



Association Between Systemic Lupus Erythematosus Disease Activity and Hearing Loss

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ABSTRACT

Systemic lupus erythematosus (SLE) is a chronic autoimmune inflammatory disease that may cause multiorgan inflammation and tissue damage, including auditory involvement. This study evaluated the association between SLE disease activity and hearing loss at Adam Malik Hospital. This analytic observational study used a cross-sectional design and was conducted at the Otorhinolaryngology and Internal Medicine outpatient clinics of Adam Malik Hospital from May to December 2025. The study population comprised patients with SLE diagnosed by an internal medicine rheumatology consultant. Forty-two patients who fulfilled the inclusion and exclusion criteria were enrolled in the study using a non-probability consecutive sampling technique. Data were analyzed using univariate and bivariate analyses, and receiver operating characteristic (ROC) analysis was performed to assess disease duration as a predictor of hearing loss. The study population was predominantly female (97.6%) and consisted of young adults. Mean disease duration was 5.21 ± 3.96 months, with a median of 5.5 months. Moderate disease activity based on the SLE Disease Activity Index (SLEDAI) was the most frequent category (38.1%). Mean hearing thresholds tended to increase with increasing frequency, indicating predominant high-frequency involvement. ROC analysis showed that disease duration had acceptable discriminative ability for hearing loss (AUC = 0.704), with an optimal cut-off of 6 months. Disease duration and SLE disease activity level were significantly associated with sensorineural hearing loss and hearing-loss severity. Higher SLE disease activity was associated with more severe hearing loss.

Keywords: audiometry; disease activity; sensorineural hearing loss; systemic lupus erythematosus

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INTRODUCTION

Systemic lupus erythematosus (SLE) is a chronic autoimmune inflammatory disease in which the immune system mistakenly attacks self-tissues, resulting in inflammation and damage across multiple organs. (Arnaud L et al., 2018) SLE is characterized by autoantibody production and immune-complex formation. Immune complexes and autoantibodies may involve auditory structures, and inflammatory or vascular involvement of the inner ear may lead to auditory dysfunction. Studies have shown that hearing loss in SLE is predominantly sensorineural, reflecting inner-ear involvement, and its incidence is clinically relevant. (Athanasopoulos M et al., 2024)

Previous studies have reported variable rates of hearing loss among patients with SLE. Yuen et al. reported a prevalence of 27%, Tharwat reported 24%, and Alzokm and Ghanem reported a prevalence ranging from 8% to 66%. Cheema et al. reported hearing impairment in 29% of patients with SLE. (Alzokm SM et al., 2022; Cheema A et al., 2023)

Hearing loss in SLE is usually mild to moderate, bilateral, and sensorineural. It may occur gradually or acutely and most commonly affects high frequencies, resembling a presbycusis-like pattern,

although low and middle frequencies may also be affected. Frequencies between 2,000 and 8,000 Hz are frequently involved. Hearing loss should not be overlooked because it is associated with communication difficulties and may contribute to cognitive decline in children and adults. (Chen H et al., 2022; Liu CM et al., 2019) The severity and duration of SLE have been linked to sensorineural hearing loss (SNHL), suggesting that more severe and longer-standing disease may worsen auditory dysfunction. (Alzokm SM et al., 2022; Alzokm SSG et al., 2021)

Globally, the prevalence of SLE has been estimated at 43.7 per 100,000 persons, corresponding to approximately 3.41 million affected individuals. The incidence is approximately 5.14 per 100,000 person-years, with an estimated female-to-male ratio of approximately 9:1. Peak incidence occurs between 15 and 40 years of age; therefore, SLE is considered one of the most common autoimmune diseases affecting women of reproductive age. (Tian J et al., 2022) SLE prevalence and incidence vary substantially across regions. North America has reported some of the highest rates, with an incidence of 23.2 per 100,000 person-years and a prevalence of 241 per 100,000 persons. Lower incidence rates have been reported in Africa and Ukraine, with estimates as low as 0.3 per 100,000 person-years. These variations may reflect genetic, environmental, socioeconomic, health-care access, and diagnostic-practice differences. (Rees F et al., 2017; Goman AM et al., 2016; Barber MRW et al., 2021)

In Indonesia, epidemiological information on SLE, its effect on quality of life, occupational outcomes, disability, and patient survival remains limited. Rheumatology outpatient data from several Indonesian hospitals have shown increasing SLE visits, from 17.9%-27.2% in 2015 to 18.7%-31.5% in 2016 and 30.3%-58% in 2017. At Dr. Cipto Mangunkusumo Hospital, Jakarta, SLE accounted for 1.4% of rheumatology outpatient visits in 2002, while Hasan Sadikin Hospital, Bandung, reported 291 SLE patients, or 10.5% of annual rheumatology outpatient visits. (Kementerian Kesehatan RI 2017; Hasanah RM et al., 2016)

SLE disease activity can be assessed using the SLE Disease Activity Index (SLEDAI), which evaluates the severity of disease activity and can guide clinical management. SLEDAI was introduced in 1985 as a global index assessing disease activity over the preceding 10 days. It includes 24 clinical and laboratory variables across nine organ systems, with weighted scores ranging from 1 to 8. Disease activity is commonly categorized as mild (score 1-5), moderate (score 6-12), and severe (score 13-19). (Pradesta R et al., 2018; Perhimpunan Reumatologi Indonesia 2019) To date, evidence from Indonesia regarding the association between SLE disease activity and hearing loss is limited. This study therefore aimed to evaluate the association between SLE disease activity level and hearing loss at Adam Malik Hospital.

METHOD

This analytic observational study used a cross-sectional design. The study was conducted at the Otorhinolaryngology and Internal Medicine outpatient clinics of Adam Malik Hospital from May 2025 to December 2025. The study population consisted of patients with systemic lupus erythematosus (SLE) diagnosed by an Internal Medicine Rheumatology Consultant. A total of 42 patients who met the inclusion and exclusion criteria were recruited using a non-probability consecutive sampling method.

After providing written informed consent, eligible participants were enrolled consecutively. Demographic and clinical data, including age, sex, disease duration, and disease activity based on the Systemic Lupus Erythematosus Disease Activity Index (SLEDAI), were obtained from patients' medical records. All participants subsequently underwent routine otorhinolaryngological examinations to exclude ear conditions that could affect hearing assessment, such as cerumen impaction, ear infection, or tympanic membrane perforation. Hearing function was then evaluated using pure-tone audiometry with a calibrated GSI audiometer to determine the presence, type, and

severity of hearing loss. All collected data were recorded in standardized research forms and analyzed according to the study objectives.

Data were analyzed using univariate and bivariate analyses. Univariate analysis was used to summarize frequency distributions and percentages. Bivariate analysis was performed to assess associations between clinical variables and hearing loss. Chi-square testing was used when assumptions were met, whereas Fisher's exact test was applied when Chi-square assumptions were not fulfilled. Statistical significance was set at $p < 0.05$. Receiver operating characteristic (ROC) analysis was performed to evaluate disease duration as a predictor of hearing loss. This study was conducted after obtaining ethical approval from the Health Research Ethics Committee of the Faculty of Medicine, Universitas Sumatera Utara, Medan, with approval number 509/KEPK/USU/2025.

RESULT

Baseline Characteristics

A total of 42 patients with SLE diagnosed by an internal medicine rheumatology consultant at Adam Malik Hospital were included. Baseline characteristics are shown in Table 1.

Table 1.

Baseline characteristics of patients with systemic lupus erythematosus

Characteristic	n = 42
Sex, f (%)	
Male	1 (2.4)
Female	41 (97.6)
Age, years	
Mean $\pm$ SD	24.69 $\pm$ 4.12
Median (min-max)	24 (18-33)
Disease duration, months	
Mean $\pm$ SD	5.21 $\pm$ 3.96
Median (min-max)	5.5 (0.25-12)
SLE disease activity level, f (%)	
Mild	15 (35.7)
Moderate	16 (38.1)
Severe	11 (26.2)

The study population was predominantly female (97.6%). The mean age was 24.69 $\pm$ 4.12 years, with a median of 24 years and an age range of 18-33 years. Mean disease duration was 5.21 $\pm$ 3.96 months, with a median of 5.5 months and a range of 0.25-12 months, indicating that most patients were in the early phase after diagnosis. Disease activity categories were relatively balanced. Moderate disease activity was most frequent (38.1%), followed by mild (35.7%) and severe disease activity (26.2%).

Pure-Tone Audiometry Findings

Pure-tone audiometry was performed to evaluate auditory function in patients with SLE. The mean hearing thresholds are summarized in Table 2.

Table 2.

Hearing thresholds in patients with SLE based on pure-tone audiometry

Frequency	Right ear (n = 42), mean $\pm$ SD, dB HL	Left ear (n = 42), mean $\pm$ SD, dB HL
250 Hz	19.17 $\pm$ 9.03	20.60 $\pm$ 10.31
500 Hz	21.43 $\pm$ 10.95	21.19 $\pm$ 9.87
1000 Hz	23.93 $\pm$ 13.32	24.29 $\pm$ 11.51
2000 Hz	25.95 $\pm$ 14.07	26.19 $\pm$ 15.17
3000 Hz	28.10 $\pm$ 12.25	27.86 $\pm$ 14.83
4000 Hz	30.00 $\pm$ 14.82	31.79 $\pm$ 16.30
6000 Hz	32.26 $\pm$ 12.55	32.26 $\pm$ 14.45
8000 Hz	34.17 $\pm$ 14.48	34.64 $\pm$ 1

Mean hearing thresholds increased gradually with increasing frequency. At 250-1,000 Hz, mean thresholds in both ears remained within the normal range (≤ 25 dB HL). Mild elevation began at 2,000-3,000 Hz and became more evident at 4,000-8,000 Hz (Figure 1).

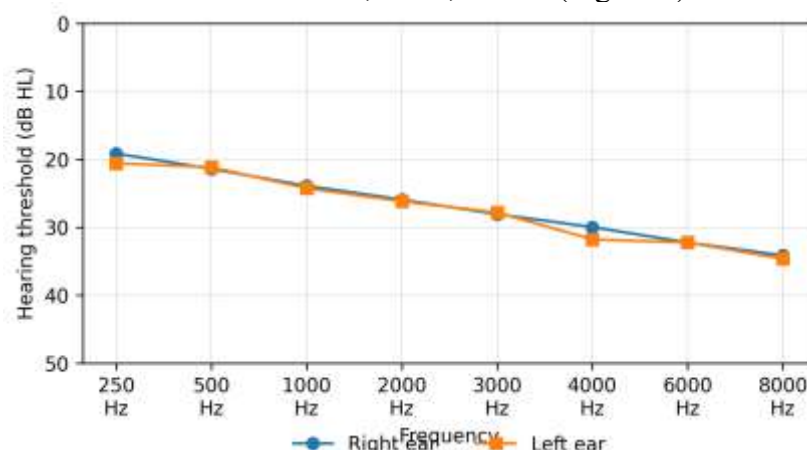


Figure 1. Pure-tone audiometry findings in patients with SLE.

Type and Severity of Hearing Loss

Table 3 shows the distribution of hearing-loss type and severity among the 42 patients, analyzed separately for the right and left ears.

Table 3.

Type and severity of hearing loss in patients with SLE

Variable	Right ear (n = 42)	Left ear (n = 42)
Type of hearing loss, n (%)		
Sensorineural	18 (42.9)	18 (42.9)
None	24 (57.1)	24 (57.1)
Severity of hearing loss, n (%)		
Normal	24 (57.1)	24 (57.1)
Mild	9 (21.4)	9 (21.4)
Moderate	8 (19.0)	8 (19.0)
Moderately severe	1 (2.4)	1 (2.4)

More than half of the patients had normal hearing in each ear (57.1%). Among patients with hearing loss, all cases were sensorineural (42.9%). Mild hearing loss was observed in 21.4%, moderate hearing loss in 19.0%, and moderately severe hearing loss in 2.4% of ears.

Disease Duration as a Predictor of Hearing Loss

ROC analysis was performed to evaluate the discriminative ability of SLE disease duration for predicting hearing loss. The analysis included 84 ears from 42 patients, comprising 36 positive and 48 negative cases.

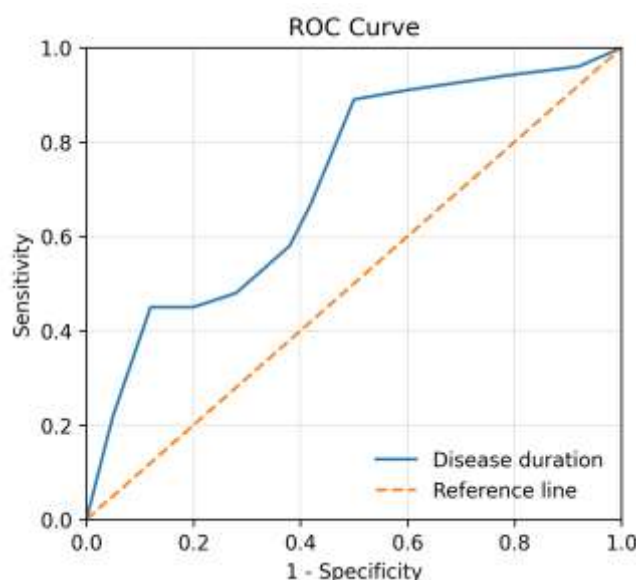


Figure 2. ROC curve for disease duration as a predictor of hearing loss in patients with SLE.

Disease duration showed acceptable discriminative ability for predicting hearing loss in patients with SLE. The area under the curve (AUC) was 0.704 (SE = 0.058; $p = 0.001$; 95% CI: 0.591-0.817), indicating that the probability that a patient with hearing loss had a longer disease duration than a patient with normal hearing was 70.4%. The statistically significant p value and 95% CI excluding 0.5 support the predictive value of disease duration beyond chance.

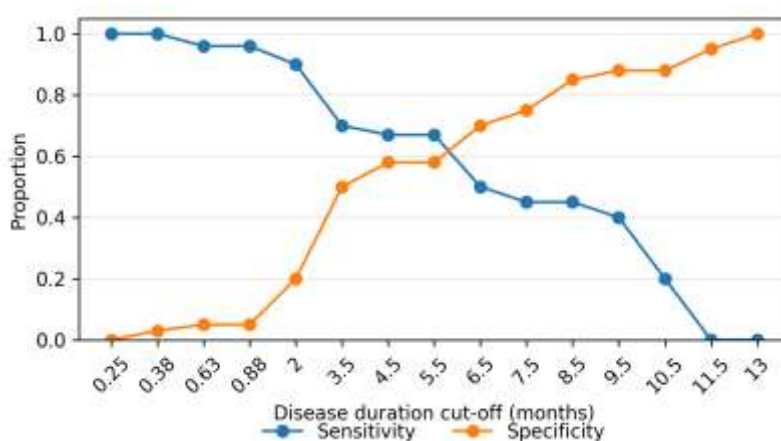


Figure 3. Line graph for determining the optimal disease-duration cut-off for predicting hearing loss in patients with SLE.

The optimal disease-duration cut-off for predicting hearing loss was 6 months, based on the line graph. Table 4 summarizes the AUC, significance level, and cut-off value.

Table 4.

AUC, significance level, and cut-off value for disease duration in predicting hearing loss in patients with SLE

Variable	AUC	95% CI	p value	Cut-off
Disease duration	0.704	0.591-0.817	0.001	6 months

Association of Disease Duration and Disease Activity with Type of Hearing Loss

Associations between disease duration, SLE disease activity level, and type of hearing loss (sensorineural vs. none) were analyzed using the Chi-square test for dichotomized disease duration

and the Kruskal-Wallis test for ordinal disease activity. Statistical significance was set at $p < 0.05$. The distribution is shown in Table 5.

Table 5.

Association of disease duration and disease activity with type of hearing loss in patients with SLE

Variable	Sensorineural hearing loss	Normal hearing	p value
Disease duration, months			
≥6 months	24 (57.1)	18 (42.9)	0.008 ^a
<6 months	12 (28.6)	30 (71.4)	
SLE disease activity level, f (%)			
Mild	0 (0.0)	30 (71.4)	0.001 ^b
Moderate	14 (43.8)	18 (56.3)	
Severe	22 (100.0)	0 (0.0)	

^aChi-square test; ^bKruskal-Wallis test.

Disease duration was significantly associated with SNHL ($p = 0.008$). Patients with disease duration ≥6 months had a higher proportion of SNHL (57.1%) than those with disease duration <6 months (28.6%). SLE disease activity level was also significantly associated with SNHL ($p = 0.001$). All ears from patients with mild disease activity had normal hearing, whereas all ears from patients with severe disease activity had SNHL. In the moderate activity group, 43.8% had SNHL and 56.3% had normal hearing.

Association of Disease Duration and Disease Activity with Hearing-Loss Severity

Associations between disease duration, SLE disease activity level, and hearing-loss severity (normal, mild, moderate, and moderately severe) were analyzed using tests for ordinal data. Gamma (γ) coefficients were used to assess the strength and direction of associations. The distribution is shown in Table 6.

Table 6.

Association of disease duration and disease activity with hearing-loss severity in patients with SLE

Variable	Normal	Mild	Moderate	Moderately severe	p value	γ
Disease duration, f (%)						
<6 months	30 (71.4)	10 (23.8)	2 (4.8)	0	0.001	0.584
≥6 months	18 (42.9)	8 (19.0)	14 (33.3)	2 (4.8)		
SLE disease activity level, f (%)						
Mild	30 (100.0)	0	0	0	<0.001	1.000
Moderate	18 (56.3)	14 (43.7)	0	0		
Severe	0	4 (18.2)	16 (72.7)	2 (9.1)		

γ = Gamma coefficient.

Both disease duration and disease activity level showed statistically significant associations with hearing-loss severity. Disease activity level showed a strong progressive gradient ($p < 0.001$; $\gamma = 1.000$): all ears in the mild activity group were normal, the moderate activity group showed normal or mild hearing loss, and the severe activity group showed predominantly moderate hearing loss with a small proportion of moderately severe hearing loss. Disease duration was also significantly associated with severity ($p = 0.001$; $\gamma = 0.584$). Compared with disease duration <6 months, disease duration ≥6 months was associated with a lower proportion of normal hearing and a higher proportion of moderate or moderately severe hearing loss.

DISCUSSION

Baseline Characteristics

The study population was predominantly female (97.6%) and had a mean age of 24.69 years. This profile is consistent with the epidemiology of SLE, which shows a strong predilection for women of reproductive age. The present findings are in line with Dai et al., who reported that SLE most commonly occurs in women between puberty and menopause, and with the scoping review by

Albrecht et al., which reported female-to-male ratios ranging from 4:1 to 11:1 across studies. Estrogen may amplify Th2-mediated diseases, including SLE, by suppressing Th1 proinflammatory cytokine production, including IL-12, TNF- α , and IFN- γ . Prolactin has also been shown to stimulate key components of innate and adaptive immunity, including T cells, B cells, dendritic cells, natural killer cells, macrophages, neutrophils, and hematopoietic stem cells. (Dai X et al., 2025; Albrecht K et al., 2025)

Soares et al. analyzed 27 immune-cell types from 125 women with SLE and 66 healthy controls and found increased X-linked gene expression in T cells, B cells, and plasmablasts, but decreased expression in monocytes and plasmacytoid dendritic cells. A key finding was reduced expression of X-inactive specific transcript (XIST), a master regulator of X-chromosome inactivation, particularly in monocytes and Th1 cells. This reduction correlated with increased SLE-related genes, interferon signaling, and epigenetic regulators. These findings suggest that women may be more susceptible to SLE not only because they carry two X chromosomes, but also because unstable X-linked gene dosage compensation may promote immune dysregulation. (Soares M et al., 2025) Disease duration in this study was relatively short, with a mean of 5.21 months, suggesting that most patients were in the early phase after diagnosis. This is important because early SLE may show broad variation in disease activity, ranging from mild to severe. Patients were selected from newly diagnosed or early-disease groups to minimize bias from prolonged exposure to potentially ototoxic therapy, particularly antimalarial agents such as hydroxychloroquine. Hearing loss in SLE is multifactorial and may result from autoimmune mechanisms, immune-complex deposition, microvascular injury, and, in some cases, medication-related audiovestibular dysfunction. (Chen JJ et al., 2024)

Pure-Tone Audiometry Findings

This study showed a gradual increase in hearing thresholds with increasing frequency, with a gently sloping audiometric pattern that was most prominent at high frequencies. Mean thresholds at 250-1,000 Hz remained within the normal range, while mild elevation began at 2,000 Hz and became more evident at 4,000-8,000 Hz. Clinically, this pattern is consistent with bilateral, relatively symmetric, high-frequency hearing loss and supports cochlear involvement in SLE through possible microvascular vasculitis, immune-complex deposition, or long-term treatment effects.

High-frequency hearing loss may be subclinical in the early stages but can still affect consonant discrimination and speech clarity, particularly in noisy environments. These findings are consistent with Chen et al., who reported that hearing loss in SLE is commonly mild to moderate, bilateral, and predominantly sensorineural. That study also found significantly higher hearing thresholds in patients with SLE at middle and high frequencies, beginning at 2,000 Hz, compared with controls. A recent systematic review further noted that inner-ear injury in SLE may be influenced by immune-complex deposition in the microvasculature and other immune-mediated mechanisms affecting the audiovestibular system. (Chen H et al., 2022; Chen JJ et al., 2024) The present findings also agree with Yuen et al., who found that hearing loss in SLE often occurs bilaterally and predominantly affects high frequencies between 2,000 and 8,000 Hz. (Yuen E et al., 2021)

Type and Severity of Hearing Loss

Classifying hearing loss as conductive, sensorineural, or mixed provides clinically important information regarding the underlying pathophysiological site, whether involving the middle-ear conductive system, cochlear-retrocochlear structures, or both. In systemic autoimmune diseases such as SLE, identifying the type of hearing loss is particularly relevant because inflammation, cochlear vasculitis, immune-complex deposition, and ototoxic medication exposure may all affect auditory pathways. The present study showed that hearing loss in SLE was sensorineural, bilateral, and generally mild to moderate. Although mean thresholds at low frequencies remained normal, the middle- to high-frequency range showed progressive elevation, suggesting early or subclinical high-frequency involvement.

This pattern is consistent with Chen et al., who reported that hearing loss in SLE is generally sensorineural, bilateral, and mild to moderate in severity. The near-identical thresholds between right and left ears in this study, without marked asymmetry, support the interpretation that hearing loss in SLE more commonly reflects a systemic process rather than a unilateral local lesion. (Chen H et al., 2022) Overall, these findings support routine audiological screening in patients with SLE, including in those without subjective hearing complaints. Pure-tone audiometry may serve as a baseline and follow-up assessment, particularly in patients with longer disease duration, higher disease activity, or prolonged therapy with potentially ototoxic medications. Early detection may help prevent communication difficulties and quality-of-life impairment. (Paraschou V et al., 2021)

Disease Duration as a Predictor of Hearing Loss

ROC analysis showed that disease duration had acceptable discriminative ability for predicting hearing loss in patients with SLE, with an AUC of 0.704 (95% CI: 0.591-0.817; $p = 0.001$). Clinically, this suggests that longer disease duration is associated with a higher likelihood of hearing loss.

An AUC between 0.70 and 0.80 is generally interpreted as acceptable discrimination. Therefore, disease duration may be considered an initial risk-stratification indicator, although it is insufficient as a standalone diagnostic tool. (Chen JJ et al., 2024) These findings are consistent with Ghanem and Alzokm, who directly assessed the association between disease duration and hearing loss in SLE. They reported a significant relationship between disease severity, disease duration, and SNHL, including a strong positive correlation between SLE duration and SNHL ($r = 0.6395$, $p \leq 0.001$). Although their statistical approach differed from the ROC analysis used in the present study, the direction of the association was consistent: longer disease duration was associated with greater risk of hearing loss. The 6-month cut-off identified in the present study may therefore be interpreted as a clinically useful screening trigger in this study setting. (Alzokm SM et al., 2022)

Associations of Disease Duration and Disease Activity with Hearing Loss

Disease duration was significantly associated with hearing-loss severity ($p = 0.001$). Patients with disease duration <6 months were more likely to have normal hearing, whereas those with duration ≥ 6 months showed a lower proportion of normal hearing and a higher proportion of moderate to moderately severe hearing loss.

This finding supports the hypothesis that longer exposure to SLE-related systemic inflammation increases the probability of progressive auditory injury, particularly through chronic inflammation, cochlear microcirculatory disturbance, and immune-complex deposition in the inner ear. (Yuen E et al., 2021) The findings are consistent with Ghanem and Alzokm, who reported a significant association between disease duration and SNHL in patients with SLE. Their study also found that the severity and duration of SLE were associated with the occurrence and degree of hearing loss, supporting the interpretation that longer disease course is not only related to the presence of hearing loss but also to greater hearing-loss severity. (Alzokm SM et al., 2022) Disease activity level was also significantly associated with both SNHL and hearing-loss severity. A stepwise pattern was observed: patients with mild activity had normal hearing, those with moderate activity generally had normal or mild hearing loss, and those with severe activity predominantly had moderate hearing loss. This pattern suggests that active systemic inflammation may contribute to cochlear or microvascular injury in SLE. These results support the need for closer audiological surveillance in patients with moderate-to-severe disease activity.

CONCLUSION

This study demonstrated that hearing loss is a common auditory manifestation in patients with systemic lupus erythematosus (SLE), predominantly presenting as bilateral sensorineural hearing loss with greater involvement at high frequencies. Disease duration and SLE disease activity level

were significantly associated with both the occurrence and severity of hearing loss. Patients with disease duration ≥ 6 months and moderate-to-severe disease activity were more likely to develop hearing impairment and experience more severe hearing loss. Furthermore, disease duration showed acceptable discriminative ability for predicting hearing loss, with an optimal cut-off value of 6 months. These findings suggest that ongoing disease activity and longer disease duration may contribute to progressive cochlear involvement in SLE, highlighting the importance of routine audiological evaluation and early hearing screening, particularly in patients with higher disease activity. Early identification and regular monitoring of auditory dysfunction may facilitate timely intervention and help minimize the impact of hearing impairment on communication and quality of life in patients with SLE.

REFERENCES

- Albrecht K, Troll W, Callhoff J, Strangfeld A, Ohrndorf S, Mucke J. Sex- and gender-related differences in systemic lupus erythematosus: a scoping review. *Rheumatology International*. 2025;45(7):160.
- Alzokm SM, Ghanem SS. Hearing disorders in lupus patients: correlation with duration and severity of the disease. *Egyptian Rheumatology and Rehabilitation*. 2022;49(1):23.
- Alzokm SSG, Ghanem SM. Hearing impairment in patients with systemic lupus: correlation with duration and severity of the disease. *Journal of Phonetics & Audiology*. 2021;9:221.
- Arnaud L, Van Vollenhoven R. *Advanced handbook of systemic lupus erythematosus*. Springer International Publishing; 2018.
- Athanasopoulos M, Samara P, Athanasopoulos I. Decoding the impact of autoinflammatory/autoimmune diseases on inner ear harmony and hearing loss. *Exploration of Immunology*. 2024;4(1):73-89.
- Barber MRW, et al. Global epidemiology of systemic lupus erythematosus. *Nature Reviews Rheumatology*. 2021;17(9):515-532.
- Cheema A, Khan MSG, Mazhar F, Qasim MM, Ahmed M, Badar SA, et al. Prevalence of hearing impairment among systemic lupus erythematosus patients. *Journal of Health and Rehabilitation Research*. 2023;3(2):573-578.
- Chen H, et al. Characteristics of hearing loss in patients with systemic lupus erythematosus. *Journal of Clinical Medicine*. 2022;11(24):7527.
- Chen JJ, Hsu CW, Chen YW, Chen TY, Zeng BS, Tseng PT. Audiovestibular dysfunction in systemic lupus erythematosus patients: a systematic review. *Diagnostics*. 2024;14(15):1670.
- Dai X, Fan Y, Zhao X. Systemic lupus erythematosus: updated insights on the pathogenesis, diagnosis, prevention and therapeutics. *Signal Transduction and Targeted Therapy*. 2025;10(1):102.
- Goman AM, Lin FR. Prevalence of hearing loss by severity in the United States. *American Journal of Public Health*. 2016;106:1820-1822.
- Hasanah RM, Pramudo SG, Hellmi RY. Hubungan tingkat aktivitas penyakit dengan kecenderungan kejadian depresi pada pasien lupus eritematosus sistemik: studi kasus di RSUP Dr. Kariadi, Semarang. 2016.
- Kementerian Kesehatan RI. *Situasi Lupus di Indonesia*. Jakarta: Pusat Data dan Informasi; 2017.
- Liu CM, Lee CTC. Association of hearing loss with dementia. *JAMA Network Open*. 2019;2:e198112.
- Paraschou V, Chaitidis N, Papadopoulou Z, Theocharis P, Siolos P, Festas C. Association of systemic lupus erythematosus with hearing loss: a systemic review and meta-analysis. *Rheumatology International*. 2021;41(4):681-689.
- Perhimpunan Reumatologi Indonesia. *Diagnosis dan pengelolaan lupus eritematosus sistemik*. Perhimpunan Reumatologi Indonesia; 2019.
- Pradesta R, Liana P, Haryadi K. Hubungan hasil laboratorium pasien lupus eritematosus sistemik dengan skor LESDAI di RSUP Dr Mohammad Hoesin Palembang. *Jurnal Fakultas Kedokteran Universitas Sriwijaya*. 2018;4.

- Rees F, et al. The worldwide incidence and prevalence of systemic lupus erythematosus: a systematic review of epidemiological studies. *Rheumatology*. 2017;56(11):1945-1961.
- Soares M, Wemans IS, Caldas P, da Rocha ST, Grosso AR. X-linked transcriptome dysregulation across immune cells in systemic lupus erythematosus. *Biology of Sex Differences*. 2025;16(1):69.
- Tian J, et al. Global epidemiology of systemic lupus erythematosus: a comprehensive systematic analysis and modelling study. *Annals of the Rheumatic Diseases*. 2022;82(3):351-356.
- Yuen E, Fried J, Nguyen SA, Rizk HG, Ward C, Meyer TA. Hearing loss in patients with systemic lupus erythematosus: a systematic review and meta-analysis. *Lupus*. 2021;30(6):937-945.