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Correlation between oral zinc sulfate supplementation and auditory recovery in patients with sudden sensorineural hearing loss

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Abstract: Sudden sensorineural hearing loss (SSNHL) is an otologic emergency with limited treatment options. This study evaluated the efficacy of oral zinc sulfate supplementation, alongside conventional dexamethasone treatment, on auditory recovery in SSNHL patients. A retrospective cohort study included 230 SSNHL patients treated between June 2021 and June 2023. Patients received either conventional treatment (intravenous dexamethasone, n=102) or oral zinc sulfate in addition to conventional treatment (n=128). Audiological parameters, serum zinc levels, and quality of life (SF-36) were assessed at baseline and after two weeks. The data was analyzed using SPSS 22.0 software and the R software package version 3.0.2. Baseline characteristics and audio logical parameters were comparable between groups. The zinc sulfate group showed significant improvements in pure tone thresholds at 250 Hz, 500 Hz, 1000 Hz and 2000 Hz, as well as speech discrimination scores, compared to the conventional treatment group ($p<0.05$ for all). Serum zinc levels increased significantly in the zinc sulfate group ($p<0.001$). Quality of life, both physical and mental health scores, significantly improved in the zinc sulfate group ($p<0.05$). Oral zinc sulfate supplementation, as an adjunct to conventional dexamethasone treatment, significantly enhances audiological recovery, elevates serum zinc levels and improves quality of life in SSNHL patients. Zinc sulfate shows promise as an adjunctive treatment for SSNHL.

Keywords: Sudden sensorineural hearing loss, zinc supplementation, dexamethasone, auditory recovery, serum zinc levels, quality of life.

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INTRODUCTION

Sudden sensorineural hearing loss (SSNHL) is defined as a rapid-onset hearing impairment occurring within a 72-hour period, characterized by a decrease in hearing of at least 30 dB over at least three contiguous frequencies (Bayoumy *et al.*, 2020). SSNHL serves as a medical emergency requiring prompt intervention to maximize the potential for hearing recovery. SSNHL affects approximately 5-30 per 100,000 individuals annually worldwide, with a slightly higher incidence in women and older adults (Ponzetto *et al.*, 2020). Despite its clinical importance, the etiopathogenesis of SSNHL remains largely idiopathic in a significant proportion of cases, which complicates the development of standardized treatment protocols (Joshua *et al.*, 2022). Conventional management typically includes corticosteroids, antiviral agents, hyperbaric oxygen therapy and vasodilators, but their efficacy is variable and often incomplete (Doweck *et al*., 2022).

In recent years, there is growing interest in the role of micronutrients in managing SSNHL, particularly focusing on their potential to ameliorate oxidative stress a known contributor to cochlear damage (Wood *et al*., 2021). Oxidative stress leads to the production of reactive oxygen species (ROS) that harm cochlear structures, including hair cells, supporting cells and vasculature (Joshua *et al*., 2022). This pathophysiological insight serves as a foundation for considering antioxidants, such as zinc, as therapeutic adjuncts in SSNHL (Yang *et al*., 2011; Saba *et al*., 2023). Zinc is a crucial trace element that plays vital roles in enzymatic functions, cellular metabolism, immune modulation and maintenance of cellular integrity, particularly through its involvement in antioxidant defense mechanisms (Yang *et al*., 2011).

Emerging evidence has linked zinc deficiency with auditory dysfunction, highlighting its potential relevance in otologic conditions (Simoes *et al*., 2023). Several experimental and clinical studies suggest that zinc supplementation can enhance the antioxidant defense system, reduce inflammation and modulate cellular repair processes all of which are pertinent to mitigating cochlear injury and promoting auditory recovery (Waissbluth *et al*., 2022; Ranjdoost *et al*., 2023). Despite these promising findings, the clinical efficacy of zinc supplementation in SSNHL remains an area of active investigation, warranting robust comparative studies to establish its therapeutic value definitively (Herrera *et al*., 2019).

This study aims to contribute to the existing knowledge by examining the correlation between oral zinc sulfate

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supplementation and auditory recovery in patients with SSNHL. Conducted as a retrospective cohort study, this research includes 230 patients treated between June 2021 and June 2023. Participants were categorized into two treatment groups: One receiving conventional corticosteroid therapy and the other receiving both conventional therapy and oral zinc sulfate supplementation. The primary endpoint of this study is to evaluate the extent of auditory recovery, as measured by changes in pure-tone audiometry thresholds and speech discrimination scores. Secondary endpoints include examining changes in serum zinc levels, treatment compliance, quality of life scores and hearing recovery outcomes.

MATERIALS AND METHODS

Case selection

This retrospective cohort study included 230 patients with sudden hearing loss, admitted to the First Affiliated Hospital of Henan University of Chinese Medicine in Zhengzhou, China between June 2021 and June 2023. The study collected demographic information through patient records, encompassing baseline characteristics, initial hearing parameters, changes in serum zinc levels, hearing parameters after two weeks of treatment, hearing recovery outcomes in the control group, treatment compliance, and quality of life scores. The sample size was calculated using the Cochran formula, taking α=0.05, -β=0.9 and considering a dropout rate of 20%, the sample size was calculated to be 100 cases. The required sample size for both groups is at least 200 patients. A convenience sampling method was used to select the patients who presented to our hospital within the study period.

Since this retrospective study utilized anonymized patient data and posed no potential harm or impact on patient care, informed consent was waived. This waiver, along with the study itself, received approval from our hospital's ethics review board and ethics committee, adhering to the regulatory and ethical guidelines for retrospective research.

Inclusion, exclusion and grouping criteria

Inclusion Criteria: The study included patients who met the following criteria: aged between 20 and 70 years, no history of mental illness, normal cognitive function and the ability to cooperate with treatments and exams. Patients also had to meet the diagnostic criteria (Herrera *et al*., 2019) for sudden deafness as confirmed by electro-audiometry, impedance mastoid CT and MRI of the internal auditory canal. Additionally, all patients had unilateral ear lesions and were fully informed about the study, consenting to participate voluntarily. Exclusion Criteria: The study excluded individuals with drug-induced sudden deafness, congenital ear canal deformities, or coexisting organic lesions, such as acoustic neuroma. Grouping Criteria: Patients were divided into two groups based on their treatment plans: a conventional treatment group (n=102) and a zinc sulfate oral supplement group (n=128).

Treatment methods

The conventional treatment group received intravenous injections of dexamethasone. Each day, 10mg of dexamethasone (Suicheng Pharmaceutical, national standard H41021254) was administered with 10ml of 0.9% sodium chloride solution via intravenous drip. The dosage was reduced by 5mg every three days. In addition to the standard treatment, the zinc sulfate oral supplement group received one daily dose of zinc sulfate oral solution (Wuhan Jun'an Pharmaceutical Co., Ltd., national standard H2006714148).

Baseline audiological parameters

All audiograms were conducted under standard hearing conditions in a soundproof chamber. The Pure Tone Average was calculated using frequencies of 500, 1000, 2000 and 4000 Hz. When available, the Speech Discrimination Score was also analyzed. This study recorded the initial audiogram taken immediately after the onset of hearing loss.

Serum zinc levels

This study employed flame atomic absorption spectrophotometry to measure serum zinc levels. Using aseptic techniques, a whole blood sample of 2-5 milliliters was drawn from the patient's elbow vein or another suitable site. The sample was placed in a test tube without anticoagulant and allowed to coagulate naturally. The test tube was then centrifuged at approximately 3000 rpm for 10-15 minutes to separate the serum.

A precise amount of the separated serum was transferred into a colorimetric tube using a pipette. An appropriate amount of hydrochloric acid or nitric acid and pure water was added to dilute the sample according to the required ratio. Zinc standard solutions with various concentration gradients were prepared and passed through the atomic absorption spectrophotometer (Shimadzu, Japan).

The diluted serum samples were also analyzed using the atomic absorption spectrophotometer (Shimadzu, Japan). The absorbance of each sample was recorded, and the sample concentrations were calculated by referencing a standard curve.

Quality of life assessment

The SF-36 Quality of Life Scale was utilized to assess various aspects of patients' quality of life, including social functioning, self-management, mental health and overall life functioning. Higher scores on this scale indicate a higher quality of life. The scale demonstrated a Cronbach's alpha coefficient of 0.814 (Prince and Stucken, 2021).

ETHICAL APPROVAL

This study was approved by the First Affiliated Hospital of Henan University with approval No.ZY-20200509.

STATISTICAL ANALYSIS

Measurement data are presented as mean ± standard deviation or median interquartile range, depending on whether they follow a normal distribution. Categorical data are expressed in frequencies and percentages. Unpaired t-tests were used to compare continuous variables between the two groups. Univariate and multivariate logistic regression analyses were performed to calculate the odds ratio (OR) and 95% confidence interval (CI) for each parameter treated as a continuous variable. Statistical significance was set at P<0.05. All statistical analyses were conducted using SPSS 22.0 software (SPSS Inc., Chicago, IL, USA) and the R software package version 3.0.2 (Free Software Foundation, Inc., Boston, MA, USA).

RESULTS

Baseline Characteristics

A total of 230 patients were enrolled in the study, with 102 patients receiving conventional treatment and 128 patients receiving oral zinc sulfate supplementation. Baseline characteristics were comparable between the two groups (table 1). These results indicate that the two groups were well-matched in terms of baseline characteristics, minimizing the risk of confounding variables affecting the study outcomes.

Baseline audiological parameters

The baseline audiological parameters were similar between the conventional treatment group and the zinc sulfate oral supplementation group, indicating well-matched groups (fig. 1). The pure tone thresholds at various frequencies showed no significant differences between the groups: at 250 Hz, the pure tone threshold was 45.3±10.4 dB in the conventional group and 44.9±10.6 dB in the zinc sulfate group (P=0.776); at 500 Hz, it was 48.1±11.2 dB and 47.8±11.0 dB, respectively (P=0.836); at 1000 Hz, it was 51.5±12.3 dB versus 51.1±12.5 dB (P=0.81) and at 2000 Hz, the thresholds were 55.2±13.1 dB in the conventional group and 54.8±13.3 dB in the zinc sulfate group (P=0.818). The speech discrimination scores also showed no significant difference, with a mean score of 58.3±14.5% in the conventional group and 57.1±14.7% in the zinc sulfate group (P=0.538). These data confirm that the initial audiological conditions of the patients were comparable between the two treatment groups, ensuring that any observed differences in auditory recovery could be attributed to the interventions rather than baseline discrepancies.

Changes in serum zinc levels

The changes in serum zinc levels were analyzed to assess the impact of zinc sulfate oral supplementation in patients with SSNHL (table 2). At baseline, the serum zinc levels were similar between the conventional treatment group (10.2±1.5mg/dL) and the zinc sulfate oral supplementation group (10.1±1.6mg/dL), with no significant difference (t=0.506, P=0.613). However, after 2 weeks of treatment, a significant increase in serum zinc levels was observed in the zinc sulfate group (12.8±1.7 mg/dL) compared to the conventional group (10.3±1.4 mg/dL), with a t-value of 12.197 and a P<0.001. Within-group comparisons showed a statistically insignificant change in serum zinc levels in the conventional group over the 2-week period (t=0.492, P=0.312), whereas the zinc sulfate group exhibited a significant increase in serum zinc levels (t=3.085, P<0.001). These results confirm that oral zinc sulfate supplementation effectively elevates serum zinc levels in patients, while no significant change is observed with conventional treatment alone.

Audiological parameters after 2 weeks of treatment

After 2 weeks of treatment, significant improvements were noted in the audiological parameters for patients receiving zinc sulfate oral supplementation compared to those receiving conventional treatment (fig. 2). In the zinc sulfate group, the pure tone thresholds at 250 Hz decreased to 39.2±10.1 dB, significantly lower than the 42.0±10.3 dB observed in the conventional group (P=0.04). At 500 Hz, the pure tone threshold was 41.8± 10.8 dB for the zinc sulfate group, compared to 44.9±11.1 dB in the conventional group (P=0.034). For the 1000 Hz frequency, thresholds were 44.5±11.9 dB in the zinc sulfate group and 48.2±12.2 dB in the conventional group (P=0.022). The most pronounced difference was seen at 2000 Hz, with the zinc sulfate group showing a threshold of 48.2±12.7 dB, significantly lower than the 53.9±13.0 dB in the conventional group (P<0.001). Additionally, speech discrimination scores improved more in the zinc sulfate group, with a mean score of 68.7±14.1%, compared to 63.2±13.4% in the conventional group (P=0.003). These findings indicate that oral zinc sulfate supplementation leads to more substantial auditory recovery across multiple frequencies and improved speech discrimination in patients with SSNHL.

Hearing recovery outcomes

The hearing recovery outcomes between the conventional treatment group and the zinc sulfate oral supplementation group demonstrated some notable differences. The severity of tinnitus before treatment was similar between the two groups, with a mean score of 7.2±1.4 in the conventional group and 7.3±1.5 in the zinc sulfate group (P=0.594) (fig. 3). After treatment, both groups showed a reduction in tinnitus severity, with mean scores of 5.9±1.3 in the conventional group and 5.6±1.1 in the zinc sulfate group; however, this reduction was not statistically significant (P=0.065).

Table 1: Baseline Characteristics

Parameter	Conventional (n=102)	Zinc Sulfate Oral Supplement (n=128)	*P*
Age (years)	45.2±13.3	44.9±12.7	0.862
Gender (Male/Female)	56/46	68/60	0.892
Duration of Hearing Loss (days)	5±2	5±3	0.996
Previous Treatment (Corticosteroids/ Antivirals/Other) (Yes/No)	21/81	28/100	0.94
Baseline Audiogram (dB)	52.1±10.2	51.5±10.5	0.663

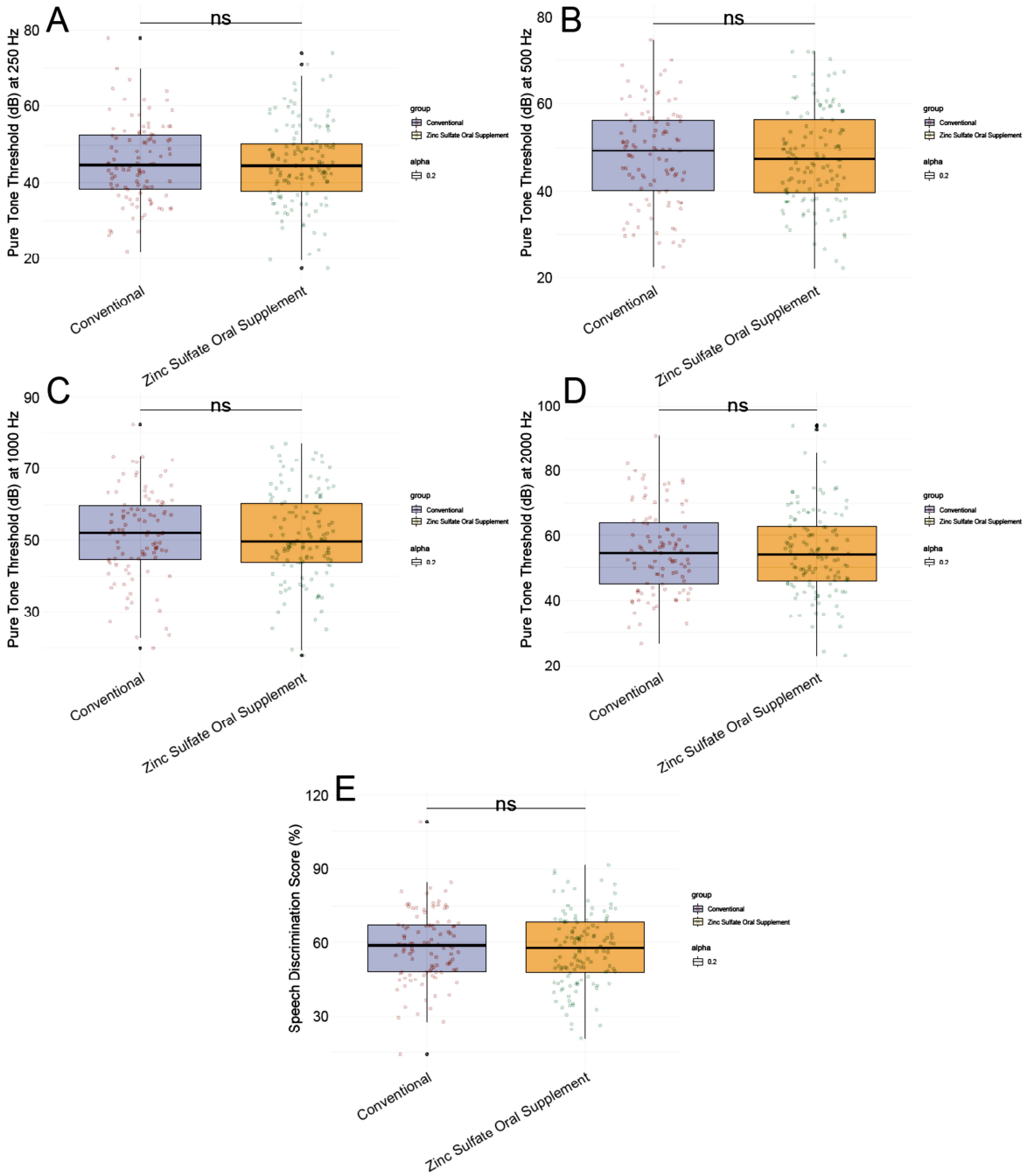

Fig. 1: Baseline Audiological Parameters. (A) Pure Tone Threshold (dB) at 250 Hz; (B) Pure Tone Threshold (dB) at 500 Hz; (C) Pure Tone Threshold (dB) at 1000 Hz; (D) Pure Tone Threshold (dB) at 2000 Hz; (E) Speech Discrimination Score (%). ns: no significant difference.

Table 2: Changes in Serum Zinc Levels

Parameter	Conventional (n=102)	Zinc Sulfate Oral Supplement (n=128)	*t*	*P*
Baseline Serum Zinc Level (mg/dL)	10.2±1.5	10.1±1.6	0.506	0.613
2 Weeks Serum Zinc Level (mg/dL)	10.3±1.4	12.8±1.7	12.197	<0.001
t	0.492	13.085		
P	0.312	< 0.001		

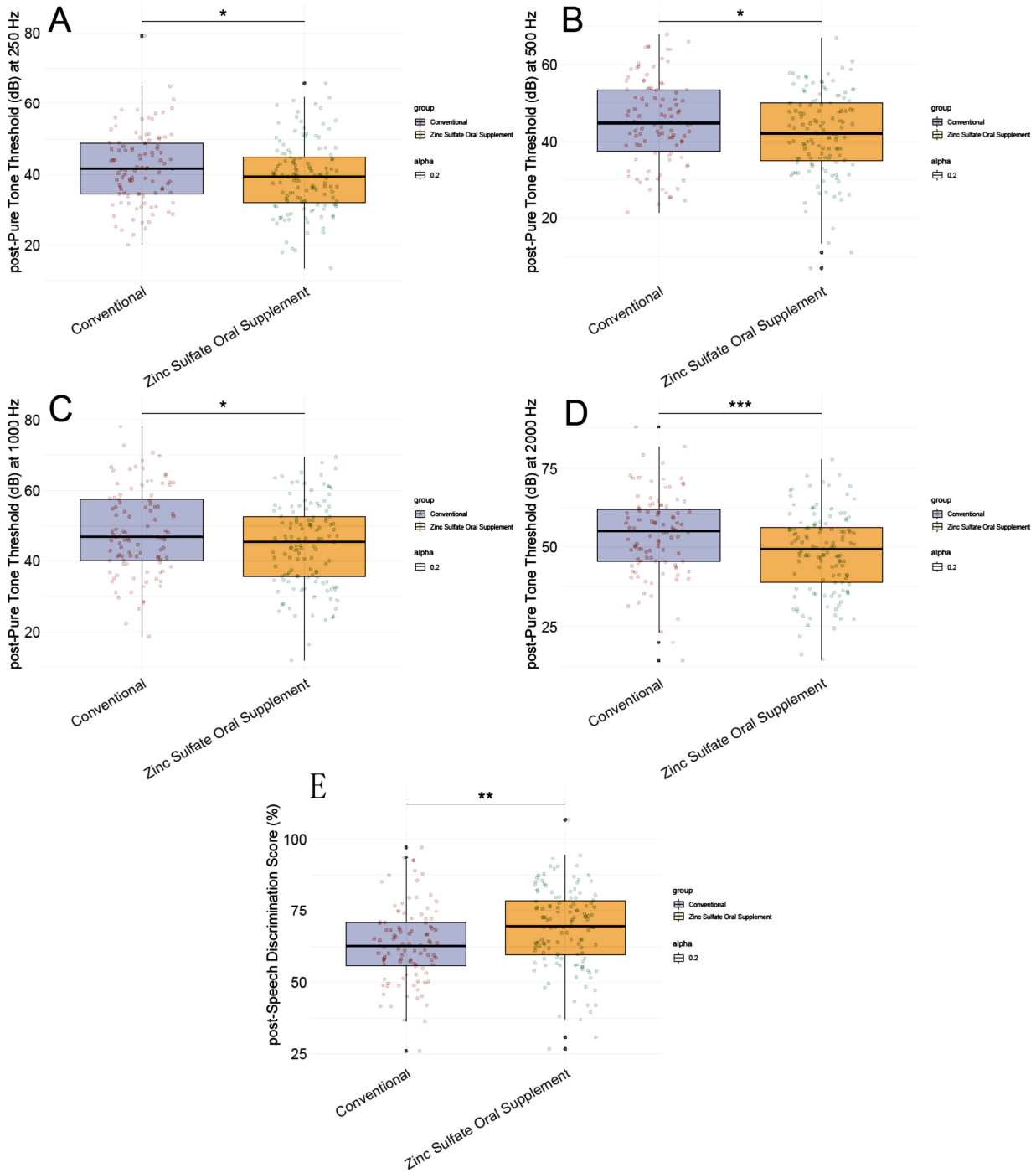

Fig. 2: Audiological Parameters After 2 Weeks of Treatment (A) Pure Tone Threshold (dB) at 250 Hz; (B) Pure Tone Threshold (dB) at 500 Hz; (C) Pure Tone Threshold (dB) at 1000 Hz; (D) Pure Tone Threshold (dB) at 2000 Hz; (E) Speech Discrimination Score (%). *: *P*<0.05; **: *P*<0.01; ***: *P*<0.001.

Table 3: Assessment of adverse effects

Parameter	Conventional (n=102)	Zinc Sulfate Oral Supplement (n=128)	*P*
Nausea (Y/N)	12/90	17/111	0.885
Vomiting (Y/N)	3/99	6/122	0.737
Metallic Taste Disturbance (Y/N)	5/97	8/120	0.879
Headache (Y/N)	8/94	12/116	0.862
Diarrhea (Y/N)	2/99	5/123	0.641

Table 4: Compliance with Treatment

Parameter	Conventional (n=102)	Zinc Sulfate Oral Supplement (n=128)	*P*
Number of Missed Doses	2.3±0.7	2.4±0.7	0.286
Overall Treatment Compliance (%)	87.4±10.2	85.9±10.5	0.276

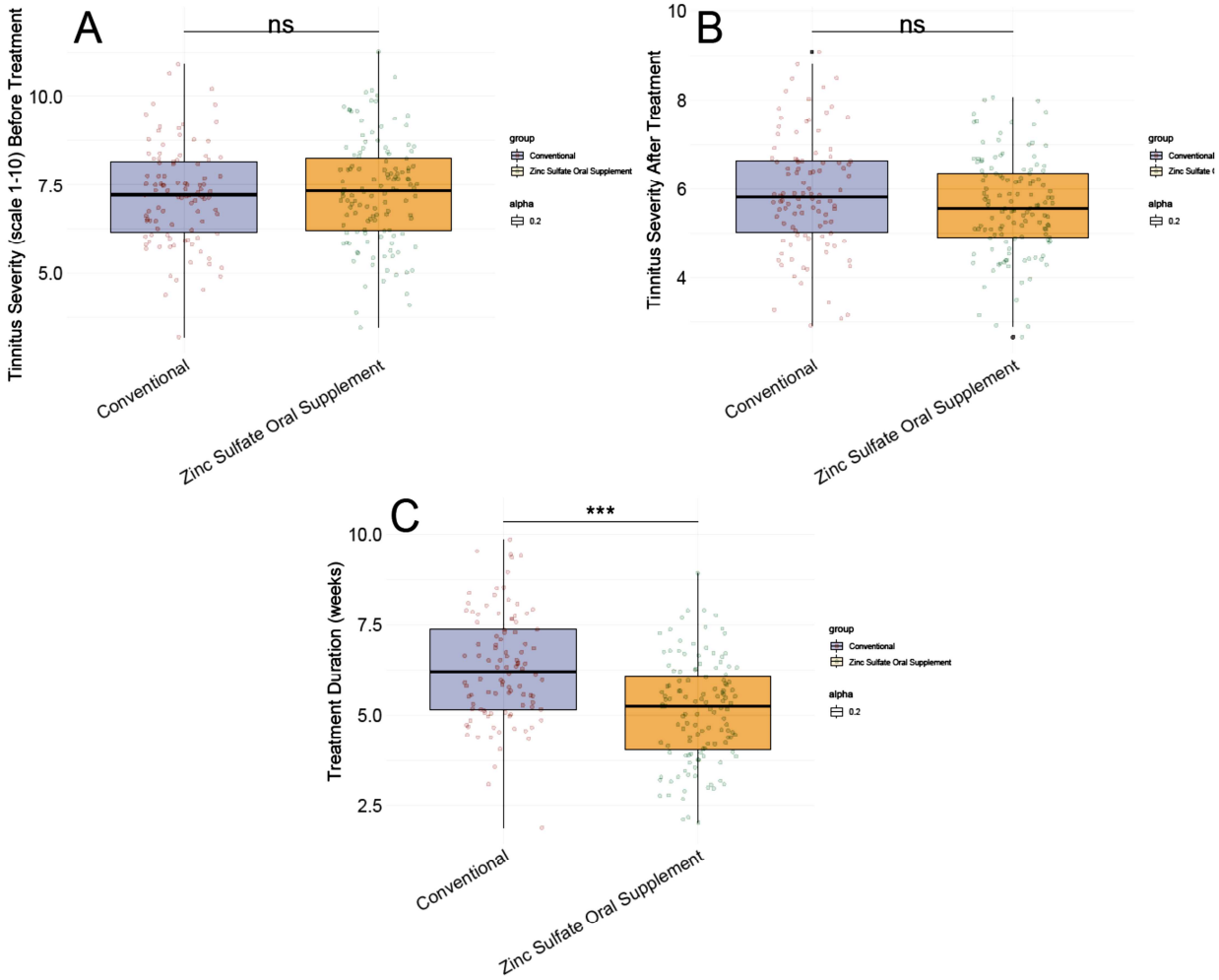

Fig. 3: Hearing Recovery Outcomes. (A) Tinnitus Severity (scale 1-10) Before Treatment; (B) Tinnitus Severity After Treatment; (C) Treatment Duration (weeks). ns: no significant difference; ***: $P<0.001$.

The duration of treatment was significantly shorter in the zinc sulfate group (5.1±1.4 weeks) compared to the conventional group (6.3±1.5 weeks), with a $P<0.001$.

Assessment of adverse effects revealed no significant differences between the groups: nausea was reported by 12 patients in the conventional group and 17 patients in the zinc sulfate group ($P=0.885$); vomiting was reported by 3 and 6 patients, respectively ($P=0.737$); metallic taste disturbance by 5 and 8 patients, respectively ($P=0.879$); headache by 8 and 12 patients, respectively ($P=0.862$); and diarrhea by 2 and 5 patients, respectively ($P=0.641$) (table 4). These results indicate that zinc sulfate supplementation can reduce the duration of treatment without increasing the incidence of adverse effects and shows a trend towards greater reduction in tinnitus

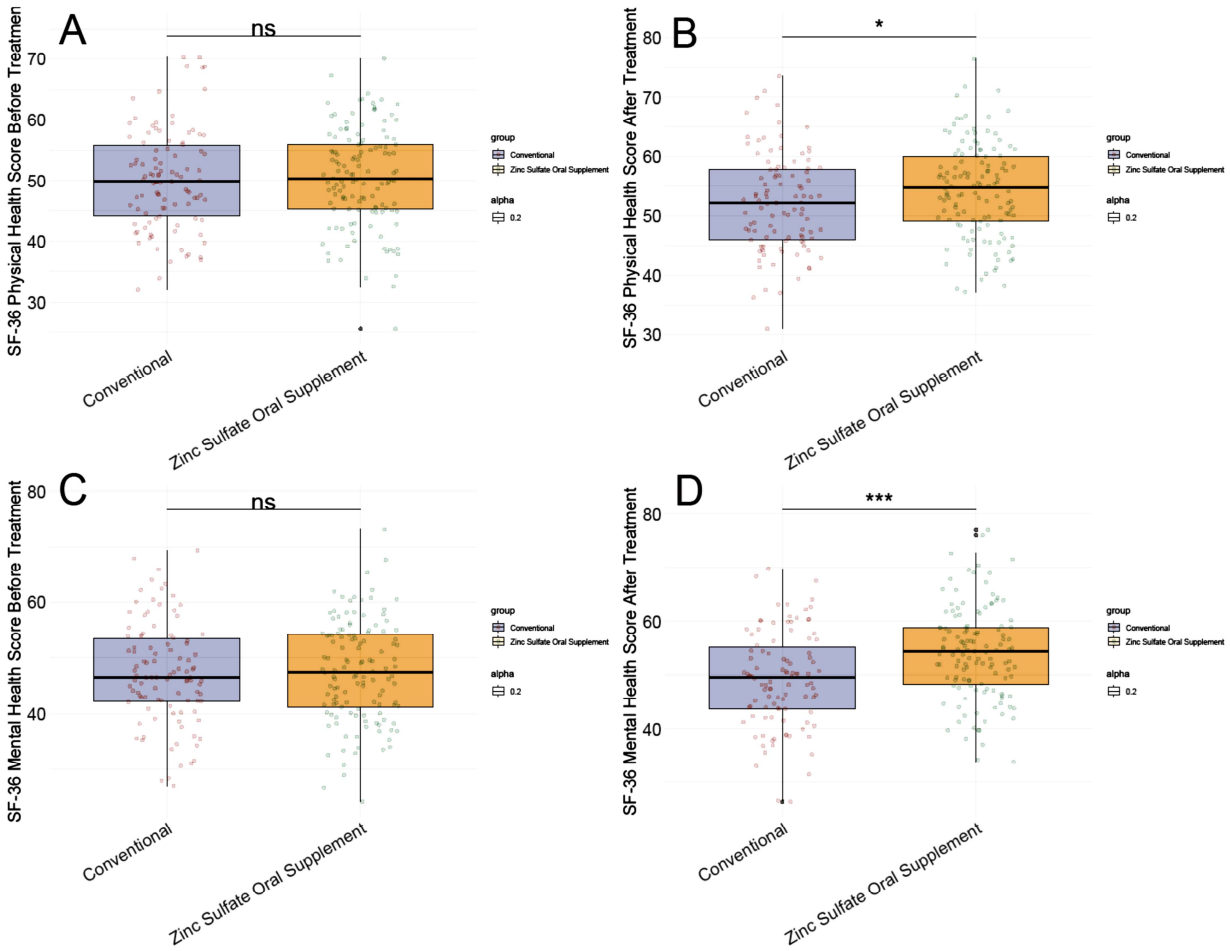

Fig. 4: Changes in Quality of Life Scores. (A) SF-36 Physical Health Score Before Treatment; (B) SF-36 Physical Health Score After Treatment; (C) SF-36 Mental Health Score Before Treatment; (D) SF-36 Mental Health Score After Treatment. *: $P<0.05$; ***: $P<0.001$; ns: no significant difference.

severity, although this did not reach statistical significance.

Compliance with treatment

Compliance with treatment was assessed by medication log reviewed by a nurse in both the conventional treatment group and the zinc sulfate oral supplementation group and showed no significant differences between the two groups. The average number of missed doses was comparable, with 2.3±0.7 missed doses in the conventional group and 2.4±0.7 missed doses in the zinc sulfate group ($P=0.286$). Overall treatment compliance, measured as a percentage, was also similar between the groups, with the conventional group exhibiting an 87.4±10.2% compliance rate and the zinc sulfate group showing an 85.9 ±10.5% compliance rate ($P=0.276$). These findings indicate that patient adherence to the treatment regimen was high and consistent across both treatment groups, suggesting that compliance did not significantly impact the outcome measures evaluated in this study.

Changes in quality of life scores

The impact of treatment on quality of life, as measured by the SF-36 scores, was evaluated for both the conventional treatment group and the zinc sulfate oral supplementation group (fig. 4). Baseline SF-36 physical health scores were similar between the two groups, with the conventional group scoring 50.2±8.3 and the zinc sulfate group scoring 50.5±8.1 ($P=0.785$). After treatment, there was a significant improvement in the physical health scores in the zinc sulfate group (54.3±7.9) compared to the conventional group (52.1±8.2), with a P value of 0.04. Similarly, the baseline SF-36 mental health scores showed no significant difference between the two groups, with scores of 47.3±9.1 in the conventional group and 47.5±9.0 in the zinc sulfate group ($P=0.868$). However, after treatment, the mental health scores improved markedly in the zinc sulfate group, reaching 54.1±8.6 compared to 49.2±8.9 in the conventional group ($P<0.001$). These results suggest that oral zinc sulfate supplementation not only enhances physical health outcomes but also significantly improves mental health compared to conventional treatment in patients with SSNHL.

DISCUSSION

This retrospective cohort study comprehensively investigates the impact of oral zinc sulfate supplementation on auditory recovery in patients with sudden sensorineural hearing loss (SSNHL). The primary objective was to compare the efficacy of oral zinc sulfate supplementation with conventional treatment alone over a two-week period. We focused on baseline characteristics, audiological outcomes, serum zinc levels, hearing recovery, quality of life, and treatment compliance. Our results reveal significant insights into the benefits of zinc supplementation and contribute to the growing body of literature emphasizing the role of micronutrients, particularly zinc, in managing SSNHL.

Efficacy of zinc in auditory recovery

Zinc's role as an essential trace element involved in numerous biochemical processes, including antioxidant defense systems, is well-established. Its importance extends to neural plasticity and repair mechanisms, making it a potential candidate for treating conditions like SSNHL (Yang *et al*., 2011; Hunchaisri *et al*., 2015) Numerous studies have investigated the potential benefits of zinc supplementation in improving hearing outcomes. A analysis concluded that zinc supplementation, as an adjunct to corticosteroids, significantly enhanced hearing recovery in patients with SSNHL, particularly in those with lower baseline serum zinc levels (Yang *et al*., 2011). Our findings demonstrate that the zinc sulfate supplementation group exhibited significantly greater improvements in audiological parameters across multiple frequencies, notably at 2000 Hz, where the reduction in pure tone threshold was most pronounced. Additionally, the speech discrimination scores were substantially better in the zinc supplementation group compared to the conventional treatment group.

These audiological improvements can likely be attributed to zinc's role in protecting against oxidative stress-mediated damage within the cochlea. The cochlea is particularly susceptible to reactive oxygen species (ROS) due to its high metabolic activity and limited antioxidant defenses (Heilen *et al*., 2020; Xie and Wu, 2020). Zinc plays a critical role in stabilizing cell membranes, modulating synaptic function, and regulating apoptosis through the activity of super oxide dismutase (SOD) and metallothioneins (Hunchaisri *et al*., 2015; Doo *et al*., 2020). Supplementing zinc may thus enhance endogenous antioxidant defenses, mitigate ROS-induced damage, and promote recovery of the auditory nerve and hair cells.

Serum zinc levels and auditory outcomes

Our analysis of serum zinc levels showed a substantial increase in the zinc supplementation group two weeks post-treatment, correlating with improved hearing outcomes. This finding underscores the importance of adequate zinc bioavailability for its protective effects to manifest within the auditory system. The lack of significant change in serum zinc levels in the conventional treatment group further emphasizes that the observed benefits are specifically tied to zinc supplementation rather than other nonspecific factors.

The elevation in serum zinc levels indicates successful absorption and systemic availability of the supplement. Given zinc's involvement in numerous enzymatic processes, its systemic increase likely supports more efficient cellular repair and neuroprotection mechanisms within the inner ear (Al-Azzawi and Stapleton, 2023; Niknazar *et al*., 2023). Higher zinc levels can enhance the activity of zinc-dependent enzymes and proteins, bolster cellular repair processes, and improve the resilience of auditory structures against ongoing oxidative damage (Qian *et al*., 2021).

Quality of life and treatment compliance

Quality of life (QoL) assessments using the SF-36 questionnaire revealed significant improvements in both physical and mental health domains for the zinc supplementation group. These findings suggest that the benefits of zinc extend beyond auditory recovery, impacting overall well-being and mental health. The noticeable improvement in mental health scores can be partly attributed to the reduction in hearing-related distress and increased communication abilities, which are critical for social functioning and psychological health (Tien and Young, 2021; Barron *et al*., 2023).

Moreover, the enhanced physical health scores suggest that zinc's systemic benefits may contribute to overall physiological well-being, further corroborating its role in cellular health and repair. Zinc's function in immune modulation, wound healing, and anti-inflammatory processes could provide broader health benefits, enhancing patient resilience and perceived quality of life (Riera *et al*., 2020; Young, 2020).

Potential mechanisms

Several potential mechanisms underpin the beneficial effects of zinc on SSNHL. First, Zinc's pivotal role in the antioxidant defense system, particularly through SOD activity, helps mitigate oxidative stress (Cavallaro *et al*., 2023). Zinc supplementation can potentiate the antioxidant capacity of cells, reducing ROS-induced cochlear damage (Yang *et al*., 2023). Second, Zinc contributes to neuroprotective processes by stabilizing neuronal membranes, regulating neurotransmitter release, and modulating synaptic plasticity (LeGros and Murphy-Lavoie, 2020; Chaushu *et al*., 2023). These functions are crucial for the recovery of auditory nerve function after sudden hearing loss (Wang *et al*., 2021). Third, Zinc exhibits anti-inflammatory properties by inhibiting the release of pro-inflammatory cytokines and modulating immune responses (Deewani and Siddiqui, 2023).

Reducing inflammation within the cochlea and auditory pathways can facilitate recovery and reduce secondary damage (Prince and Stucken, 2021). Fourth, Zinc is integral to DNA synthesis, cell division, and apoptosis regulation (Simani *et al*., 2022). By enhancing cell proliferation and inhibiting excessive apoptosis in the cochlea, zinc aids in the regenerative processes essential for hearing recovery (Murray *et al*., 2022).

Implications for future research and clinical practice

While our findings underscore the potential benefits of zinc supplementation in the management of SSNHL, several areas warrant further investigation. First, future studies should examine the long-term benefits and potential risks associated with chronic zinc supplementation. Understanding the sustainability of auditory improvements and overall health impacts is crucial for developing long-term treatment guidelines. Second, further research is needed to determine the optimal dosing regimen for zinc supplementation, balancing efficacy with safety. Ensuring adequate, but not excessive, zinc levels is essential to avoid potential adverse effects associated with zinc overload. Third, detailed mechanistic studies exploring the cellular and molecular pathways through which zinc exerts its protective effects in the auditory system are necessary. Such studies can identify specific targets for therapeutic interventions and optimize treatment protocols. Fourth, investigating the synergistic effects of zinc with other micronutrients, pharmacological agents, or novel therapeutics could enhance treatment efficacy. Combination therapies may provide more comprehensive neuroprotection and improve patient outcomes. Fifth, identifying patient subgroups that benefit most from zinc supplementation can refine treatment strategies. Factors such as age, severity of hearing loss and baseline zinc levels might influence individual responses to treatment.

Limitations

While our study provides valuable insights into the role of oral zinc sulfate supplementation in treating SSNHL, several limitations must be considered. Firstly, as a retrospective cohort study, it inherently carries the risk of selection bias and cannot establish causality. The sample size, although substantial, remains limited and may not wholly represent the broader SSNHL patient population. Additionally, the study's reliance on self-reported quality of life measures could introduce subjective bias. We did not control for potential confounding factors such as patients' nutritional status, comorbidities, or concurrent medications, which could influence the outcomes. Furthermore, the short follow-up period of two weeks is insufficient to assess long-term effects and sustainability of auditory recovery.

CONCLUSION

Our study demonstrates that oral zinc sulfate supplementation significantly enhances auditory recovery in patients with SSNHL compared to conventional treatment alone. These benefits are likely mediated through zinc's antioxidant, neuroprotective, anti-inflammatory, and cellular repair mechanisms. Additionally, improved quality of life and mental health outcomes in the zinc group highlight the extensive systemic benefits of zinc. These findings support the integration of zinc supplementation into treatment protocols for SSNHL, with further research needed to optimize dosing, elucidate mechanisms, and explore combination therapies.

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