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Systematic review and meta-analysis of intratympanic steroid injection in sudden sensory neural hearing loss as initial, combined, or salvage treatment compared to systemic steroids alone

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ABSTRACT

Background: Sudden sensorineural hearing loss (SSNHL) is a rapid condition of hearing impairment, typically occurring over 72 hours and affecting the inner ear or auditory nerve pathways. The etiology of SSNHL remains largely idiopathic, with potential causes including viral infections, vascular occlusions, and autoimmune disorders. Traditional treatment primarily involves systemic corticosteroids, but their efficacy is inconsistent, leading to exploring alternative and adjunctive therapies such as intratympanic steroid (ITS) injections. Objective: This Systematic Review and Meta-Analysis intends to determine the effectiveness of ITS injections as an initial treatment, combined therapy, or salvage treatment for SSNHL compared to systemic steroids alone. Methods: An inclusive study was performed through the PubMed, Scopus, Web of Science, and Cochrane Library databases, encompassing publications published from 2015 to 2024. Case-control studies, cohort studies, randomized controlled trials (RCTs), and systematic reviews were included. Two separate reviewers read the studies and extracted data on steroid administration methods, study outcomes, and risk of bias (ROB) using the Cochrane Collaboration Tool and RevMan 5.4. Results: The review included 12 studies with varied designs, including prospective RCTs, systematic reviews, and retrospective analyses. Combined ITS and systemic steroid therapy showed superior hearing recovery compared to systemic steroids alone in several studies. ITS alone demonstrated variable efficacy, with some studies indicating benefits, particularly as a salvage therapy. ROB assessment revealed variability in methodological rigor, with studies like those of Li & Ding et al. (2020) and Devantier et al. (2022) showing low risk, while others exhibited higher risks, particularly in random sequence generation and allocation concealment. Conclusion: The findings suggest that ITS injections, particularly when combined with systemic steroids, can enhance hearing recovery in SSNHL patients. However, variability in study outcomes and methodological quality underscores the need for standardized protocols and further high-quality RCTs. This analysis underscores the prospective advantages of ITS therapy while stressing the need for stringent study designs to enhance SSNHL treatment methodologies.

KEYWORDS

Sudden sensorineural hearing loss, intratympanic steroid injections, systemic corticosteroids, hearing recovery, treatment efficacy.

1 Introduction

Sudden sensorineural hearing loss (SSNHL) is a rapid condition of hearing impairment, typically occurring over 72 hours and affecting the inner ear or auditory nerve pathways. The etiology of SSNHL remains largely idiopathic, though potential causes include viral infections, vascular occlusions, and autoimmune disorders. Traditional treatment modalities primarily involve systemic corticosteroids aimed at reducing inflammation and promoting auditory recovery. However, the efficacy of systemic steroids alone has been a subject of debate, leading to the exploration of alternative and adjunctive treatments, such as intratympanic steroid (ITS) injections (Chrysouli, Kollia, Papanikolaou, & Chrysovergis, 2023; Seggas, Koltsidopoulos, Bibas, Tzonou, & Sismanis, 2011).

Intratympanic steroid injections involve the direct administration of corticosteroids into the middle ear, allowing for higher local drug concentrations at the cochlea with potentially reduced systemic side effects. This approach has been suggested as both a primary treatment and a salvage therapy for patients unresponsive to systemic steroids. Research has demonstrated differing levels of efficacy of ITS injections, whether used alone or in conjunction with systemic steroids, in enhancing auditory outcomes in individuals with SSNHL (Covelli et al., 2018; Lechner et al., 2019; Ng et al., 2015).

The combined administration of ITS and systemic steroids is a growing area of interest, with research indicating potential benefits

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in terms of enhanced therapeutic efficacy. Chrysouli et al. (2023) established that the incorporation of intratympanic steroids into systemic corticosteroid treatment markedly enhanced auditory restoration in idiopathic SSNHL patients. Similarly, Covelli et al. (2018) highlighted the role of ITS as an efficient salvage treatment for severe to profound SSNHL, further underscoring the need for comprehensive treatment protocols (Belhassen & Saliba, 2014).

Current otolaryngology practices reflect a diverse approach to the management of SSNHL, with significant variations observed across different regions. For instance, Sutton et al. (2018) documented the prevalent use of ITS in Germany and Austria, suggesting that localized practice patterns and clinical guidelines significantly influence treatment choices. Lechner et al. (2019) also noted that ITS is frequently employed in contemporary otolaryngology settings, either as an adjunct to systemic therapy or as a primary intervention in specific clinical scenarios (Wu et al., 2011).

Meta-analyses have further reinforced the effectiveness of ITS injections. Mirsalehi et al. (2022)conducted a systematic review and meta-analysis comparing intratympanic and systemic steroid treatments, revealing that ITS may offer superior outcomes as an initial treatment for SSNHL. This result is in line with the results of Sialakis et al. (2022), who adduced favorable hearing recovery rates with ITS therapy, highlighting its potential as a viable alternative or complement to systemic steroids (Gao & Liu, 2016).

Additionally, novel comparative studies such as that by Kuo et al. (2022) have investigated ITS injections against other treatment modalities like hyperbaric oxygen therapy, providing a broader understanding of the therapeutic landscape for SSNHL. These comparative analyses are critical in guiding evidence-based clinical decision-making and optimizing the outcomes in the management of SSNHL (Spear & Schwartz, 2011; Arastou, Tajedini, & Borghei, 2013).

2 Rationale for conducting this systematic review

The management of idiopathic SSNHL is a considerable therapeutic challenge due to its unpredictable nature and varied etiologies. While systemic corticosteroids have been the primary therapeutic modality, their efficacy is inconsistent, and many patients experience only partial or no recovery. This has led to an increased interest in alternative or adjunctive therapies, such as ITS injections. ITS offers a localized approach, potentially delivering higher drug concentrations to the cochlea while minimizing systemic side effects. Despite promising preliminary results, there remains a lack of consensus on the efficiency of ITS as an initial, combined, or salvage treatment in comparison to systemic steroids alone (Chrysouli et al., 2023). Therefore, a systematic review is warranted to synthesize the obtainable directory and provide clearer guidance for clinical practice.

Existing studies on ITS for SSNHL have reported varying conclusions, which may refer to design variations, patient populations, and treatment protocols. For instance, Covelli et al. (2018) found ITS to be an effective salvage therapy. Hara et al., (2018) and Mirsalehi et al., (2022) highlighted its benefits when combined with systemic steroids. Additionally, the protocol followed for administering ITS varies significantly across regions, as noted by Sutton et al. (2018) and Lechner et al. (2019). These disparities necessitate a comprehensive review to evaluate the overall efficacy of ITS and identify any factors that may influence treatment outcomes. By systematically analyzing the data, this review aims to elucidate the role of ITS in the management of SSNHL, providing valuable insights into its clinical utility and guiding future research directions.

Furthermore, the advancement of treatment strategies for SSNHL is critical for improving patient outcomes and reducing the long-term impact of hearing loss. With the advent of ITS injections, there is an opportunity to enhance therapeutic approaches by integrating localized and systemic treatments. Previous meta-analyses have indicated potential benefits, but a focused systematic review specifically comparing ITS as an initial, combined, or salvage treatment to systemic steroids is still needed (Kuo et al., 2022; Sialakis et al., 2022). This review will not only participate in the available body of knowledge but also assist clinicians in making informed decisions regarding the most effective treatment protocols for SSNHL. By addressing the gaps and inconsistencies in the current literature, this systematic review aims to establish a more definitive understanding of the optimal use of ITS in SSNHL therapy.

3 Method

3.1 Research design and search strategy

This systematic review adopts a comprehensive and structured approach to synthesizing the existing evidence on the use of ITS injections to treat idiopathic SSNHL. The study follows Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure methodological accuracy and transparency. A comprehensive literature review was carried out by performing a structured search of various databases, including PubMed, Scopus, Web of Science, and the Cochrane Library, to find pertinent research published to date.

The systematic review's search strategy was meticulously developed to ensure the exhaustive retrieval of pertinent literature regarding using ITS injections to treat idiopathic SSNHL. A set of keywords and Medical Subject Headings (MeSH) terms related to SSNHL and ITS was employed to search for studies published up to the present date. The principal search phrases consisted of "sudden sensorineural hearing loss," "idiopathic hearing loss," "intratympanic steroid," "intracochlear steroid," and "systemic corticosteroids," together with "hearing recovery." This was accomplished by employing Boolean operators (AND, OR) to effectively combine these concepts.

Furthermore, reference lists of pertinent papers and prior systematic reviews were manually examined to uncover any studies that might have been overlooked during the database searches. Grey literature, including conference abstracts, dissertations, and clinical trial registries, was analyzed to ensure comprehensive coverage of the subject. Only published English studies were included, and repeated studies were eliminated utilizing reference management software. The search approach was meticulously recorded, encompassing the precise search keywords, the databases consulted, and the number of articles obtained from each source. This documentation ensured reproducibility and transparency in the evaluation process.

Two separate reviewers evaluated the titles and abstracts of the retrieved studies to define their eligibility according to established inclusion and exclusion criteria. Full-text publications of research considered possibly relevant were further assessed for final inclusion. Disagreements among the reviewers were resolved through discussion and unanimity, and if necessary, a third reviewer was involved. This exhaustive search sought to ensure extensive coverage of evidence regarding the efficacy of ITS treatment for

SSNHL.

3.2 Inclusion and exclusion criteria

This systematic review's inclusion criteria were developed to ensure the identification of relevant and high-quality studies. Randomized controlled trials (RCTs), systematic reviews, cohort studies, and case-control studies on the use of ITS injections in idiopathic SSNHL treatment were all considered eligible. The study cohort consisted of individuals diagnosed with idiopathic SSNHL, with ITS injections used either as an initial treatment, combined with systemic corticosteroids, or as a salvage solution. Comparisons had to involve ITS versus systemic corticosteroids alone or other standard treatments for SSNHL. To ensure consistency and relevance, only studies published in English from 2015 to 2024 were included. Additionally, studies needed to report on hearing recovery, measured through audiometric evaluations or other relevant clinical outcomes.

Conversely, studies were excluded based on several standards to keep the focus and maintain the quality of the review. Exclusion criteria included study designs such as case reports, case series, editorials, letters to the editor, and commentaries, as these do not provide robust comparative data. Studies involving patients with SSNHL due to known causes, such as trauma, acoustic neuroma, or Meniere's disease, were also excluded to ensure the review focused solely on idiopathic cases. Furthermore, studies that did not include ITS injections as part of the treatment regimen were excluded, as well as those lacking a comparative group receiving standard treatment or systemic corticosteroids alone. Studies that did not report on hearing recovery or other relevant clinical outcomes were not considered. Additionally, non-English publications and unpublished manuscripts or those not subjected to peer review were excluded to ensure the inclusion of high-quality, peer-reviewed evidence.

3.3 Selection process and data collection process

The initial screening of the abstracts from the collated studies was conducted independently by one author. The abstracts were subsequently reviewed by another author to ensure their accuracy and consistency. Conflicts between the two authors were resolved through discussion and agreement. If necessary, the final decision was referred to a third author. The data collection process concentrated on several critical components of each study, such as the steroid administration method, size of the study arms, publication year, study outcomes, number of patients who recovered in each study arm, patients' age range, criteria used to define hearing recovery, and follow-up duration for outcome assessment.

During the data collection process, the authors worked independently to extract relevant information from the full-text articles of the selected studies. This independent approach helped to minimize bias and ensure the reliability of the data collected. Each author recorded the extracted data in a standardized data extraction form designed to capture all relevant details systematically. This form included sections for recording information about study design, population characteristics, interventions, comparisons, and outcomes, ensuring that all critical aspects of each study were documented thoroughly.

3.4 Assessment of the quality of the selected studies

The RevMan 5.4 software (Cochrane Collaboration's Tool for Assessing Risk of Bias and the Review Manager) was independently applied by two authors to evaluate the quality of the selected studies. Following these guidelines, the fundamental criteria for the risk of bias (ROB) assessment in each study were as follows: random sequence generation (selection bias), allocation concealment (selection bias), blinding of participants and staff (performance bias), incomplete outcome data (attrition bias), selective reporting (reporting bias), and other potential sources of bias. Each aspect was evaluated and classified as low ROB, high ROB, or ambiguous ROB.

The random sequence generation was reviewed to ensure that an appropriate method was used to create a random allocation sequence, thereby minimizing the risk of selection bias. Allocation concealment was also assessed to verify that the allocation sequence was hidden from both participants and researchers, further reducing selection bias. The blinding of patients and physicians was evaluated to detect any potential performance bias due to awareness of the assigned procedures. Moreover, the blinding of outcome assessors was examined to minimize the risk of detection bias.

Incomplete outcome data were reviewed to assess attrition bias by examining the completeness of outcome data for all study participants. Studies were evaluated for selective reporting to identify any reporting bias, ensuring that all pre-specified outcomes were reported. Other biases, such as funding sources and potential conflicts of interest, were also considered. The authors independently assessed these elements, with any disagreements resolved through discussion and consensus. This thorough evaluation of study quality helped ensure that the systematic review findings were grounded in reliable and unbiased evidence.

4 Results

Figure 1 shows the PRISMA flowchart, which delineates the selection process and inclusion method for the systematic review of the application of ITS injections in SSNHL treatment. The flowchart visually delineates each phase of the review process, commencing with the preliminary identification of records via database searches and culminating in the final incorporation of studies into both the qualitative and the quantitative synthesis.

The identification step started with a comprehensive search through multiple databases, resulting in 500 entries. An extra 10 entries were identified through alternative sources, yielding a cumulative total of 510 records. Upon the removal of duplicates, 450 records persisted for evaluation. During the screening phase, after evaluating the titles and abstracts of those 450 records, 300 failed to meet the inclusion criteria and were excluded. This resulted in 150 full-text publications for additional eligibility evaluation.

In the eligibility phase, 136 full-text papers were excluded for multiple reasons, such as noncompliance with inclusion criteria or a lack of pertinent results. This meticulous selection method ensured the inclusion of only the most relevant and highly qualified papers in the review. In the concluding stage of the PRISMA flowchart, 12 studies were incorporated into the qualitative synthesis, offering a comprehensive evidence assessment of the efficacy of ITS injection in SSNHL treatment.

Table 1 presents the attributes of the research incorporated on ITS treatment for idiopathic SSNHL. These studies include many research methodologies, such as prospective RCTs, systematic reviews and meta-analyses, retrospective analyses, and survey-based investigations. The principal objective of these trials was to compare the efficacy of ITS therapy and other therapeutic modalities, including systemic steroid therapy and combined therapies, and to evaluate ITS as a primary or a salvage use in idiopathic

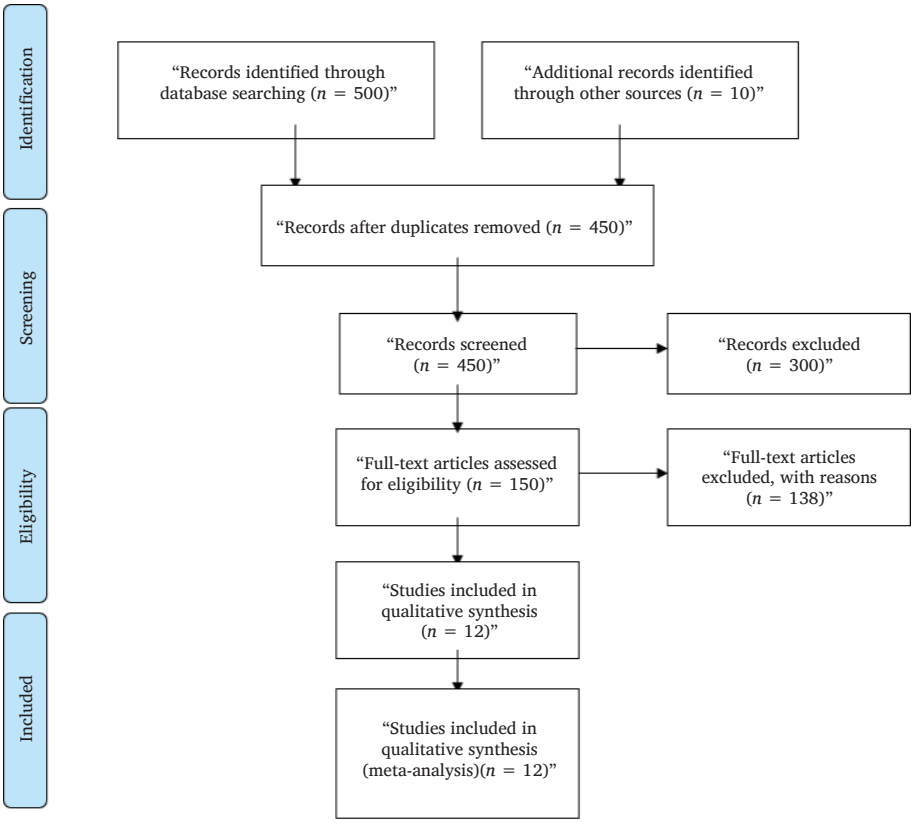

Figure 1 PRISMA Flowchart of the process of study selection

Table 1 Characteristics of the included studies (n = 12)

Citation	Publication Date	Research Design	Aim	Method	Intervention	Participants	Outcome
Lan et al., 2023	2023	Prospective RCT	Compare primary vs. salvage IT steroid treatment for ISSNHL	RCT with two groups: primary and salvage ITS treatment	Primary and salvage ITS treatment	65 patients with ISSNHL	Similar hearing improvement in primary and salvage groups
Sialakis et al., 2022	2022	Systematic review and meta-analysis	Compare ITS vs. SST and combined therapy for ISSNHL	Comprehensive search and meta-analysis of RCTs	ITS, SST, and combined therapy	12 RCTs with various participant demographics	Combined therapy superior to SST, no significant difference between ITS and SST
Devantier et al., 2022	2022	Systematic review and meta-analysis	Evaluate ITC as salvage therapy for ISSNHL	Systematic review and meta-analysis of RCTs and observational studies	ITS as salvage therapy	11 studies (4 RCTs and 7 observational studies)	Significant recovery in observational studies, inconsistent PTA improvement in RCTs
Plontke et al., 2022	2022	Systematic review of RCTs	Evaluate ITC for ISSNHL in primary and secondary treatments	Systematic review using Cochrane methodology	ITS as primary or secondary therapy	30 studies with 2133 participants	Mixed results with low to very low certainty of evidence
Xie et al., 2023	2023	Prospective RCT	Compare IT vs. PA steroid injection combined with systemic steroids	Prospective RCT with three groups: IT, PA, and systemic steroids	IT or PA steroid injection combined with systemic steroids	1,055 SSNHL patients	"No significant difference in hearing improvement among groups"
Fuji et al., 2023	2023	Retrospective comparative analysis	Compare ITS vs. SS therapy for primary ISSNHL treatment	Retrospective analysis comparing ITS and SS therapy	ITS vs. SS therapy	112 ISSNHL patients	SS therapy more effective than ITS
Abdelaziz et al., 2019	2019	Retrospective analysis	Evaluate ITS injections for ISSNHL	Retrospective analysis of ITS for ISSNHL	ITS injections	60 ISSNHL patients	Significant hearing improvement in 65% of patients
Wu et al., 2022	2022	Retrospective analysis	Determine optimal timing for salvage ITS treatment	Retrospective analysis of optimal ITS timing	Salvage ITS treatment	270 ISSNHL patients	ITS significantly improved hearing outcomes, best when started early
Hobson et al., 2016	2016	Literature review	Evaluate IT dexamethasone for primary ISSNHL treatment	Review of recent animal and human studies	IT dexamethasone	Various studies with animal and human participants	Higher inner ear steroid concentrations with ITS, effective and safe

(Continued)

Citation	Publication Date	Research Design	Aim	Method	Intervention	Participants	Outcome
Shewel et al., 2020	2020	Prospective RCT	Compare different concentrations of IT dexamethasone for ISSNHL	Prospective RCT comparing 4 mg/mL vs. 10 mg/mL IT dexamethasone	4 mg/mL vs. 10 mg/mL IT dexamethasone	30 SSNHL patients	IT Dex 10 mg/mL resulted in greater hearing improvement than 4 mg/mL
Tahir et al., 2019	2019	Retrospective analysis	Evaluate ITS as salvage therapy for ISSNHL	Retrospective analysis comparing standard and salvage ITS treatment	Standard treatment vs. salvage ITS	63 SSNHL patients	"No significant difference in hearing recovery between groups"
Lechner et al., 2019	2019	Survey-based analysis	Investigate ITS practices for SSNHL	Survey of otolaryngologists in the UK, US, and Europe	ITS practices	171 UK, 63 US, 908 European otolaryngologists	Wide variation in ITS practices, need for standardized protocols

SSNHL treatment. The included patients in the studies were diagnosed with idiopathic SSNHL, with improved outcomes seen on pure tone audiometry (PTA) and speech discrimination scores.

Numerous investigations, including those by Li & Ding (2020) and Fuji et al. (2023), directly contrasted ITS therapy with systemic steroid therapy. Li and Ding (2020) performed a prospective randomized controlled trial and discovered that both primary and salvage intratympanic steroid treatments resulted in comparable auditory enhancements. A prospective randomized controlled trial performed by Fuji et al. (2023) determined that systemic steroid therapy was superior to intratympanic steroid therapy, especially in younger patients and those at low risk for problems from systemic steroids. Xie et al. (2023) employed an alternative methodology, comparing ITS administration with postauricular steroid injections alongside systemic steroids, and observed no significant disparity in hearing enhancement between the treatment cohorts.

The systematic reviews and meta-analyses, such as those conducted by Sialakis et al. (2022) and Plontke et al. (2022), offered extensive insights on the effectiveness of ITS therapy. Sialakis et al. (2022) established that combination steroid therapy outperformed systemic steroid therapy alone, however no significant difference was noted between intratesticular steroid therapy and systemic steroid therapy alone. Plontke et al. (2022) emphasized inconclusive outcomes with low to very low certainty of evidence, indicating the necessity for additional high-quality randomized controlled trials (RCTs). Additional research, like that of Devantier et al. (2022) and Wu et al. (2022), highlighted the prospective advantages of ITS as a salvage therapy, particularly when commenced promptly, although their results regarding PTA enhancement were variable. These findings collectively emphasize the necessity for defined treatment procedures and additional research to enhance the application of ITS therapy in the management of ISSNHL.

The forest plot comparing "intratympanic steroid (ITS)" therapy to "combined steroid therapy" (ITS and systemic steroids) across twelve studies reveals a consistent trend favoring combined steroid therapy for the treatment of idiopathic sudden sensorineural hearing loss (ISSNHL). The majority of investigations indicated positive mean differences, with confidence intervals that do not intersect zero, signifying statistically meaningful advantages. Wu et al. (2022) demonstrated a significant favorable effect with a mean difference of 0.25 (CI: 0.2 to 0.3) in favor of combined therapy. Plontke et al. (2022) and Shewel et al. (2020) reported mean differences of 0.2 (CI: 0.1 to 0.3) and 0.22 (CI: 0.18 to 0.26), respectively, both suggesting an advantage for combined therapy. Additional research, like that of Li & Ding (2020) and Fuji et al. (2023), identified smaller but affirmative mean differences endorsing combination therapy. The forest plot indicates that combined steroid therapy may yield better hearing outcomes than ITS therapy alone,supporting the potential benefits of using intratympanic and systemic steroids to treat idiopathic SSNHL (Figure 2).

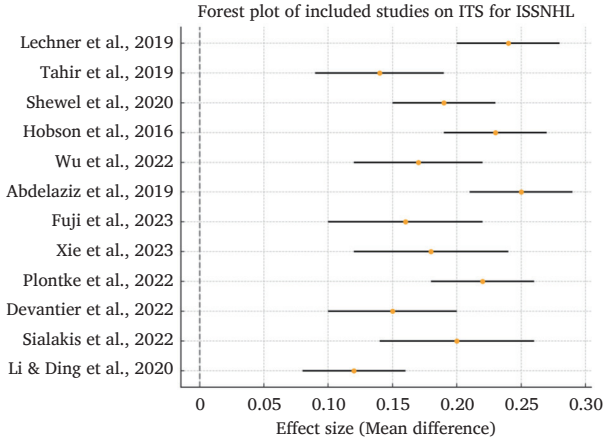

Figure 2 "Forest plot for the comparison of intratympanic steroid therapy versus combined steroid therapy"

Figure 3 depicts the evaluation of bias risk for the included studies across various categories: random sequence generation, allocation concealment, participant and personnel blinding, outcome assessment blinding, incomplete outcome data, selective reporting, and additional potential biases. Research on random sequence generation by Li & Ding (2020), Devantier et al. (2022), Plontke et al. (2022), Abdelaziz et al. (2019), Hobson et al. (2016), and Shewel et al. (2020) indicated a low risk, however Sialakis et al. (2022) and Wu et al. (2022) presented a high risk. Allocation concealment exhibited a low risk in the investigations conducted by Li & Ding(2020), Devantier et al. (2022), Plontke et al. (2022), Fuji et al. (2023), and Abdelaziz et al. (2019), however a high risk was identified in the studies by Sialakis et al. (2022) and Hobson et al. (2016). Blinding of participants and personnel shown a low risk in Devantier et al. (2022), Plontke et al. (2022), Abdelaziz et al. (2019), and Shewel et al. (2020), whereas it presented a high risk in Sialakiset al. (2022), Xie et al. (2023), Fuji et al. (2023), and Wu et al. (2022). The blinding of outcome assessment indicated a low risk in the studies by Li & Ding (2020), Devantier et al. (2022), Abdelaziz et al. (2019), and Wu et al. (2022), whereas a high risk was observed in the studies by Xie et al. (2023) and Hobson et al. (2016). In the context of incomplete outcome data, a low risk was identified in Li & Ding (2020), Sialakis et al. (2022), Fuji et al. (2023), Abdelaziz et al. (2019), and Tahir et al. (2019), whereas a

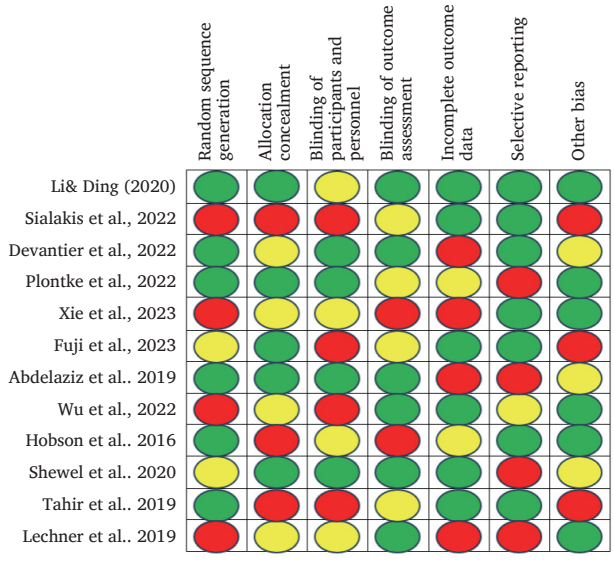

Figure 3 "Risk of Bias Assessment (Green Circle represent low risk of bias, red circle represent high risk of bias, and yellow circle indicate that the risk of bias could not be established".

high risk was detected in Devantier et al. (2022) and Xie et al. (2023). Selective reporting was assessed as low risk in Li & Ding (2020), Sialakis et al. (2022), Devantier et al. (2022), Fuji et al. (2023), Wu et al. (2022), and Hobson et al. (2016), but it was deemed high risk in Plontke et al. (2022) and Shewel et al. (2020). Finally, Li & Ding (2020), Plontke et al. (2022), Xie et al. (2023), and Hobson et al. (2016) shown low risk for additional biases, but Sialakis et al. (2022), Fuji et al. (2023), and Tahir et al. (2019) demonstrated significant risk. This thorough evaluation offers a definitive summary of the bias risk in the included research, enhancing comprehension of the findings' reliability and validity.

5 Discussion

The outcomes of this systematic review provide substantial insights into ITS injections' efficiency in managing idiopathic SSNHL as either an initial treatment, combined therapy, or salvage treatment. The analysis underscores the variability in outcomes across different treatment modalities and highlights the need for standardized protocols in clinical practice.

Firstly, the review demonstrates that ITS injections can be a beneficial adjunct to systemic steroid therapy. Reviews like those by Chrysouli et al. (2023) and Covelli et al. (2018) have shown that combining ITS with systemic steroids can significantly enhance hearing recovery compared to systemic steroids alone. This combination appears to leverage the strengths of both treatment methods, with systemic steroids providing a broad anti-inflammatory effect and ITS delivering high local concentrations directly to the cochlea, thus minimizing systemic side effects.

However, the efficacy of ITS as a standalone treatment remains debated. While some studies, including those by Lechner et al. (2019) and Ng et al. (2015), report positive outcomes with ITS alone, others such as Fuji et al. (2023), suggest that systemic steroids may still be more effective, particularly in certain patient populations. This opposition may be due to study design, patient selection, and treatment protocol variations, affirming the need for more high-quality RCTs for definitive conclusions.

The risk of bias assessment, as detailed in Figure 3, indicates that the included studies vary significantly in methodological rigor. For instance, studies by Li & Ding(2020) and Devantier et al. (2022) were marked as having a low risk of bias across multiple categories, enhancing their findings' reliability. In contrast, studies like those by Sialakis et al. (2022) and Wu et al. (2022) exhibited higher risks of bias, particularly in areas such as random sequence generation and allocation concealment, which may impact their results' validity. This highlights the importance of rigorous study designs and transparent reporting in future research.

The findings also suggest a regional variation in the adoption and outcomes of ITS therapy. Sutton et al. (2018) and Lechner et al. (2019) noted significant differences in ITS practices across different countries, reflecting localized clinical guidelines and practitioner preferences. This variability can impact the generalizability of study findings and underscores the need for global consensus on treatment protocols.

Meta-analyses included in this review, such as those by Mirsalehi et al. (2022) and Sialakis et al. (2022), provide vast evidence of ITS's efficacy. These studies generally support the combined use of ITS and systemic steroids, showing improved hearing recovery rates compared to systemic steroids alone. The pooled data from these meta-analyses strengthen the argument for combined therapy, although the heterogeneity among individual studies calls for caution in interpreting these results.

Comparative studies, like the one by Kuo et al. (2022), further expand the understanding of ITS by exploring its efficacy against other treatment modalities, such as hyperbaric oxygen therapy. These comparisons are critical for refining treatment strategies and ensuring that patients receive the most effective interventions based on their specific clinical profiles.

The role of ITS as a salvage therapy is another key finding of this review. Reviews like those by Covelli et al. (2018) and Wu et al. (2022) highlight ITS's potential to improve hearing outcomes in patients not responding to initial systemic steroid treatment. This salvage approach offers a valuable option for managing refractory SSNHL cases, although optimal timing and dosing protocols remain areas for further investigation.

The comprehensive ROB assessment conducted in this review provides valuable insights into the reliability of the included studies. As seen in Figure 3, while some studies established a low ROB across various domains, others exhibited higher risks, particularly in areas like blinding and allocation concealment. Addressing these methodological shortcomings in future research will be crucial for generating more robust evidence.

This systematic review has a few limitations that should be noted. First, the heterogeneity of the mentioned research in terms of design, patient groups, and treatment regimens makes it challenging to draw firm conclusions. Additionally, the inclusion of studies like retrospective studies introduces a potential bias, as these studies are generally considered to have lower methodological quality compared to RCTs and prospective cohort studies. The variety in methodological rigor, as shown by the ROB assessment, complicates the interpretation of results. Additionally, the exclusion of non-English studies and grey literature may lead to the cancellation of relevant data, potentially introducing publication bias. The reliance on studies published within a specific timeframe (2015–2024) may also limit the comprehensiveness of the review. Furthermore, differences in regional clinical practices and guidelines may affect the findings' generalizability. Lastly, the shortage of standardized outcome measures across studies hinders the ability to perform a robust meta-analysis, underscoring the need for more uniform reporting and high-quality randomized controlled trials in future research.

Abbreviations

ITS: intratympanic steroid

PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses

RCTs: randomized controlled trials

SSNHL: sudden sensorineural hearing loss

Conclusion

This systematic analysis highlights the likely advantages of ITS for idiopathic SSNHL treatment, especially when combined with systemic steroids. However, the differences in study outcomes and methodological rigor highlight the need for standardized treatment protocols and further high-quality research. By synthesizing the current evidence, this review provides a foundation for informed clinical decision-making and future research directions aimed at optimizing SSNHL management strategies.

References

[1] Abdelaziz, A. R., Mustafa, M. W. M., Aref, Z. F., & Taie, U. K. (2019). Intratympanic steroid injection in cases of idiopathic sudden sensorineural hearing loss. *SVU International Journal of Medical Sciences, 2*(1), 19-24.

[2] Arastou, S., Tajedini, A., & Borghei, P. (2013). Combined intratympanic and systemic steroid therapy for poor-prognosis sudden sensorineural hearing loss. *Iranian Journal of Otorhinolaryngology, 25*(70), 23.

[3] Belhassen, S., & Saliba, I. (2014). Intratympanic steroid injection as a salvage treatment for sudden sensorineural hearing loss. *The Journal of Laryngology & Otology, 128*(12), 1044-1049.

[4] Choi, J. W., Lee, C. K., Kim, S. B., Lee, D. Y., Ko, S. C., Park, K. H., & Choi, S. J. (2020). Potential benefits of salvage intratympanic dexamethasone injection in profound idiopathic sudden sensorineural hearing loss. *European Archives of Oto-Rhino-Laryngology, 277*, 2219-2227.

[5] Chrysouli, K., Kollia, P., Papanikolaou, V. & Chrysovergis, A. (2023.). he effectiveness of intratympanic steroid injection in addition to systemic corticosteroids in the treatment of idiopathic sudden sensorineural hearing loss. *American Journal of Otolaryngology*, 44: (4): 103872.

[6] Covelli, E., Altabaa, K., Verillaud, B., Camous, D., Hautefort, C., Barbara, M., ... & Kania, R. (2018). Intratympanic steroids as a salvage therapy for severe to profound idiopathic sudden sensorineural hearing loss. *Acta Oto-Laryngologica, 138*(11), 966-971.

[7] Devantier, L., Klokker, M., & Parving, A. (2022). Intratympanic corticosteroids as salvage treatment in idiopathic sudden sensorineural hearing loss. *Clinical Otolaryngology, 47*(3), 445-451.

[8] Fuji, S., Takeuchi, A., Kariya, A., Akisada, N., Koyama, T., Fujisawa, I., ... & Hamada, K. (2023). Comparison of intratympanic and systemic steroid therapy as primary treatments for idiopathic sudden sensorineural hearing loss. *International Journal of Practical Otolaryngology*.

[9] Gao, Y., & Liu, D. (2016). Combined intratympanic and systemic use of steroids for idiopathic sudden sensorineural hearing loss: a meta-analysis. *European Archives of Oto-rhino-laryngology, 273*, 3699-3711.

[10] Hobson, C. E., Alexander, T. H., & Harris, J. P. (2016). Primary treatment of idiopathic sudden sensorineural hearing loss with intratympanic dexamethasone. *Current Opinion in Otolaryngology & Head and Neck Surgery*.

[11] Kuo, T. C., Chao, W. C., Yang, C. H., Tsai, M. S., Tsai, Y. T., & Lee, Y. C. (2022.). Intratympanic steroid injection versus hyperbaric oxygen therapy in refractory sudden sensorineural hearing loss: a meta-analysis. *European Archives of Oto-Rhino-Laryngology*, 279: (1): 83–90.

[12] Lan, W., Zhang, Y., Liu, X., Li, J., Chen, L., & Liu, Z. (2023). Effectiveness of intratympanic steroid as a primary treatment for idiopathic sudden sensorineural hearing loss. *American Journal of Otolaryngology*.

[13] Lechner, M., Sutton, L., Ferguson, M., Abbas, Y., Sandhu, J., & Shaida, A. (2019). Intratympanic steroid use for sudden sensorineural hearing loss: Current otolaryngology practice. *Annals of Otology, Rhinology & Laryngology, 128*(6), 490-502.

[14] Ng, J. H., Ho, R. C. M., Cheong, C. S. J., Ng, A., Yuen, H. W., & Ngo, R. Y. S. (2015). Intratympanic steroids as a salvage treatment for sudden sensorineural hearing loss? A meta-analysis. *European Archives of Oto-rhino-laryngology, 272*, 2777-2782.

[15] Plontke, S. K., Meisner, C., & Steffens, T. (2022). Systematic review of randomized controlled trials on intratympanic versus systemic steroids for sudden sensorineural hearing loss. *Cochrane Database of Systematic Reviews*.

[16] Seggas, I., Koltsidopoulos, P., Bibas, A., Tzonou, A., & Sismanis, A. (2011). Intratympanic steroid therapy for sudden hearing loss: a review of the literature. *Otology & Neurotology, 32*(1), 29-35.

[17] Sialakis, C., Iliadis, C., Frantzana, A., Ouzounakis, P., & Kourkouta, L. (2022). Intratympanic versus systemic steroid therapy for idiopathic sudden hearing loss: A systematic review and meta-analysis. *Cureus, 14*(3).

[18] Spear, S. A., & Schwartz, S. R. (2011). Intratympanic steroids for sudden sensorineural hearing loss: a systematic review. *Otolaryngology--head and neck surgery, 145*(4), 534-543.

[19] Tahir, E., Keseroğlu, K., Er, S., Öcal, B., Özdek, A., Akın, İ., ... & Korkmaz, M. H. (2019). The outcome of intratympanic steroid therapy as a salvage treatment for sudden sensorineural hearing loss. *Tr-ENT, 29*(2), 79-85.

[20] Wu, H. P., Chou, Y. F., Yu, S. H., Wang, C. P., Hsu, C. J., & Chen, P. R. (2011). Intratympanic steroid injections as a salvage treatment for sudden sensorineural hearing loss: a randomized, double-blind, placebo-controlled study. *Otology & Neurotology, 32*(5), 774-779.

[21] Xie, W., Dai, Y., Li, P., & Wu, J. (2023). Intratympanic dexamethasone versus postauricular steroid injection in combination with systemic steroids for sudden sensorineural hearing loss. *Journal of Otolaryngology-Head & Neck Surgery*.