Integrative Medicine Research 13 (2024) 101087

Contents lists available at ScienceDirect

Integrative Medicine Research

journal homepage: www.elsevier.com/locate/imr

Review Article

The efficacy and safety of acupuncture in the treatment of sudden sensorineural hearing loss: A systematic review and meta-analysis

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ARTICLE INFO

Keywords:
Acupuncture
SSNHL
Hearing loss
Meta-analysis
Traditional medicine

ABSTRACT

Background: Despite numerous pharmacological and therapeutic options for sudden sensorineural hearing loss(SSNHL), treatment remains challenging due to various side effects and suboptimal efficacy. Acupuncture, as a complementary and alternative therapy, has achieved some success in this field. The objective of this study was to systematically evaluate the efficacy and safety of acupuncture for SSNHL, and to seek robust evidence-based medical evidence for the therapeutic effect of acupuncture.

Methods: The following databases were searched: PubMed, EMbase, Cochrane Library, China National Knowledge Infrastructure (CNKI), Wanfang Data Knowledge Service Platform, VIP Information Database, and China Biomedical Literature Database (SinoMed) up to September 1, 2024. The quality of the RCTs was evaluated utilizing the risk of bias assessment tool from the Cochrane Collaboration. Risk ratio (RR), risk difference (RD), mean differences (MD), and 95% confidence interval (CI) were used to estimate the effect. Data analysis was used RevMan 5.3.

Results: A total of 28 randomized controlled trials involving 2,456 patients were included in this systematic review and meta-analysis. The meta-analysis results indicate that the integration of acupuncture with WMCT for SSNHL may enhance the total effective rate (RR=1.18, 95% CI: 1.14–1.23, $P<0.00001$), change in hearing threshold (MD=-10.71, 95% CI: -12.52 to -8.89, $P<0.00001$), and cure rate (RD=0.15, 95% CI: 0.11–0.19, $P<0.00001$) compared to WMCT alone. Acupuncture as a monotherapy seems to be superior to WMCT in terms of total effective rate (RR=1.19, 95% CI: 1.07–1.32, $P=0.001$) and cure rate (RD=0.11, 95% CI: 0.02–0.19, $P=0.01$). There was no significant difference observed between acupuncture alone and WMCT in improving pure tone hearing thresholds (MD=-5.45, 95%CI: -20.75 to 9.85, $P=0.48$). While the combination of acupuncture with WMCT may offer greater efficacy in reducing tinnitus symptoms (RR=1.12, 95% CI:1.01 to 1.24, $P=0.03$), but the reliability of this outcome is contested upon sensitivity analysis (RR=1.07, 95% CI:0.87–1.31, $P=0.51$).

Conclusions: The findings of the meta-analysis indicate that acupuncture, either as a standalone intervention or in conjunction with WMCT, may offer supplementary therapeutic advantages in certain respects. However, the results should be interpreted with caution due to the quality and potential bias of the included studies.

1. Introduction

Sudden sensorineural hearing loss (SSNHL) is an otolaryngological emergency affecting individuals of all ages.[1] It is characterized by an unexplained, rapid sensorineural hearing loss of at least 20 dB across at least two contiguous frequencies within 72 h.[2] The condition may present unilaterally or bilaterally[3] and is often accompanied by symptoms such as tinnitus, vertigo, and vomiting, significantly impacting patients' health and quality of life. Incidence rates vary by country,[4] with over 66,000 new cases of SSNHL occurring annually in the United States.[5] According to the World Health Organization, by 2050, it is projected that there will be hearing loss of varying degrees in a population of 200 million.[6]

The pathophysiological mechanism behind SSNHL remains unclear,[6,7] and its treatment is controversial.[8] It is currently believed that the condition may be associated with factors such as viral infections,[9,10] immune disorders,[11-13] inner ear circulation problems,[14-17] and labyrinthine membrane hydrops.[18] The 2019 updated guidelines in the United States[19] strongly recommend the systemic application or intratympanic injection of corticosteroids, but these can increase the risk of adverse events such as sleep disorders, neuropsychiatric diseases,[20] avascular necrosis of the femoral head,[21,22] and tympanic membrane perforation, and some scholars[23] believe that steroid treatment seems

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https://doi.org/10.1016/j.imr.2024.101087
Received 11 March 2024; Received in revised form 18 September 2024; Accepted 19 September 2024
Available online 21 September 2024

to offer no benefit. The guidelines also suggest hyperbaric oxygen therapy, which carries risks of barotrauma to the middle ear and sinuses,[24] as well as pulmonary and central nervous system oxygen toxicity.[25-28]

Acupuncture, as a complementary alternative therapy with fewer side effects, is increasingly being used by TCM scholars to treat sudden deafness.[29] By stimulating specific acupoints on the body, acupuncture is believed to awaken the body's self-healing abilities, clear the meridians, correct the imbalance of qi, blood, yin, and yang, and restore hearing. The primary mechanism is that acupuncture can improve peri-auricular blood circulation, decrease blood viscosity, and regulate the rhythm of neural activity within the ear,[30-32] thus improving hearing and accompanying symptoms of SSNHL. Although previous meta-analyses have evaluated the effectiveness and safety of acupuncture for sudden deafness,[33,34] there are certain limitations: firstly, past studies did not comprehensively include acupuncture methods, encompassing only manual acupuncture and electroacupuncture without considering other methods (e.g., auricular acupuncture, acupressure); secondly, the evaluation indicators in previous meta-analyses were not comprehensive; and lastly, Chinese guidelines for the diagnosis and treatment of SSNHL have been continuously updated with the progress of clinical research, with the first edition of the guidelines published in 2005.[35,36] Therefore, this study includes randomized controlled trials of acupuncture treatment for SSNHL from both domestic and international sources that meet the guideline diagnostic efficacy evaluation standards, aiming to provide a more comprehensive and objective basis for the acupuncture treatment of SSNHL.

2. Methods

The reporting of this study adheres to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines and is registered with the international prospective register of systematic reviews (PROSPERO, CRD42023459745).

2.1. Search strategy

A computerized search was conducted across databases including PubMed, EMbase, Cochrane Library, China National Knowledge Infrastructure (CNKI), Wanfang Data Knowledge Service Platform, VIP Information Chinese Journal Service Platform, and China Biomedical Literature Database (SinoMed), covering records up to September 1, 2024. The key terms of literature search in Chinese and English were: ('Hearing Loss Sudden' OR 'Sudden Sensorineural Deafness' OR 'SSHL' OR 'SSNHL') AND ('Acupuncture' OR 'Acupuncture Therapy' OR 'Electroacupuncture' OR 'Acupuncture Ear') AND ('clinical trial' OR 'clinical study' OR 'randomized controlled trial' OR 'RCT').

2.2. Eligibility criteria

2.2.1. Study design

Randomized controlled trials (RCTs) related to acupuncture treatment for sudden deafness were included.

2.2.2. Participants

The study participants were all patients meeting internationally recognized diagnostic standards for sudden deafness, e.g., the 2005[36] and 2015[37] guidelines published by the Otolaryngology Head and Neck Surgery Branch of the Chinese Medical Association.

2.2.3. Interventions

The treatment group used acupuncture or acupuncture combined with other treatments, with the only additional intervention over the control group being acupuncture.

2.2.4. Controls

Control group patients were treated with non-acupuncture therapies or were a blank control, including Western medicine, physical therapy, etc., without restrictions on acupoints selection, needle types, or course of treatment. Acupuncture therapy includes mannul acupuncture, electroacupuncture, auricular acupuncture and tumb-tack needle. Studies involving laser acupuncture, warm needling, moxibustion, or acupoint injections were excluded.

2.2.5. Outcomes

Primary outcome measures were total effective rate, pure-tone audiometric change and cure rate. Refer to the efficacy evaluation standards of the "Guidelines for the Diagnosis and Treatment of Sudden Deafness".[36,37] Recovery refers to the return of damaged frequency hearing to normal, or to the level of healthy ears, or to the level before the illness. Significant effect means that the average hearing at damaged frequencies is improved by more than 30 dB. Effective means that the average hearing at damaged frequencies is improved by 15 to 30 dB. Ineffective means that the average hearing improvement at the damaged frequency is less than 15 dB. Total effective rate = (recovery cases + significant effect cases + effective cases)/the total number of patients × 100%

Secondary outcome measures included effectiveness rate of accompanying symptoms (tinnitus, dizziness, etc.), and incidence of adverse events (infection, abdominal pain, itching, and needle fainting).

We included only published studies with full-text data were available. If the trial published several times, the most recent publication was selected. Studies were excluded for the case of no extractable data. Studies with no relevant outcome measures were also excluded.

2.3. Data extraction

Two independent researchers screened the literature according to the inclusion and exclusion criteria. The retrieved studies were imported into NoteExpress 3.8.0 for duplicate checking and removal. Initial screening was conducted by reading titles and abstracts to exclude studies that did not meet the inclusion criteria. Full texts of the remaining articles were then downloaded and re-screened. Upon final selection of the studies, two researchers independently extracted data using a pre-designed data extraction form, which included details on study characteristics, treatment details, patient characteristics, and all relevant outcomes. Extracted information included author(s), publication year, group details, average age, sample size, intervention measures, course of treatment, outcome indicators, and acupoints used. Disagreements were resolved through discussion between the two researchers or with the assistance of a third party if necessary.

2.4. Assessment of risk of bias

Two researchers evaluated the risk of bias in the included studies using the Cochrane bias risk assessment tool. The assessment covered six domains: selection bias (including the method of generating random sequences and allocation concealment), performance bias (blinding of researchers and participants), detection bias (blinding of outcome assessors), attrition bias (completeness of outcome data), reporting bias (selective reporting of study results), and other sources of bias. For each domain, the risk of bias was categorized as 'low', 'high', or 'unclear'. Bias risk assessment figures were generated using RevMan 5.3 software based on the evaluation results.

2.5. Data analysis

Meta-analysis was performed using RevMan 5.3, along with tests for heterogeneity, publication bias, and sensitivity analysis. Count data were analyzed using risk ratios (RR) and risk differences (RD), and measurement data using mean difference (MD) statistics. Considering the clinical or methodological variations among studies, random-effects

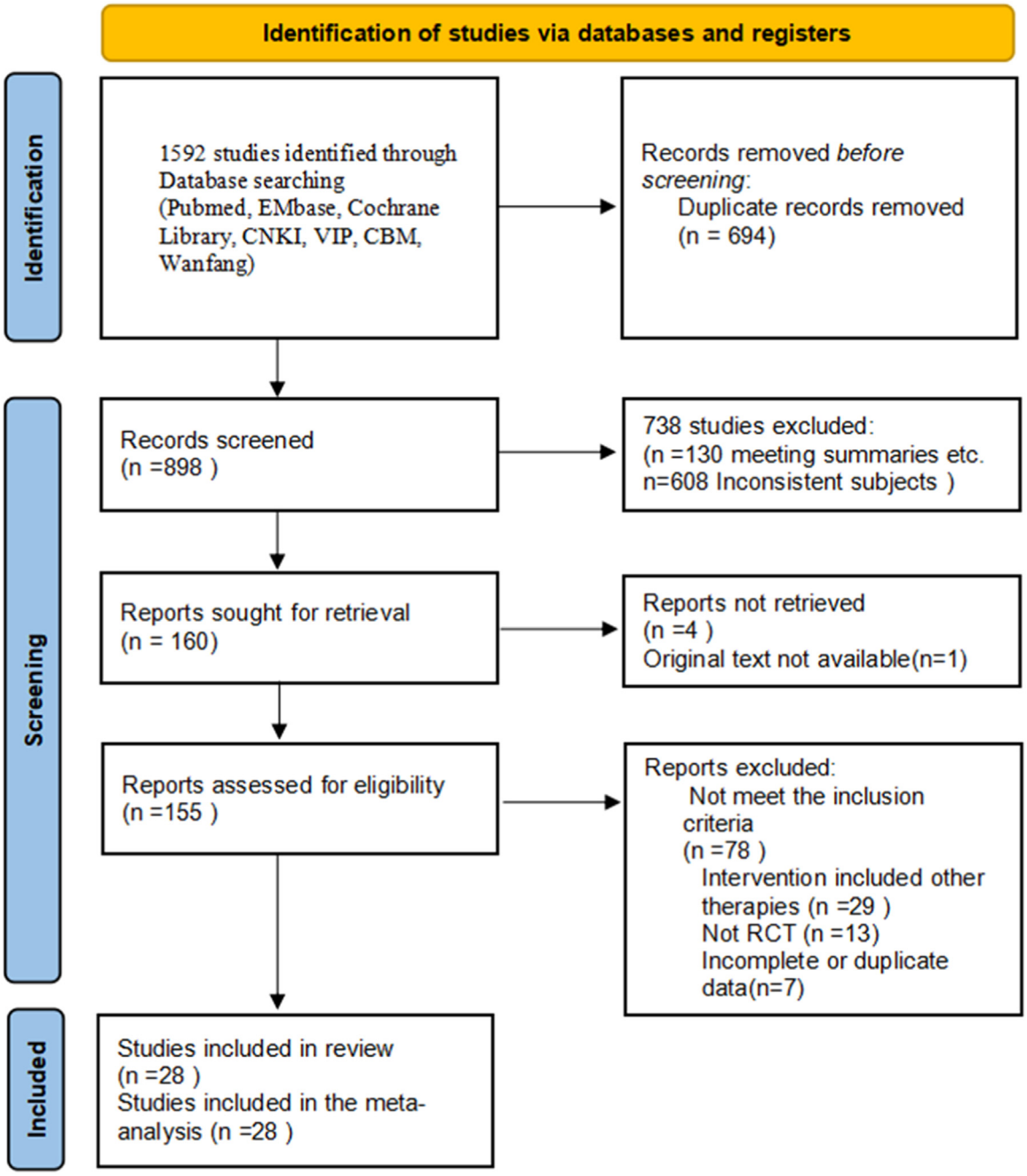


Fig. 1. Flow diagram of sudden deafness patients included in quantitative studies.

models were employed to provide a more robust estimation of the overall effect size. For publication bias test, funnel plots were used to assess the risk of bias in the included studies. Moreover, for sensitivity analysis, each study included in the meta-analysis was excluded one by one to explore the impact of the removal on the combined effect size. If the results did not change substantially, the findings were considered reliable; if the sensitivity analysis led to a different conclusion, it suggested the presence of potential factors influencing the effectiveness of the intervention. Due to the inclusion of different intervention methods, subgroup analyses were performed for different interventions.

3. Results

3.1. Study identification

A preliminary search of the aforementioned seven databases yielded 1592 potentially relevant articles. After excluding duplication, 898 articles remained. Title and abstract screening excluded 738 articles, leaving 160 full-text articles to be re-screened, culminating in 28 RCTs included in the analysis. The literature screening process is depicted in Fig. 1.

3.2. Study characteristics

The review included 28 randomized controlled trials with a total of 2456 patients with SSNHL, including 1189 patients in the experimental group and 1267 patients in the control group. The sample size of these studies ranged from 25 to 152 participants, mostly conducted in China and only one sample published in English.[38] Of these, two studies[38,39] featured three-group comparisons, while the rest compared two groups. All studies reported comparable baseline characteristics across groups. Seventeen studies[38-53,55] followed the 2005 guidelines of the Otolaryngology Head and Neck Surgery Branch of the Chinese Medical Association, and 11[54,56-65] used the 2015 version. Acupuncture methods in the experimental groups included electroacupuncture, manual acupuncture, auricular acupuncture, and tumb-tack needle. Control groups received WMCT. Outcome measures in the included studies comprised: total effective rate, pure-tone audiometric change, tinnitus efficacy rate, vertigo efficacy rate, adverse event occurrence. Main characteristics of the included studies are presented in Table 1. The 28 included studies used a total of 38 different acupoints, of which five were auricular points, and the rest were meridian points, extra-meridian points, and experienced points. The top five most frequently used acupoints were TE17, GB2, SI19, TE21, and TE3. The frequency of acupoints usage is shown in Supplement 1.

3.3. Assessment of methodological quality

The Cochrane risk of bias assessment tool was employed to evaluate the 28 included studies. One study[50] grouped by treatment modality was rated as high risk, thirteen further studies[39,40,46,48,51,54,58-64] described using random number tables or computer random number generators were rated as low risk, fourteen studies[38,41-45,47,49,52,53,55,56,57,65] mentioned randomization were rated as unclear risk. One study[59] used envelopes without stating whether they were sealed or opaque was rated as low risk, and the rest did not describe allocation concealment methods. Two studies[49,54] described the use of double-blinding were rated as low risk, the others did not mention blinding. One study[64] described the use of blinding for outcome assessment was rated as low risk. One study[63] reported the number of dropouts was rated as high risk, and the remaining 27 studies had complete outcome data. The 28 included studies were assessed as low risk for selective reporting and unclear risk for other biases, the assessment of the risk of bias is shown in Fig. 2.

3.4. Main outcomes

3.4.1. Total effective rate

Twenty-seven included trials reported total effective rate. Twenty-two RCTs[39-50,53-61,65] used acupuncture combined with WMCT and five trials[38,51,52,62,63] used acupuncture alone. The meta-analysis showed that the effect of acupuncture combined with WMCT was better than WMCT alone (RR=1.18, 95%CI:1.14–1.23, $P < 0.00001$) (Fig. 3A). In addition, meta-analyses showed that acupuncture alone was more effective than WMCT. (RR=1.19, 95%CI:1.07–1.32, $P = 0.001$) (Fig. 3A).

3.4.2. Pure-tone audiometric change

Seventeen studies reported changes in pure-tone audiometric thresholds. Fifteen studies[41,42,47-49,53,54,56,57,58-61,64,65] using acupuncture therapy combined with WMCT compared to WMCT showed that the combined therapy improved pure tone thresholds more than WMCT alone (MD=−10.71, 95%CI:−12.52 to −8.89, $P < 0.00001$) (Fig. 3B). Two studies[38,63] comparing acupuncture therapy with WMCT showed no significant difference between acupuncture alone and WMCT (MD=−5.45, 95%CI: −20.75 to 9.85, $P = 0.48$) (Fig. 3B).

3.4.3. Cure rate

Cure rate was an outcome measure in 26 trials. Twenty-one[39-50,53,55-57,58-61,65] RCTs using acupuncture combined with WMCT showed a higher cure rate for treated conditions than with WMCT alone (RD=0.15, 95%CI:0.11–0.19, $P < 0.00001$) (Supplement 2). A meta-analysis of five trials[38,51,52,62,63] showed that acupuncture treatment had a higher cure rate than WMCT treatment (RD=0.11, 95%CI:0.02–0.19, $P = 0.01$) (Supplement 2).

3.5. Other clinical symptoms assessment

3.5.1. Effective rate of tinnitus reduction

Four studies evaluated the effectiveness of acupuncture treatment in the disappearance of tinnitus symptoms in patients with SSNHL. Three studies[45,59,60] combined acupuncture with WMCT, and the meta-analysis showed that this combination had a higher effective rate in improving tinnitus than WMCT alone (RR = 1.12, 95% CI:1.01 to 1.24, $P = 0.03$) (Supplement 4A). One study[62] that applied acupuncture alone showed no significant difference from WMCT (RR = 1.09, 95% CI:0.93 to 1.26, $P = 0.29$).

3.5.2. Effective rate of vertigo reduction

Two studies were conducted to evaluate the efficacy of acupuncture in the management of vertigo symptoms associated with SSNHL. The findings of both studies indicated that there were no statistically significant differences between the treatment and control groups. One[45] employed acupuncture in conjunction with Western medicine (RR = 1.09, 95% CI:0.83 to 1.42, $P = 0.55$), while the other[62] utilized acupuncture in isolation (RR = 1.03, 95% CI:0.78 to 1.37, $P = 0.83$).

3.5.3. Incidence of adverse events

Only one study[56] was conducted to ascertain the incidence of adverse events in patients undergoing acupuncture in combination with WMCT as opposed to WMCT alone. There is no significant difference in the incidence of adverse reactions between the two groups (RR = 0.67, 95% CI:0.12 to 3.81, $P = 0.65$). It is unclear whether patients in the other studies experienced adverse reactions.

3.5.4. Publication bias

The funnel plot for the primary outcome exhibited an asymmetrical inverted funnel shape on both sides of the vertical line, indicating the potential presence of publication bias within the study. However, a quantitative assessment of this bias was precluded by the small sample size (less than 10 studies) in one of the included studies, which limited the statistical power for a robust evaluation (Supplement 3).

3.6. Sensitivity analysis

Sensitivity analyses were conducted separately for the total effective rate, pure-tone audiometric change, cure rate. The exclusion of any single study did not lead to a shift in the overall trend depicted by the forest plot, nor did it cause the results to contradict each other. This suggests that the findings of the studies are relatively consistent and robust.

For the groups assessing the effective rate of tinnitus reduction, sensitivity analysis was performed. In the "Acupuncture + WMCT vs WMCT" group, removal of one study[59] shifted the combined effect estimate to the left. The results indicated no difference in the effectiveness rate for tinnitus reduction between Acupuncture + WMCT and WMCT alone (RR=1.07, 95%CI:0.87–1.31, $P = 0.51$) (Supplement 4B), which was inconsistent with the meta-analysis results. Upon analysis, it was found that the removed study had a large sample size, significantly impacting the results. Therefore, the meta-analysis results concerning the effectiveness rate of tinnitus reduction for acupuncture therapy compared to WMCT should be approached with caution, and more high-quality research evidence is needed.

Table 1
Characteristics of included RCTs.

First author (Year) [Ref]	Sample size (M/F) Age (year) Course of disease		Interventions		Treatment duration	Outcome	Results
	T	C	T	C			
Chen 2010[41]	30(14/16) 40.3 1d-4w	30(15/15) 41.2 1d-4w	EA (SI19, GB2, TE17) +WMCT	WMCT	10d	1) Total effective rate 2) Pure-tone audiometric change	1) RR, 1.50[1.09,2.06] 2) MD, −14.80[−16.81, −12.79]
Cui 2019[56]	47(30/17) 40.7 2–14d	47(31/16) 41.2 1–15d	MA (GB7, GB2, TE21, TE17) +WMCT	WMCT	20d	1) Total effective rate 2) Pure-tone audiometric change 5) Adverse event	1) RR, 1.22[1.03,1.46] 2) MD, −11.30[−15.33, −7.27] 5) RR, 0.67[0.12,3.81]
Dong 2011[42]	30(17/13) 37.5 NR	30(14/16) 38.2 NR	MA (SI19, TE17, GB20, LI4, TE3, TE5, GB43) +WMCT	WMCT	14d	1) Total effective rate 2) Pure-tone audiometric change	1) RR, 1.27[1.01,1.61] 2) MD, −13.50[−16.54, −10.46]
Gao 2019[57]	55(29/26) 46.6 NR	55(30/25) 46.8 NR	MA (GV24, GV20, TE17, SI19) +WMCT	WMCT	28d	1) Total effective rate 2) Pure-tone audiometric change	1) RR, 1.18[1.03,1.35] 2) MD, −10.16[−11.46, −8.86]
Guo 2016[43]	63(31/32) 32.0 5–30d	63(30/33) 43.0 4–28d	EA (TE21, SI19, GB2, TE17, LI4, TE3) +WMCT	WMCT	>15d	1) Total effective rate	1) RR, 1.06[0.92,1.21]
Han 2011[44]	67(37/30) 41.0 4–42d	152(73/79) 39.0 3–39d	MA (erlong acupoint) +WMCT	WMCT	20d	1) Total effective rate	1) RR, 1.24[1.08,1.43]
Huang 2014[45]	59(33/26) 37.0 NR	53(29/24) 38.0 NR	MA (TE17, TE21, GB2, TE5, LI4, ST36, SP6, KI3, LR3, GB44) +WMCT	WMCT	20d	1) Total effective rate 3) Effective rate of tinnitus 4) Vertigo effective rate	1) RR, 1.20[0.99,1.44] 3) RR, 1.00[0.83,1.21] 4) RR, 1.09[0.83,1.42]
Jiang 2023[59]	66(22/44) 48.1 NR	66(28/38) 44.2 NR	MA (GB20, GB8, TE21, TE17, TE18, TE3, GB34) +WMCT	WMCT	12d	1) Total effective rate 2) Pure-tone audiometric change 3) Effective rate of tinnitus	1) RR, 1.15[0.95,1.39] 2) MD, −5.60[−12.48,1.28] 3) RR, 1.16[1.03,1.31]
Li 2020[39]	25 NR <15d	25 NR <15d	TN (SI19, GB2, TE21, TE17, GB12) +WMCT	WMCT	14d	1) Total effective rate	1) RR, 1.40[0.97,2.01]
Liang 2014[46]	30(16/14) 33.8 3.8d	30(12/18) 31.5 3.7d	EA (SI19, GB2, TE21, TE17, TE5, TE3, GB34, GB41) +WMCT	WMCT	28d	1) Total effective rate	1) RR, 1.30[0.97,1.74]
Luo 2022[48]	30(18/12) 50.5 6.3d	30(16/14) 51.3 7.4d	AA (LO6, TF4, CO10, AH6a, AT4) +WMCT	WMCT	10d	1) Total effective rate 2) Pure-tone audiometric change	1) RR, 1.39[1.00,1.94] 2) MD, −12.60[−22.67, −2.53]
Luo 2009[51]	30(15/15) 50.3 2.1d	30(15/15) 51.2 2.2d	EA (GB2, TE17, LI4, GB43, TE3)	WMCT	10d	1) Total effective rate	1) RR, 1.44[1.04,2.00]
Nie 2023[49]	41(25/16) 35.1 10.0d	41(24/17) 35.2 10.1d	MA (GV24, SI19, TE17, GV20) +WMCT	WMCT	24d	1) Total effective rate 2) Pure-tone audiometric change	1) RR, 1.22[1.02,1.45] 2) MD, −13.05[−17.15, −8.95]
Liu 2015[47]	30(18/12) 45.0 3–30d	30(21/9) 45.0 3–30d	MA (GV16, BL10, GB20, GB12, TE17, TE21, SI19, GB2) +WMCT	WMCT	28d	1) Total effective rate 2) Pure-tone audiometric change	1) RR, 1.27[1.01,1.61] 2) MD, −12.10[−15.14, −9.06]
Sun 2021[50]	50(25/25) 45.2 7.5m	50(20/30) 45.8 8.3m	MA (TE21, SI19, GB2, TE17, LR3, GB40, TE3) +WMCT	WMCT	60d	1) Total effective rate	1) RR, 1.20[1.03,1.39]
Wang 2021[58]	45(30/15) 57.0 16.1d	45(27/18) 56.4 16.3d	MA (GB20, BL10, TE16) +WMCT	WMCT	14d	1) Total effective rate 2) Pure-tone audiometric change	1) RR, 1.24[1.03,1.48] 2) MD, −14.37[−16.53, −12.21]
Wang 2017[60]	28(7/21) 43.6 4.5d	30(11/19) 43.8 7.0d	MA (TE21, SI19, GB2, TE17, TE3) +WMCT	WMCT	28d	1) Total effective rate 2) Pure-tone audiometric change 3) Effective rate of tinnitus	1) RR, 1.23[0.84,1.80] 2) MD, 5.30[−2.00,12.60] 3) RR, 1.25[0.89,1.74]
Wei 2022[61]	30(11/19) 34.8 12.0d	30(12/18) 35.4 11.2d	MA (GV20, GV24, EX-HN3, GV3, GV4) +WMCT	WMCT	28d	1) Total effective rate 2) Pure-tone audiometric change	1) RR, 1.17[0.93,1.48] 2) MD, −7.34[−11.00, −3.68]
Wang 2015[38]	30(14/16) 44.0 NR	30(15/15) 42.4 NR	MA (GB2, TE17, GB43, TE3)	WMCT	15d	1) Total effective rate 2) Pure-tone audiometric change	1) RR, 1.06[0.69,1.62] 2) MD, 1.51[−7.54,10.56]
Xie 2023[62]	100(46/54) 43.9 NR	100(49/51) 45.6 NR	TN (SI19, GB2, LO6)	WMCT	14d	1) Total effective rate 3) Effective rate of tinnitus 4) Vertigo effective rate	1) RR, 1.12[0.97,1.28] 3) RR, 1.09[0.93,1.26] 4) RR, 1.03[0.78,1.37]
Xu 2013a[40]	30(19/11) 44.2 1–5d	32(20/12) 45.5 2–4d	EA (TE21, SI19, GB2, TE17, LI4, TE5, TE3, GB43, LR3, SP6, GV20) +WMCT	WMCT	15d	1) Total effective rate	1) RR, 1.11[0.88,1.40]

(*continued on next page*)

Table 1 (*continued*)

First author (Year) [Ref]	Sample size (M/F) Age (year) Course of disease		Interventions		Treatment duration	Outcome	Results
	T	C	T	C			
Xu 2013b[52]	30(19/11) 40.5 3–45d	30(16/14) 40.5 3–45d	EA (GB12, SI19, GB2, TE17)	WMCT	30d	1) Total effective rate	1) RR, 1.35[1.02,1.79]
Yang 2016[53]	45(21/24) 37.9 14.6d	45(21/24) 37.0 13.7d	MA (sizhong, tounie, GB20, TE17, TE5) +WMCT	WMCT	30d	1) Total effective rate 2) Pure-tone audiometric change	1) RR, 1.10[0.98,1.23] 2) MD, −3.75[−8.25,0.75]
Yu 2016[63]	25 48.2 NR	25 48.2 NR	EA (TE21, SI19, GB2, TE17)	WMCT	18d	1) Total effective rate 2) Pure-tone audiometric change	1) RR, 1.21[0.88,1.69] 2) MD, −14.20[−27.98, −0.42]
Zhang 2024[54]	34(15/19) 38.4 ≦15d	34(16/18) 42.0 ≦15d	MA (GV20, EX-HN1, GV24, GB13, EX-HN3, GB2, TE5, TE3, GB34, LR3) +WMCT	WMCT	24d	1) Total effective rate 2) Pure-tone audiometric change	1) RR, 1.32[1.07,1.63] 2) MD, −17.00[−24.49, −9.51]
Zhang 2020[64]	50(24/26) 39.9 7.4d	50(22/28) 41.3 7.3d	EA (TE21, SI19, GB2, TE17, TE3, TE5, GB34, GB41, SP6) +WMCT	WMCT	28d	2) Pure-tone audiometric change	2) MD, −10.10[−14.01, −6.19]
Zhou 2020[65]	53(28/25) 54.3 9.3d	52(27/25) 54.1 9.2d	MA (TE21, SI19, GB2, TE17) +WMCT	WMCT	14d	1) Total effective rate 2) Pure-tone audiometric change	1) RR, 1.21[1.01,1.44] 2) MD, −11.78[−13.85, −9.71]
Zuo 2010[55]	36(22/14) 43.0 NR	32(19/13) 42.5 NR	MA (GB2, TE17, TE3, GB43) +WMCT	WMCT	14d	1) Total effective rate	1) RR, 1.08[0.93,1.26]

Abbreviations: T, Treatment group; C, Control group; MA, Manual acupuncture; EA, Electro acupuncture; AA, Auricular acupuncture; TN, thumb-tack needle; WMCT, Western Medicine Comprehensive Treatment;.
NR, No Report; d, days; w, weeks; m, month; M, male; F, female; MD, mean difference; RR, risk ratio.

4. Discussion

4.1. Summary of evidence

In our study, we conducted an extensive literature search of clinical trials published in both English and Chinese databases. There are three key points to consider in this study. Firstly, we included 28 trials that strictly adhered to the SSNHL standard treatment guidelines, making the conclusions more persuasive and applicable. Included studies used acupuncture combined with or without WMCT versus WMCT. WMCT mainly includes treatments such as steroids, hyperbaric oxygen, and psychotherapy. Steroids are considered a first-line medication for treating SSNHL, and hyperbaric oxygen therapy is also recommended by guidelines, therefore, this comparison is meaningful.

Secondly, we conducted a statistical analysis of the main acupuncture points used in all included studies. The selection of points was primarily around the ear area, with types mainly divided into auricular points (1 study) and body points (27 studies). The five most frequently used points were: TE17 > GB2 > SI19 > TE21 > TE3.

Thirdly, we used a more comprehensive set of subjective and objective outcome indicators to evaluate the effectiveness of acupuncture, including total effective rate, pure-tone audiometric change, cure rate, effective rate of tinnitus reduction, effective rate of vertigo reduction, and incidence of adverse events.

A total of 28 studies were included in the meta-analysis. Of these, 23 studies[39-50,53-61,64,65] employed a combination of acupuncture and WMCT, with the remaining five studies[38,51,52,62,63] utilising acupuncture alone in comparison to WMCT. All studies exhibited low methodological quality. Only one study[59] mentioned allocation concealment, two studies[49,54] described the use of double-blinding, one study[64] described the use of blinding for outcome assessment, the detection and perform bias of the remaining studies were unclear.

The findings of the meta-analysis indicated that the total effective rate, pure tone hearing threshold change, and cure rate of acupuncture in conjunction with WMCT were superior to those of WMCT alone. However, since most of the included studies had unclear risk of bias and were of low quality, the results should be treated with caution. In addition, the meta-analysis showed that acupuncture alone was superior to WMCT in terms of total effective rate and cure rate, but the number of studies included in the analysis was limited to five, and the quality of evidence for this outcome was deemed to be of low level. Acupuncture alone does not demonstrate a significant difference compared to Western medicine in enhancing pure tone hearing thresholds. In terms of effective rate of tinnitus reduction, the meta results indicated that acupuncture in conjunction with WMCT was more efficacious than WMCT. However, sensitivity analysis demonstrated that this result was not reliable, Acupuncture combined with WMCT does not outperform WMCT alone in reducing the incidence of vertigo. Regarding the safety assessment, only one study reported adverse reactions, and there was no statistical difference in the incidence of adverse reactions between acupuncture combined with WMCT and WMCT alone, thus we cannot draw a definitive conclusion about the relative safety of acupuncture therapy.

4.2. Possible mechanism of acupuncture treatment for sudden deafness

TCM posits that the main pathogenic mechanisms of sudden deafness are blood stasis and qi stagnation in the ear, blood deficiency, and malnourishment, which are dysfunctions of qi and blood. Patients often present with negative psychological states and sleep disorders. Some scholars believe that immune factors and mental states are important contributors to sudden deafness. Negative emotions can promote the release of catecholamines like adrenaline, which then alter hemorheology and cause inner ear microcirculatory dysfunction, creating a vicious cycle that severely affects patients' quality of life. The most frequently used primary acupoints in the 28 included studies were around the ear, and it is believed that stimulating specific auricular points can effectively excite the nerves around the ear auricle,[66-67] enhance nerve excitability,[68] increase capillary permeability in the inner ear, and improve microcirculation,[51] thereby aiding in the recovery of hearing function. In TCM, acupoints like TE17, GB2, SI19, TE21 are located on the Triple energizer Meridian of hand lesser yang, the Gallbladder Meridian of foot lesser yang, and the Small Intestine Meridian of hand greater yang—all of which pass through the ear. As stated in the "Huangdi Neijing," the

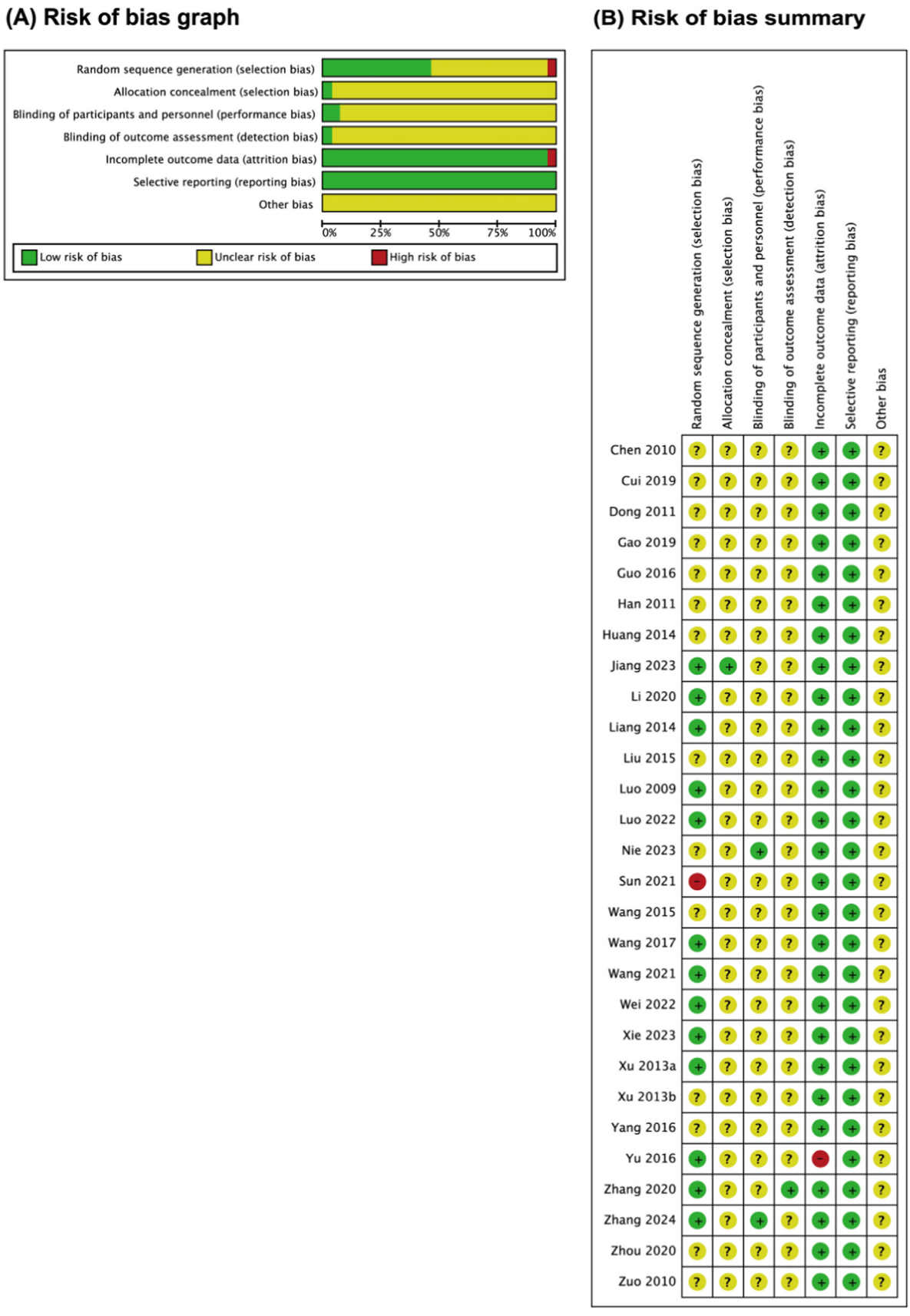
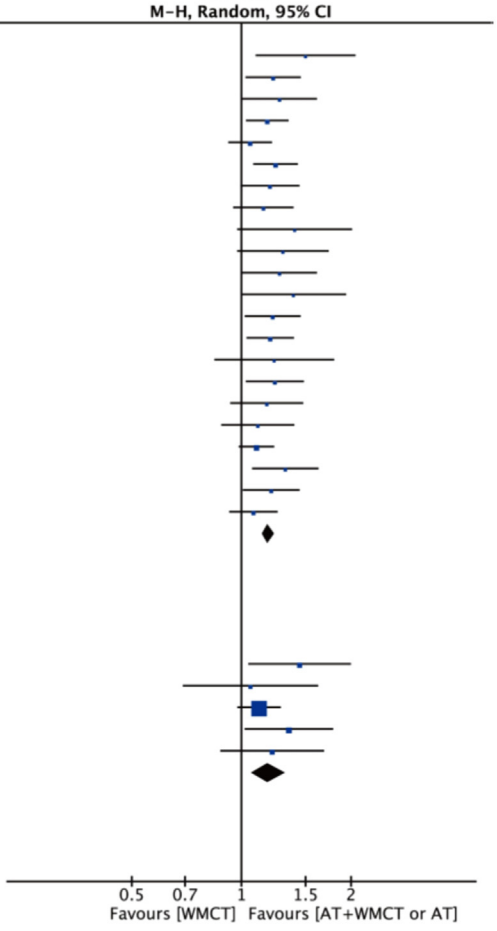


Fig. 2. Risk of bias (A) Graph. (B) Summary.

(A) Total effective rate

Study or Subgroup	AT+WMCT or AT Events	Total	WMCT Events	Total	Weight	Risk Ratio M-H, Random, 95% CI
Acupuncture+WMCT VS WMCT						
Chen 2010	27	30	18	30	1.6%	1.50 [1.09, 2.06]
Cui 2019	44	47	36	47	5.1%	1.22 [1.03, 1.46]
Dong 2011	28	30	22	30	2.8%	1.27 [1.01, 1.61]
Gao 2019	53	55	45	55	8.5%	1.18 [1.03, 1.35]
Guo 2016	56	63	53	63	8.1%	1.06 [0.92, 1.21]
Han 2011	58	67	106	152	7.8%	1.24 [1.08, 1.43]
Huang 2014	52	59	39	53	4.4%	1.20 [0.99, 1.44]
Jiang 2023	54	66	47	66	4.2%	1.15 [0.95, 1.39]
Li 2020	21	25	15	25	1.2%	1.40 [0.97, 2.01]
Liang 2014	26	30	20	30	1.8%	1.30 [0.97, 1.74]
Liu 2015	28	30	22	30	2.8%	1.27 [1.01, 1.61]
Luo 2022	25	30	18	30	1.4%	1.39 [1.00, 1.94]
Nie 2023	39	41	32	41	5.0%	1.22 [1.02, 1.45]
Sun 2021	48	50	40	50	6.9%	1.20 [1.03, 1.39]
Wang 2017	22	32	19	34	1.1%	1.23 [0.84, 1.80]
Wang 2021	42	45	34	45	4.6%	1.24 [1.03, 1.48]
Wei 2022	27	30	23	30	2.9%	1.17 [0.93, 1.48]
Xu 2013a	26	30	25	32	2.9%	1.11 [0.88, 1.40]
Yang 2016	44	45	40	45	12.2%	1.10 [0.98, 1.23]
Zhang 2024	33	34	25	34	3.5%	1.32 [1.07, 1.63]
Zhou 2020	48	53	39	52	4.8%	1.21 [1.01, 1.44]
Zuo 2010	34	36	28	32	6.6%	1.08 [0.93, 1.26]
Subtotal (95% CI)		**928**		**1006**	**100.0%**	**1.18 [1.14, 1.23]**
Total events	835		746			
Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 13.90$, df = 21 (P = 0.87); $I^2 = 0\%$						
Test for overall effect: Z = 8.46 (P < 0.00001)						
Acupuncture VS WMCT						
Luo 2009	26	30	18	30	10.6%	1.44 [1.04, 2.00]
Wang 2015	18	30	17	30	6.1%	1.06 [0.69, 1.62]
Xie 2023	85	100	76	100	58.8%	1.12 [0.97, 1.28]
Xu 2013b	27	30	20	30	14.2%	1.35 [1.02, 1.79]
Yu 2016	19	23	17	25	10.3%	1.21 [0.88, 1.69]
Subtotal (95% CI)		**213**		**215**	**100.0%**	**1.19 [1.07, 1.32]**
Total events	175		148			
Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 3.25$, df = 4 (P = 0.52); $I^2 = 0\%$						
Test for overall effect: Z = 3.18 (P = 0.001)						



(B) Pure-tone audiometric change

Study or Subgroup	AT+WMCT or AT Mean	SD	Total	WMCT Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Acupuncture+WMCT VS WMCT								
Chen 2010	28.8	4.3	30	43.6	3.6	30	9.0%	-14.80 [-16.81, -12.79]
Cui 2019	31.2	9.6	47	42.5	10.3	47	6.8%	-11.30 [-15.33, -7.27]
Dong 2011	28.7	6.3	30	42.2	5.7	30	7.9%	-13.50 [-16.54, -10.46]
Gao 2019	17.8	4.02	55	27.96	2.86	55	9.6%	-10.16 [-11.46, -8.86]
Jiang 2023	58.3	15.81	66	63.9	23.71	66	4.1%	-5.60 [-12.48, 1.28]
Liu 2015	28.2	5.8	30	40.3	6.2	30	7.9%	-12.10 [-15.14, -9.06]
Luo 2022	40.9	18.5	30	53.5	21.2	30	2.5%	-12.60 [-22.67, -2.53]
Nie 2023	27.12	8.12	41	40.17	10.66	41	6.7%	-13.05 [-17.15, -8.95]
Wang 2017	23.8	17.5	28	18.5	9.4	30	3.8%	5.30 [-2.00, 12.60]
Wang 2021	29.4	4.44	45	43.77	5.91	45	8.8%	-14.37 [-16.53, -12.21]
Wei 2022	41.38	6.94	30	48.72	7.53	30	7.2%	-7.34 [-11.00, -3.68]
Yang 2016	30.7	10.57	45	34.45	11.22	45	6.2%	-3.75 [-8.25, 0.75]
Zhang 2020	17.65	4.35	50	27.75	13.4	50	6.9%	-10.10 [-14.01, -6.19]
Zhang 2024	29	13.11	34	46	18	34	3.7%	-17.00 [-24.49, -9.51]
Zhou 2020	27.49	5.34	53	39.27	5.46	52	8.9%	-11.78 [-13.85, -9.71]
Subtotal (95% CI)			**614**			**615**	**100.0%**	**-10.71 [-12.52, -8.89]**
Heterogeneity: $Tau^2 = 8.50$; $Chi^2 = 65.76$, df = 14 (P < 0.00001); $I^2 = 79\%$								
Test for overall effect: Z = 11.55 (P < 0.00001)								
Acupuncture VS WMCT								
Wang 2015	38.06	19.19	30	36.55	16.46	30	55.7%	1.51 [-7.54, 10.56]
Yu 2016	38.5	23.28	23	52.7	25.43	25	44.3%	-14.20 [-27.98, -0.42]
Subtotal (95% CI)			**53**			**55**	**100.0%**	**-5.45 [-20.75, 9.85]**
Heterogeneity: $Tau^2 = 88.03$; $Chi^2 = 3.49$, df = 1 (P = 0.06); $I^2 = 71\%$								
Test for overall effect: Z = 0.70 (P = 0.48)								

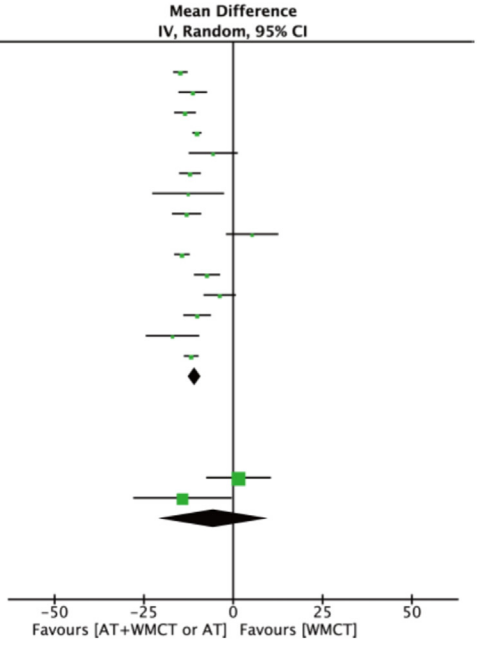


Fig. 3. Forest plot of (A) Total effective rate. (B) Pure-tone audiometric change.

meridians govern the areas they traverse. TCM holds that Shaoyang is the pivotal hub for the rise and fall of qi, and selecting local and Shaoyang meridian points can regulate the body's qi mechanism, clear the meridians and blood of the ear, promote the circulation of qi and blood in the ear, and thus return to a balanced state of yin and yang to facilitate the restoration of hearing.

4.3. Limitations

Firstly, although this study collated 28 trials, the sample sizes were relatively small and all derived from China, which may contribute to a strong source bias and impact the methodological quality of the literature, resulting in language bias. Secondly, due to small sample sizes in each subgroup, we were unable to conduct multilevel meta-analysis and other clinically characteristic methods, thus the source of heterogeneity remains unclear. Clinical heterogeneity exists due to variations in acupuncture methods, Western medicine applications, acupuncture points selected, needling depth, and non-uniform acupuncture courses. Thirdly, although the 28 studies were consistent in their descriptions of efficacy, it was not possible to eliminate the potential bias introduced by the use of audiometers and assessors. Fourthly, regarding safety assessment, only one study reported adverse reactions, and the remaining 27 studies did not mention any, making it impossible to ascertain the relative safety of acupuncture compared to WMCT. Finally, despite our extensive search, there is still a certain degree of publication bias in this study, because only 5 of the included studies used acupuncture alone. In future studies, further verification should be carried out if the sample size is sufficient. In conclusion, the findings should be considered with caution.

4.4. Conclusions

Considering the cost and perceived benefits of acupuncture, its use as an alternative or adjunct treatment for SSNHL is supported. However, the included randomized controlled trials have many methodological flaws, and the overall quality of research and literature is low. Therefore, future work will focus on conducting multi-center, large-sample, high-quality RCT studies.

Author contributions

Wenqi Ren participated in all aspects of the study: conceptualization, design, study registration, data extraction and analysis, and drafting of the manuscript. Haixia Deng and Bo Tao were involved in the selection of studies, data extraction, and assessment of methodological quality. Ren, Deng, and Tao all participated in the revision of the manuscript.

Conflict of interest

The authors declares that there is no conflict of interest in the publication of this article.

Funding

There was no funding for this study.

Ethical statement

Not applicable.

Data availability

All data utilized and analyzed in the course of this study are available in public databases.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.imr.2024.101087.

Supplement 1. Acupoint frequency charts for all included studies.

Supplement 2. Forest plot of cure rate.

Supplement 3. Funnel plot of total effective rate.

Supplement 4. Forest plot of (A) Tinnitus reduction rate. (B) Sensitivity analysis of tinnitus reduction rate.

Supplement 5. PRISMA checklist.

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