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Evaluating Inflammatory Markers in Sudden Sensorineural Hearing Loss: The Neutrophil-To-Lymphocyte Ratio, The Systemic Immune Inflammation Index, and The Pan Immune Inflammation Value as Prognostic Tools

Ani Sensörinöral İşitme Kaybında İnflamatuar Belirteçlerin Değerlendirilmesi: Nötrofil-Lenfosit Oranı, Sistemik İmmün İnflamasyon İndeksi ve Pan İmmün İnflamasyon Değerinin Prognostik Rolü

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Abstract: This research sought to explore the association between sudden sensorineural hearing loss and inflammation by analyzing key inflammatory indicators, such as the neutrophil-to-lymphocyte ratio, the systemic immune inflammation index , and the pan-immune-inflammation value .This retrospective study was conducted at a tertiary medical center's otolaryngology department between 2016 and 2021, involving sudden sensorineural hearing loss patients diagnosed and treated during the specified period. Two hundred sudden sensorineural hearing loss patients and 200 healthy controls were included. Inflammatory markers were calculated from complete blood count data. Audiological evaluations categorized patients based on hearing loss severity. Patients with sudden sensorineural hearing loss demonstrated significantly elevated levels of inflammatory markers compared to the control group: NLR: 3.43 ± 2.99 vs. 2.10 ± 1.28, $p < 0.001$; SII: 953.72 ± 855.02 vs. 561.74 ± 355.60, $p < 0.001$; and PIV: 523.84 ± 455.48 vs. 342.48 ± 245.47, $p < 0.001$. ROC analysis revealed superior diagnostic performance for the systemic immune inflammation index, and the pan-immune-inflammation value, with AUC values of 0.693 and 0.648, respectively, compared to NLR (AUC = 0.692). This study provides novel insights into the relationship between inflammation and sudden sensorineural hearing loss. Elevated neutrophil-to-lymphocyte ratio, the systemic immune inflammation index, and the pan-immune-inflammation value levels in sudden sensorineural hearing loss patients suggest their potential as valuable indicators for understanding the etiology and predicting outcomes of sudden sensorineural hearing loss . The study underscores the need for further research to validate these findings and explore the underlying mechanisms connecting inflammation to sudden sensorineural hearing loss.
Keywords: Sudden sensorineural hearing loss, Inflammatory markers, SII, PIV, Hearing assessments

Özet: Bu araştırma, nötrofil lenfosit oranını , sistemik immün-inflamasyon indeksi ve panimmun inflamasyon değeri gibi temel enflamatuar göstergeleri analiz ederek ani işitme kaybı ve enflamasyon arasındaki ilişkiyi araştırmayı amaçlamıştır.Bu retrospektif çalışma, 2016-2021 yılları arasında üçüncü basamak bir tıp merkezinin kulak burun boğaz bölümünde, belirtilen dönemde tanı konulan ve tedavi edilen ani işitme kaybı hastalarını içerecek şekilde yürütülmüştür. 200 ani işitme kaybı tanılı hasta ve 200 sağlıklı kontrol dahil edilmiştir. Enflamatuvar belirteçler tam kan sayımı verilerinden hesaplanmıştır. Odyolojik değerlendirmeler hastaları işitme kaybı şiddetine göre kategorize edilmiştir. Ani işitme kaybı hastalar kontrol grubuna kıyasla anlamlı derecede yüksek enflamatuar belirteç seviyeleri göstermiştir: NLR: 3.43 ± 2.99 vs. 2.10 ± 1.28, $p < 0.001$; SII: 953.72 ± 855.02 vs. 561.74 ± 355.60, $p < 0.001$; ve PIV: 523.84 ± 455.48 vs. 342.48 ± 245.47, $p < 0.001$. ROC analizi, NLR (AUC = 0,692) ile karşılaştırıldığında sırasıyla 0,693 ve 0,648 AUC değerleri ile sistemik immün-inflamasyon indeksi ve panimmun inflamasyon değeri için üstün tanısal performans ortaya koymuştur.Bu çalışma enflamasyon ve ani işitme kaybı arasındaki ilişkiye dair yeni bilgiler sunmaktadır. Ani işitme kaybı hastalarında yüksek nötrofil lenfosit oranını sistemik immün-inflamasyon indeksi ve panimmun inflamasyon değeri düzeyleri, ani işitme kaybının etiyolojisini anlamak ve sonuçlarını öngörmek için değerli göstergeler olarak potansiyellerini göstermektedir. Çalışma, bu bulguları doğrulamak ve enflamasyonu ani işitme kaybına bağlayan altta yatan mekanizmaları keşfetmek için daha fazla araştırma yapılması gerektiğinin altını çizmektedir.
Anahtar Kelimeler: Ani sensörinöral işitme kaybı, Enflamatuar belirteçler, SII, PIV, İşitme değerlendirmeleri

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1. Introduction

Sudden sensorineural hearing loss (SSNHL) is characterized by a rapid onset of hearing loss greater than 30 dB across at least three consecutive audiometric frequencies within 72 hours. This condition, which typically occurs in one ear, remains a significant clinical challenge due to its often-unknown etiology and unpredictable prognosis [1,2].

SSNHL prognosis varies, with one-third of patients fully recovering, another third partially improving, and the rest showing little to no recovery. Outcomes are influenced by factors such as initial hearing loss severity, vertigo, treatment timing, unaffected ear condition, and audiogram patterns [3]. These variables underscore the complexity of SSNHL and the challenges in predicting patient outcomes.

The exact cause of SSNHL is often unclear, with fewer than 30% of patients receiving a definitive diagnosis. The annual incidence ranges from 5 to 27 cases per 100,000 individuals, with approximately 66,000 new cases annually in the U.S. Despite its prevalence, over 70% of cases remain idiopathic. Proposed mechanisms include viral or bacterial infections, vascular compromise, cochlear cellular stress, and autoimmune disorders. Nutritional deficiencies, such as low vitamin D and B12, may increase oxidative stress and inflammation susceptibility. Additionally, traumatic events, including otologic surgery, temporal bone fractures, acoustic trauma, and barotrauma, can trigger SSNHL. Despite these associations, idiopathic cases dominate, highlighting the need for further research into underlying mechanisms [2,4-7].

A key area of investigation is the link between viral infections and SSNHL. Viruses such as herpes simplex, HIV, hepatitis, measles, rubella, mumps, Lassa virus, and enteroviruses have been implicated in its pathogenesis. Postmortem studies of SSNHL patients have shown degeneration of the organ of Corti and stria vascularis, consistent with viral labyrinthitis. These findings suggest that virus-induced inflammation may contribute to cochlear damage, a theory supported by the observed effectiveness of steroid therapy in many SSNHL cases [5-9].

Inflammatory markers have recently gained increasing attention as potential diagnostic and prognostic tools in SSNHL. Markers such as the neutrophil-to-lymphocyte ratio (NLR) and platelet-to-lymphocyte ratio (PLR) have been widely studied in various inflammatory and malignant conditions, and their relevance in SSNHL is now being recognized. These markers provide a quick, cost-effective means of assessing systemic inflammation, which could be linked to the onset and progression of SSNHL [10,11].

Recently, novel indices such as the Systemic Immune-Inflammation Index (SII) and Pan Immune-Inflammation Value (PIV) have emerged as comprehensive measures of systemic immune-inflammatory status. The SII is calculated by multiplying the platelet count by the neutrophil count and dividing by the lymphocyte count, while the PIV incorporates neutrophil, platelet, and monocyte counts in its calculation, divided by the lymphocyte count [12,13].

The present study investigated the association between inflammation and SSNHL by analyzing SII and PIV derived from routine complete blood count (CBC) tests. Using these cost-effective and widely available markers provides a novel approach to understanding the inflammatory mechanisms underlying SSNHL and their potential diagnostic and prognostic implications. To the best of our knowledge, this is one of the first studies to explore the utility of SII and PIV in SSNHL patients, contributing new insights into this complex and multifactorial condition.

2. Material ve Methods

Study Design

This retrospective observational study was carried out at the otolaryngology department of a tertiary medical center over a five-year period, from 2016 to 2021. The primary aim was to evaluate patients diagnosed with SSNHL and investigate the relationship between inflammatory markers and disease progression. The study adhered to rigorous ethical standards, with approval granted by the Izmir Bakıircay University Local Ethics Committee [No 1141, Research No 1121 at 24.08.2023].

All procedures and protocols were conducted in alignment with the principles outlined in the Declaration of Helsinki, ensuring the research maintained the highest standards of ethical integrity. Informed consent was obtained from every participant prior to their inclusion in the study. In the department, informed consent was always obtained from SSNHL patients for treatment agreement purposes and for using their information in research activities. Patients were assured that their data would remain confidential and anonymized throughout the

research process, and steps were taken to safeguard their privacy.

Additionally, the study emphasized transparency and impartiality. No conflicts of interest were identified, and all relevant ethical guidelines were strictly followed to ensure the validity and reliability of the findings. This meticulous approach aimed to establish a robust framework for analyzing the role of systemic inflammation in SSNHL while upholding the integrity of the research.

Patient Selection

The study included 200 patients with a confirmed diagnosis of SSNHL and 200 healthy individuals as a control group. The inclusion criteria for the SSNHL group required patients to present with hearing loss of more than 30 dB in at least three consecutive audiometric frequencies within three days and no identifiable external cause. Participants in the control group were healthy individuals undergoing routine preoperative evaluations for elective surgeries, such as septoplasty, with no history of otologic or systemic conditions.

Exclusion criteria for both groups included acute or chronic inflammatory conditions, active infections, renal or hepatic failure, chronic obstructive pulmonary disease, connective tissue disorders, inflammatory bowel diseases, malignancies, and otologic diseases, including chronic otitis media, otosclerosis, acoustic trauma, or Meniere's disease. Patients with a history of recent otologic surgery or head trauma were also excluded to ensure homogeneity of the study population.

All SSNHL patients underwent detailed clinical evaluations, including magnetic resonance imaging (MRI) with gadolinium enhancement, to exclude structural or other underlying otologic pathologies. Treatment for SSNHL consisted of a standardized regimen of oral prednisolone, initiated at 1 mg/kg per day and tapered gradually over 10 days. Laboratory investigations included a complete blood count (CBC) performed prior to treatment initiation. Relevant hematologic and biochemical data were extracted from patient medical records for analysis. These measures ensured the systematic assessment of inflammatory and clinical parameters across both groups.

Control Group

The control group consisted of 200 healthy individuals scheduled for elective septoplasty or septorhinoplasty, with routine preoperative blood tests conducted during anesthesia evaluations. These individuals were carefully screened to exclude any inflammatory conditions, malignancies, or chronic diseases, ensuring their suitability as controls.

Auditory Assessment

In a controlled clinical setting, hearing thresholds were evaluated using a calibrated audiometer (AC 40, Interacoustics, Denmark). The measurements were conducted in compliance with established audiological standards to ensure accuracy and reproducibility. Pure-tone audiometry was performed to determine air and bone conduction thresholds at standard frequencies of 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz, following established audiological standards. This comprehensive assessment ensured accuracy and reproducibility, forming the basis for evaluating hearing function and categorizing patients by hearing loss severity.

The severity of hearing loss was classified according to the American Speech-Language-Hearing Association (ASHA) criteria [14,15]. Patients were stratified into five distinct categories based on their average pure-tone threshold across key frequencies (500 Hz, 1 kHz, 2 kHz, and 4 kHz):

- **Mild Hearing Loss:** Average thresholds between 16–40 dB HL.
- **Moderate Hearing Loss:** Average thresholds between 41–55 dB HL.
- **Moderately Severe Hearing Loss:** Average thresholds between 56–70 dB HL.
- **Severe Hearing Loss:** Average thresholds between 71–90 dB HL.
- **Profound Hearing Loss:** Thresholds exceeding 91 dB HL.

These classifications allowed for a detailed grouping of patients according to the severity of their auditory impairment. The categorization was critical for analyzing the relationship between hearing loss severity and associated inflammatory markers. Additionally, these standardized criteria ensured consistency across all evaluations, enabling meaningful comparisons within the study cohort and with external research.

The audiological profiles derived from this assessment formed a foundation for the subsequent analysis of clinical outcomes, aiding in identifying

potential prognostic factors related to sudden sensorineural hearing loss.

Laboratory Analysis

Complete blood count (CBC) tests were performed for all participants. Blood samples were collected into EDTA (ethylenediaminetetraacetic acid) containing tubes and analyzed using an automated hematology analyzer (Beckman Coulter LH 780 Hematology Analyzer, USA). The Systemic Immune-Inflammation Index (SII) and Pan Immune-Inflammation Value (PIV) were calculated using CBC parameters.

Statistical Analysis

Data analysis was performed using SPSS 20.0 (IBM, Chicago, IL, USA). Continuous variables were reported as mean ± SD, and categorical data as frequencies (percentages). The Mann–Whitney U test compared non-normally distributed groups, and the Chi-square test assessed categorical relationships. Univariate logistic regression evaluated factor effects. ROC curve analysis determined the predictive accuracy of preoperative eosinophil counts and the SII index, identifying optimal thresholds and diagnostic metrics. Statistical significance was set at $p < 0.05$

3. Results

Demographic and Baseline Characteristics

The study cohort included 200 patients diagnosed with SSNHL and 200 healthy controls. The mean age of the SSNHL patients was 42.47 ± 12.02 years, closely matching the control group's mean age of 42.43 ± 9.7 years, with no statistically significant difference between the groups ($p = 0.971$). The gender distribution was also comparable, with the SSNHL group consisting of 88 females and 112 males, while the control group comprised 97 females and 103 males ($p = 0.133$). These findings indicate that age and gender were not confounding factors in the analysis (Table 1).

Clinical Presentation of SSNHL Patients

Among the SSNHL group, hearing loss affected the right ear in 102 patients' left ear in 98 patients. Additional symptoms included tinnitus, reported in 105 patients (52.5%), and dizziness, experienced by 47 patients (23.5%). The severity of hearing impairment varied widely, with ten patients classified as having mild hearing loss, 41 as moderate, 47 as moderately severe, 54 as severe, and 48 as profound. On average, patients presented with symptoms 4.04 ± 3.32 days after the onset of hearing loss. These clinical characteristics provide insights into the heterogeneity of SSNHL in terms of symptomatology and severity (Table 1). The two groups had no significant differences regarding comorbidities such as diabetes, hypertension, or cardiovascular diseases. Lifestyle factors, including smoking, alcohol consumption, and other unhealthy habits, were also comparable between the groups, with no statistically significant differences observed ($p > 0.05$).

Table 1. Demographic and CBC results of the groups

Variables	Patient Group	Control Group	p
Age	42.47 ±12.02	42.43 ±9.7	=0.971
Sex			=0.133
Female	112	97	
Male	88	103	
WBC (10^3/u)	8.79±2.76	7.96±2.34	=0.001
Neutrophil (10^3/u)	6,08±2.46	4.31±1.25	=0.00
Lymphocyte (10^3/u)	2.23±0.87	2.33±0.75	=0.21
Monocyte (10^3/u)	0.60±0.26	0.60±0.18	=0.946
Platelet (10^3/u)	279.15±66.04	268±58.83	=0.081
SII (10^9/L)	953.72±855.02	561.74±355.60	=0.00
PIV	523.84±455.48	342.48±245.47	=0.00
NLR	3.43±2.99	2.10±1.28	=0.00

Table 2. Diagnostic Accuracy of SII, NLR, and PIV Parameters in SSNHL Patients: ROC Analysis

Parameters	Cut off	AUC (95% CI)	Sensitivity (95% CI)	Specificity (95% CI)	p
SII	626.96	0.693	58.5	76	<0.001
PIV	392.75	0.648	51.5	73	<0.001

Clinical Features of SSNHL Patients

Inflammatory Marker Analysis

SII: The mean SII value in the SSNHL group was significantly elevated (953.72 ± 855.02) compared to the control group (561.74 ± 355.60), with a p-value < 0.001. This indicates a marked systemic inflammatory response in patients with SSNHL.

PIV: Similarly, PIV values were notably higher in SSNHL patients (523.84 ± 455.48) than in controls (342.48 ± 245.47), demonstrating statistical significance ($p < 0.001$). These findings further emphasize the presence of heightened immune-inflammatory activity in the patient group.

NLR: The mean NLR was also significantly elevated in SSNHL patients (3.43 ± 2.99) compared to the control group (2.10 ± 1.28), with a p-value < 0.001. This highlights NLR as a potential indicator of the inflammatory burden associated with SSNHL.

Hematologic Parameters

WBC Count: Patients with SSNHL had a significantly higher mean WBC count (8.79 ± 2.76) compared to controls (7.96 ± 2.34; $p = 0.001$).

Neutrophil Count:A similar trend was observed for neutrophil counts, which were elevated in the SSNHL group (6.08 ± 2.46) relative to controls (4.31 ± 1.25; $p < 0.001$).

Other Parameters: No significant differences were detected in lymphocyte, monocyte, or platelet counts between the two groups, suggesting that these components may not be the primary drivers of the observed inflammatory response (Table 1).

Diagnostic Utility of Inflammatory Markers

SII: Receiver Operating Characteristic (ROC) analysis revealed a cut-off value of 626.96 for SII, with a sensitivity of 58.5% and specificity of 76%. The area under the curve (AUC) was 0.693 ($p < 0.001$), indicating moderate diagnostic accuracy.

PIV: For PIV, the ROC analysis identified a cut-off value of 392.75, with a sensitivity of 51.5% and specificity of 73%. The AUC for PIV was 0.648 ($p < 0.001$), reflecting its utility as a diagnostic marker.

NLR: The optimal cut-off value for NLR was determined to be 2.38, with sensitivity and specificity values of 54.5% and 76.5%, respectively. The AUC was 0.692 ($p < 0.001$), comparable to SII's.

Visualization of Diagnostic Performance

Figure 1 presents the ROC curves for SII, PIV, and NLR, illustrating their predictive capabilities in distinguishing SSNHL patients from healthy controls.

Table 2 details the ROC analysis results, including sensitivity, specificity, and AUC values.

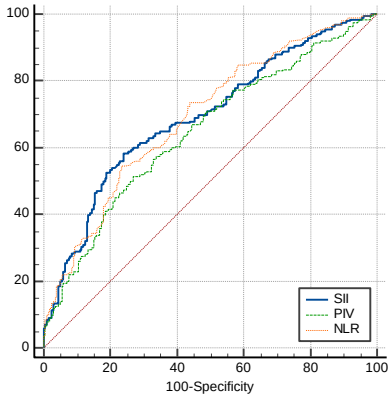

Figure 1. ROC Curves Illustrating the Diagnostic Performance of SII, NLR, and PIV Parameters in SSNHL Patients Compared to Controls

1. Discussion

Key Findings

This research highlights the significant involvement of systemic inflammation in developing SSNHL. Elevated levels of key inflammatory markers, such as the SII, PIV, and NLR, were observed in patients with SSNHL compared to healthy controls. These findings underscore a potential link between increased inflammatory activity and the pathophysiological processes underlying SSNHL, suggesting that inflammation may be pivotal in triggering or exacerbating this condition.

Elevated SII, PIV, and NLR levels in SSNHL patients may indicate an underlying immune response or inflammatory cascade. Systemic inflammation, a common factor in various conditions, could cause vascular or cochlear damage, leading to auditory impairment in SSNHL [11-13]. These results align with prior studies suggesting that inflammation may disrupt the delicate microenvironment of the inner ear, affecting cochlear homeostasis and contributing to sudden hearing loss.

The elevated SII, PIV, and NLR levels highlight their potential as diagnostic and prognostic markers in SSNHL. These indices, integrating neutrophils, lymphocytes, monocytes, and platelets, provide a comprehensive, rapid, and non-invasive measure of systemic inflammation. Our findings align with Jeon et al., who also emphasized the prognostic value of biomarkers like low NLR, monocyte counts, and fibrinogen levels in SSNHL [16]. Both studies underline the significant role of systemic inflammation in the pathogenesis and recovery of SSNHL, with our results further supporting the utility of NLR, SII, and PIV as robust indicators in clinical settings.

These findings highlight the critical role of inflammation in the pathogenesis of SSNHL, emphasizing the potential for targeted anti-inflammatory therapies as a treatment strategy. In this study, significantly elevated levels of systemic inflammatory markers were observed in SSNHL patients compared to controls, including NLR (3.43 ± 2.99 vs. 2.10 ± 1.28, $p < 0.001$), SII (953.72 ± 855.02 vs. 561.74 ± 355.60, $p < 0.001$), and PIV (523.84 ± 455.48 vs. 342.48 ± 245.47, $p < 0.001$). Early identification of these markers may help clinicians tailor treatments, improving outcomes and preventing irreversible hearing loss. Moreover, the diagnostic performance of these markers, with AUC values of 0.693 (SII), 0.648 (PIV), and 0.692 (NLR), supports their inclusion in routine clinical evaluations for SSNHL. Their use could enhance diagnostic accuracy, assist in stratifying disease severity, and provide valuable prognostic insights into recovery potential. Our study complements the findings of Andrea Frosolini et al., who identified elevated CRP levels (pooled mean difference: 1.07, 95% CI: 0.03–2.11) as a diagnostic marker in SSNHL patients [17]. Similarly, we observed significantly higher inflammatory indices in SSNHL patients compared to controls: NLR (3.43 ± 2.99 vs. 2.10 ± 1.28, $p < 0.001$), SII (953.72 ± 855.02 vs. 561.74 ± 355.60, $p < 0.001$), and PIV (523.84 ± 455.48 vs. 342.48 ± 245.47, $p < 0.001$). While Frosolini et al. noted variability in TNF-α levels, our findings underscore the diagnostic utility of composite markers like SII and PIV, which provide

consistent insights into the inflammatory mechanisms underlying SSNHL.

Our study significantly advances our understanding of the role of systemic inflammation in SSNHL and lays the groundwork for future investigations. Continued research is necessary to elucidate further the mechanisms linking these inflammatory markers to SSNHL and to determine their long-term prognostic value in diverse patient populations.

Role of Chronic Inflammation in SSNHL

SSNHL is mostly idiopathic, but evidence suggests chronic inflammation plays a key role. Studies have linked elevated markers like neutrophils, hs-CRP, and procalcitonin to disease severity [18,19]. Our study reinforces this inflammatory hypothesis, demonstrating significantly higher levels of systemic inflammatory indices in SSNHL patients compared to healthy controls: NLR (3.43 ± 2.99 vs. 2.10 ± 1.28, $p < 0.001$), SII (953.72 ± 855.02 vs. 561.74 ± 355.60, $p < 0.001$), and PIV (523.84 ± 455.48 vs. 342.48 ± 245.47, $p < 0.001$). These markers indicate increased inflammation and correlate with hearing loss severity, with 48 patients having profound and 54 severe loss. Our findings suggest that inflammation disrupts cochlear homeostasis, contributing to SSNHL.

The acute rise in inflammatory markers in SSNHL patients suggests a distinct mechanism behind the disease's rapid onset [7-13].In our study, patients with SSNHL demonstrated significantly elevated markers such as NLR (3.43 ± 2.99 vs. 2.10 ± 1.28, $p < 0.001$), SII (953.72 ± 855.02 vs. 561.74 ± 355.60, $p < 0.001$), and PIV (523.84 ± 455.48 vs. 342.48 ± 245.47, $p < 0.001$) compared to controls. These acute fluctuations suggest a unique process involving vascular permeability, oxidative stress, and immune-driven cochlear damage. The markers correlate with hearing loss severity, seen in 48 profound and 54 severe cases, highlighting systemic inflammation's role in SSNHL and the need for further study.

Neutrophil-to-Lymphocyte Ratio (NLR)

The NLR has gained widespread recognition as a simple, accessible, and reliable marker of systemic inflammation. Its utility spans multiple medical fields, including oncology, where it predicts tumor progression and outcomes [20]; cardiology, as a prognostic indicator in acute coronary syndromes and heart failure [21]; and inflammatory diseases such as ulcerative colitis, sepsis, and appendicitis [22,23]. Consistent with these applications, our study revealed significantly elevated NLR levels in SSNHL patients compared to controls (3.43 ± 2.99 vs. 2.10 ± 1.28, $p < 0.001$), supporting its role in acute inflammatory conditions.

These findings align with the work of Ulu et al., who similarly reported higher NLR values in idiopathic SSNHL patients [24]. The elevated NLR levels in our study indicate an immune imbalance, with increased neutrophil activity and reduced lymphocytes, potentially worsening cochlear inflammation and causing auditory dysfunction. NLR's simplicity, reliability, and predictive value make it a useful marker for detecting and monitoring systemic inflammation in SSNHL patients.

Systemic Immune-Inflammation Index (SII)

Initially introduced as a prognostic tool in oncology, the SII comprehensively measures immune-inflammatory status by integrating neutrophil, platelet, and lymphocyte counts [25]. In our study, the mean SII value in SSNHL patients was significantly higher compared to the control group (953.72 ± 855.02 vs. 561.74 ± 355.60, $p < 0.001$). Moreover, SII demonstrated superior sensitivity (58.5%) and AUC values (0.693) compared to NLR in differentiating SSNHL patients from healthy controls, suggesting its potential as a more robust and nuanced assessment of systemic inflammation in the context of SSNHL.

Including platelets in SII highlights their role in inflammation and vascular function. Elevated SII levels in our study suggest heightened inflammation and thrombosis, contributing to microvascular and cochlear damage. SII's integration of multiple inflammatory markers makes it a valuable tool for diagnosing and predicting SSNHL severity and outcomes**.**

Pan Immune-Inflammation Value (PIV)

The PIV is a relatively new biomarker that integrates neutrophil, platelet, monocyte, and lymphocyte counts, offering a holistic measure of systemic inflammation and immune response. In our study, PIV levels were significantly elevated in SSNHL patients compared to the control group (523.84 ± 455.48 vs. 342.48 ± 245.47, $p < 0.001$), highlighting its potential relevance in inflammation-driven conditions like SSNHL. Furthermore, the ROC analysis showed a sensitivity of 51.5% and an AUC value of 0.648, supporting its role in distinguishing SSNHL patients from healthy individuals.

PIV, unlike NLR and SII, offers a broader view of immune response by including monocytes, aiding in detecting chronic inflammation. Elevated PIV levels in our study highlight its potential as both a diagnostic marker and an indicator of disease progression and treatment response in SSNHL

Study Strengths and Limitations

This study contributes to understanding SSNHL by evaluating the relationship between NLR, SII, and PIV with the disease. It is the first to investigate SII and PIV in SSNHL, offering new insights into the link between systemic inflammation and auditory dysfunction. The use of routine, cost-effective blood tests enhances clinical practicality.

However, the single-center design may limit generalizability, and the retrospective nature prevents establishing causality. Future multicenter studies with larger, diverse cohorts are needed to validate these findings, assess the prognostic value of these markers, and explore their potential as therapeutic targets.

Implications for Future Research

Our study highlights the importance of inflammatory markers in SSNHL, but further research is essential to assess their prognostic value and role in predicting long-term outcomes. Future studies should explore the mechanisms linking systemic inflammation to SSNHL and compare how different treatment protocols affect these markers. Evaluating changes in inflammatory indices before and after treatment could provide deeper insights into their potential as indicators of therapeutic efficacy and guide the development of targeted anti-inflammatory therapies.

2. Conclusion

In summary, this study identifies elevated NLR, SII, and PIV levels as significant markers of systemic inflammation in SSNHL patients. These findings emphasize the potential utility of these indices in understanding the etiology of SSNHL and identifying patients at risk of unfavorable outcomes. Further research is essential to explore these inflammatory markers' predictive and therapeutic implications in SSNHL management.

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Abbreviations

- **AİK:** Ani İşitme Kaybı (Sudden Hearing Loss)
- **AUC:** Area Under the Curve
- **ASHA:** American Speech-Language-Hearing Association
- **CBC:** Complete Blood Count
- **CI:** Confidence Interval
- **CRP:** C-Reactive Protein
- **dB HL:** Decibels Hearing Level
- **EDTA:** Ethylenediaminetetraacetic Acid
- **hs-CRP:** High-Sensitivity C-Reactive Protein
- **MRI:** Magnetic Resonance Imaging
- **NLR:** Neutrophil-to-Lymphocyte Ratio
- **PIV:** Pan-Immune-Inflammation Value
- **PLR:** Platelet-to-Lymphocyte Ratio
- **p-value:** Probability Value (Statistical Significance)
- **ROC:** Receiver Operating Characteristic
- **SD:** Standard Deviation
- **SII:** Systemic Immune-Inflammation Index
- **SPSS:** Statistical Package for the Social Sciences
- **SSNHL:** Sudden Sensorineural Hearing Loss
- **TNF-*α*:** Tumor Necrosis Factor-alpha
- **WBC:** White Blood Cell