 25 dB at each of .125, .25, and .5 kHz. Individuals marked with Recurrence added to Cure group for initial HL outcome	Mean, range: Cure group: 16.8, 3–32 weeks No Cure group: 20.8, 4–28 weeks Recurrence group: 22.5, 2–32 weeks
Jung et al. 2016	Cohort study	Thresholds at .25 and .5 kHz >30 dB and ≤ 25 dB at 1, 2, 3, 4, and 8 kHz.	50 (10M/40F)	Mean (SD): 39.7 (12.1)	Oral prednisolone vs. IT steroids vs. Oral prednisolone and IT steroids	Hearing recovery	4 categories	8 weeks
Junicho et al. 2008a	Case series[c]	Average hearing threshold at .125, .25, and .5 kHz is worse compared to 2, 4, 8 kHz by 10 dB or more. Hearing threshold at 1 kHz within 10 dB of hearing thresholds at .5 and 2 kHz.	177 (NA)	NA	Unclear	Recurrence/ fluctuation and progression to MD	NA	For patients without recurrence, mean, range: 67, 7–210 months
Junicho et al. 2008b	Case series[c]	Average hearing threshold at .125, .25, and .5 kHz is at least 10 dB worse than that at 2, 4, 8 kHz.	82 (NA)	NA	Most received IV steroids	Recurrence/ fluctuation and progression to MD	NA	Mean, range: 67, 6–210 months
Kim et al. 2020	Case series	Average hearing loss of ≥30 dB at 125, 250, and 500 Hz and ≤20 dB at 2, 4, and 8 kHz.	58 (19M/39F)	Mean (SD): 39.3 (12.9)	Prednisolone + HCTZ	Hearing recovery and	Hearing Recovery (yes/no), defined as PTA gain of 10 dB	Range 1 to 12 weeks for hearing

Study	Design	Audiometric Definition of Low-Tone Loss	Number of Patients (M/F)	Mean Age (years)	Treatments	Outcomes Measured	Categorical Audiometric Outcome Measure (if available)	Follow-up Period
						progression to MD	or more at .125, .25, and .5 kHz.	outcomes, Mean 7.4 months for progression of MD
Kumagami and Osawa 1986	Case series	Unclear	6 (NA)	Mean 33	Isosorbide vs. steroid vs. CO2 inhalation	Hearing recovery	Improvement (Yes/No), criteria not defined by authors.	Range 42 days to 2.5 years
Lee et al. 2018	Cohort study	Thresholds at .25, .5 kHz > 30 dB and thresholds at 1, 2, 3, 4, and 8 kHz ≤ 25 dB on the affected side. Thresholds at .25, .5, 1, 2, and 4 kHz ≤ 25 dB on the unaffected side.	170 (52M/118F)	Mean (SD): 44.0 (16.8)	Low dose steroids vs. high dose steroids vs. steroids + diuretics vs. IT steroids + diuretics	Hearing recovery	Recovery (yes/no), defined as either Complete or Partial Recovery	4 weeks
Ma et al. 2021	Case series[c]	Sum of hearing levels at 0.125, 0.25 and 0.5 kHz is ≥ 70 dB or the sum of hearing levels at 2, 4 and 8 kHz ≤ 60 dB	115 (43M/72F)	Mean (SD): 42.3 (14.33)	IT steroids	Recurrence/fluctuation and progression to MD	NA	Mean follow up time of 17.61 months
Morita et al. 2010	Cohort study	2011 Japanese Ministry of Health and Welfare Definition[b]	156 (52M/104F)	Mean, range: 48.7, 14–77	Oral steroids (prednisolone or betamethasone) vs. diuretics vs. oral steroids (prednisolone or betamethasone) + diuretics vs. vitamin B12 and ATP	Hearing recovery and recurrence/fluctuation	4 categories	8 weeks
Morita et al. 2016	Cohort study	2011 Japanese Ministry of Health and Welfare Definition[b]	90 (24M/66F)	Median, range: 49.5, 13–61	Salvage IT steroids vs. salvage diuretics vs. observation. All initially treated with oral steroid, diuretic, vitamin B12, and ATP	Hearing recovery, recurrence/fluctuation, progression to MD	Recovery (yes/no), defined as either Complete or Partial Recovery	Medina, range: 36, 18–108 months
Nakashima and Yanagita 1993	Case series	Average threshold at 0.25 and 0.5 kHz surpasses average of 4 and 8 kHz by 30 dB or more. Contralateral thresholds have to be 20 dB or less at all frequencies 0.25 – 8kHz.	77 (NA)	NA	Unclear	Hearing recovery	Average thresholds of patients in six assessed frequencies	2 months
Oishi et al. 2010	Case series	Sum of thresholds at .125, .25, and .5 kHz ≥ 70 dB; hearing threshold difference between both ears < 10 dB at high frequencies[d].	49 (19M/30F)	Mean (SD): 46 (14)	Most treated with prednisone (oral or IV), diuretic, vasodilator	Hearing recovery and recurrence/fluctuation	4 categories	10–21 years
Okada et al. 2012	Cohort study	Sum of thresholds at .125, .25, and .5 kHz ≥ 70 dB. Definite ALHL: sum of thresholds at 2,4, and 8 kHz ≤ 60 dB. Probable ALHL: Sum of thresholds at 2,4, and 8 kHz > 80 dB.	178 (56M/122F)	Mean (SD): 47.3	Prednisolone vs. isosorbide vs. prednisolone + isosorbide vs. Wu-Ling San vs. Steroid + Wu-Ling San vs. no treatment	Hearing recovery	4 categories	1 week

Study	Design	Audiometric Definition of Low-Tone Loss	Number of Patients (M/F)	Mean Age (years)	Treatments	Outcomes Measured	Categorical Audiometric Outcome Measure (if available)	Follow-up Period
		Probable patients excluded if high-tone sum shows a difference of more than 10 dB from the contralateral ear or if low-tone sum shows less than a 10 dB difference from the contralateral ear.						
Park et al. 2018	Case series[c]	Average threshold at .25 and .5 kHz > 30 dB and average threshold at 1, 2, 3, 4, and 8 kHz < 25 dB.	53 (13M/40F)	Mean, range: 39, 22–64	Oral steroids, salvage IT steroid, diuretic	NA	NA	8 weeks
Psillas et al. 2019	Case Series[c]	The average threshold at .125, .25, .5 kHz ≥ 30 dB, and the average threshold at 2, 4, 8 kHz ≤ 20 dB.	27 (10M/17F)	Mean (SD): 44.1 (13.1)	IV dexamethasone	Hearing recovery, recurrence/ fluctuation, and progression to MD	4 categories	Mean follow-up of 3.3 years
Qin et al. 2021	Case series[c]	Hearing loss at frequencies under 1 kHz with the least reduction by 20 dB HL at 250 and 500 Hz	21 (12M/9F)	Mean (SD): 54.1 (8.3)	Varied; mostly IV dexamethasone	Hearing recovery	Recovery (yes/no), defined as ≥ 30 dB improvement in 250 and 500 Hz	unclear
Roh et al. 2015	Case series	Sum at .25 and .5 kHz ≥ 50 dB. Hearing threshold difference between both ears < 10 dB at 2 and 4 kHz.	33 (13M/20F)	Mean (SD): 41 (12.7)	Methylprednisolone +/− spironolactone +/− IT dexamethasone	Hearing recovery and recurrence/ fluctuation	4 categories	Mean, range: 22, 3–79 months, initial recovery assessed at 1 month
Sato et al. 2017	Epidemiological survey	2011 Japanese Ministry of Health and Welfare Definition[b]	642 (205M/ 433F/4U)	Mean (SD): 43.8 (15.5)	Unclear	Hearing recovery	4 categories	Unclear
Selivanova et al. 2005	Case series	Air conduction hearing threshold > 30 dB at 2 or more of the following: 0.125, 0.25, 0.5, 0.75, 1, and 1.5 kHz.	18 (9M/9F)	Mean, range: 50, 26–62	IT hyaluronic acid, dexamethasone	Hearing recovery and recurrence/ fluctuation	Significant improvement (yes/ no), defined as ≥ 10 dB improvement in at least 2 frequencies	Following end of IT injections
Shin et al. 2021	Cohort study	2011 Japanese Ministry of Health and Welfare Definition[b]	49 (13M/36F)	Mean (SD): 42.0 (12.6)	Oral prednisolone vs. oral prednisolone + isosorbide, HCTZ, or spironolactone	Hearing recovery	Recovery (yes/no), defined as mean hearing threshold of 125, 250, and 500 Hz ≤20 dB.	2 weeks
Stolzel et al. 2018	Case series[c]	Threshold > 30 dB in the frequencies from .125 to .5 kHz or pantonal hearing loss.	23 (NA)	NA	Unclear	Progression to MD	NA	5 years
Sugiura et al. 2003	Case series	Sum of hearing thresholds at .125, .25, and .5 kHz ≥ 100 dB and sum of hearing thresholds at 2, 4, and 8 kHz ≤ 60 dB	25 (9M/16F)	Mean (SD): 39.7 (12.7)	Unclear	Hearing recovery and recurrence/ fluctuation	4 categories	Range 1.5–3.5 years

Study	Design	Audiometric Definition of Low-Tone Loss	Number of Patients (M/F)	Mean Age (years)	Treatments	Outcomes Measured	Categorical Audiometric Outcome Measure (if available)	Follow-up Period
Suzuki et al. 2006	Cohort study	Sum of thresholds at .125, .25, and .5 kHz is ≥ 80 dB and 40 dB poorer than the contralateral side. Thresholds at frequencies 1–8 kHz do not differ more than 10 dB between right and left ears.	225 (99M/ 126F)	NA	Oral prednisolone, IV hydrocortisone, and/or diuretics. All patients received vitamin B12 and ATP	Predictors of hearing recovery	NA	1 month
Tanigawa et al. 2010	Case series	Unclear	5 (0M/5F)	Mean 42	IV Hydrocortisone vs. anti-anxiety medication	Hearing recovery and recurrence/ fluctuation	4 categories	Range 6–22 months
Waissbluth et al. 2021	Case series[c]	Upsloping audiogram	48 (NA)	NA	Varied combinations of IT steroid, oral steroid	Hearing recovery	4 categories	Range 14 days to 3 months
Wang et al. 2010	Case series	Average hearing threshold at .125, .25, and .5 kHz > 30 dB, average hearing threshold at 2, 4, and 8 kHz < 20 dB	21 (7M/14F)	Mean, range: 40, 14–61	Isosorbide	Hearing recovery	Improvement (Yes/ No), defined as > 50% recovery	3 months
Wu and Young 2004	Case control	Average hearing threshold at .125, .25, .5 kHz > 30 dB, average hearing threshold at 2, 4, 8 kHz < 20 dB	12 (5M/7F)	Mean, range: 35, 20–61	Isosorbide	Hearing recovery and progression to MD	Return to normal hearing (Yes/No). Normal hearing unclearly defined.	1 year
Yakunina et al. 2019	Randomized trial	2011 Japanese Ministry of Health and Welfare Definition[b]	92 (31M/61F)	Mean 45.5	Concurrent oral methylprednisolone + HCTZ + isosorbide vs. sequential HCTZ + isosorbide + methylprednisolone (if indicated)	Hearing recovery	4 categories	28 days
Yamasoba et al. 1994	Case series	Sum of thresholds at .125, .25, and .5 kHz ≥ 100 dB. Sum of thresholds at 2, 4, and 8 kHz ≤ 80 dB.	80 (22M/58F)	Mean 42.3	Most treated with prednisolone + diuretic + vasodilator	Hearing recovery, recurrence/ fluctuation and progression to MD	Improvement (Yes/ No), no change, progression, and fluctuation	3 months for hearing outcome, and at least 3 years for assessment of recurrence and MD progression

[a] Four categories as follows: Complete Recovery, Partial Recovery, No Change, Progression.

[b] Sum of thresholds at .125, .25, and .5 kHz ≥ 70 dB. Sum of thresholds at 2, 4, and 8 kHz ≤ 60 dB.

[c] This study was technically a cohort study. However, because all patients received the same treatment regimen, it was considered a case series for the purposes of this review.

[d] High frequencies not specified.

Note: M, Male; F, Female; U, Unknown; NA, Not Applicable; kHz, kilohertz, SD, standard deviation, dB, decibel; PTA, pure tone average, IT=intratympanic

Table 2:

Reported Predictors of Better Hearing Outcomes

	No. Studies (without adjustment)[a]	No. Studies (with adjustment)	Epidemiological Study[b]
Prognostic Factor			
Age (Younger)	2/6[d]	1/2[e]	Yes
Sex (Female)	0/6[f]	--	Yes
Time to Onset of Treatment (Shorter)	6/8[g]	2/2[h]	Yes
Severity of Initial Loss (Less Severe)	4/9[i]	1/2[j]	Yes
Tinnitus	1/2[k]	--	--
Diabetes	0/3[l]	--	No
Hypertension	0/3[m]	--	No
ECOG (elevated SP/AP ratio)	1/3[n]	--	--
ENG[c]	1/2[o]		

[a] Not including Sato et al. 2017

[b] Sato et al. 2017

[c] Evaluated for association with progression to Meniere's Disease

[d] Alatas, 2009; Choi et al., 2011; Jung et al., 2016; Lee et al., 2018; Psillas et al., 2019; Suzuki et al., 2006

[e] Lee et al., 2018; Suzuki et al., 2006

[f] Choi et al., 2011; Jung et al., 2016; Lee et al., 2018; Psillas et al., 2019; Shin et al., 2021; Suzuki et al., 2006

[g] Alatas, 2009; Chang et al., 2016; Choi et al., 2011; Jung et al., 2016; Lee et al., 2018; Psillas et al., 2019; Shin et al., 2021; Suzuki et al., 2006

[h] Lee et al., 2018; Suzuki et al., 2006

[i] Alatas, 2009; Choi et al., 2011; Im et al., 2016; Inui et al., 2019; Jung et al., 2016; Lee et al., 2018; Roh et al., 2015; Suzuki et al., 2006; Wang et al., 2010

[j] Lee et al., 2018; Suzuki et al., 2006

[k] Choi et al., 2011; Jung et al., 2016

[l] Jung et al., 2016; Lee et al., 2018; Shin et al., 2021

[m] Jung et al., 2016; Lee et al., 2018; Shin et al., 2021

[n] Choi et al., 2011; Im et al., 2016; Kim et al., 2020

[o] Fushiki et al., 2009; Im et al., 2016