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RESEARCH ARTICLE
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RADIOLOGICAL EVALUATION OF PEDIATRIC SENSORINEURAL HEARING LOSS AT A TERTIARY CARE CENTRE IN THE VINDHYA REGION

Dr. Ankita Kujur[1], Dr. Surendra Singh Moupchi[2], Dr. Vikas Patel[3], Dr. Tawn Khuma[4], Dr. Harshvardhan[5], Dr. Sheetal Soni[6*]

[1] SR, SSMC, REWA,
[2]HOD and Professor, SSMC, REWA
[3,4,5,6]JR, SSMC Rewa,

***Corresponding Author:** Dr. Sheetal Soni
Samriddhi girls hostel room no 314, Shyam Shah Medical College Rewa. Pin 486001

ABSTRACT:
Pediatric Sensorineural Hearing Loss (SNHL) is a common congenital sensory disorder affecting 1-3 per 1,000 live births. It can significantly impact speech, language, cognitive, and social development if untreated. Causes include genetic factors, infections, ototoxic exposure, or acquired conditions. Radiological evaluation is crucial for diagnosis, etiology, pre-surgical planning, genetic correlation, and prognosis. It complements genetic testing and provides information about treatment feasibility and potential success. Comprehensive management is essential for SNHL.
OBJECTIVE: The study aims to assess radiological findings in pediatric sensorineural hearing loss (SNHL) utilizing advanced imaging modalities as high-resolution CT and MRI.
METHODS AND MATERIALS:
The study was carried out at Sanjay Gandhi Memorial Hospital and Shyam Shah Medical College (S GMH), Rewa, in the Department of Otorhinolaryngology and Head and Neck Surgery.
A prospective observational study in Vindhya aimed to identify sensorineural hearing loss in children aged 0-15 years.
Data collection included clinical history, audiological findings, and radiological abnormalities.
High-Resolution Computed Tomography (HRCT) and Magnetic resonance imaging (MRI) were used to evaluate and congenital anomalies
RESULT: **Cochlear Pathology:** The most common pathology, affecting **65% (16 patients)**, includes mild abnormalities (23%), moderate to severe abnormalities (9%), hypoplasia (9%), aplasia (6%), and cochlear nerve deficiency (18%).
Vestibular Pathology : Found in **24% (6 patients)**, dominated by **enlarged vestibular aqueduct (16%)** and **vestibular hypoplasia (8%)**.
Semicircular Canal Pathology : Observed in **20% (5 patients)**, with **aplasia (8%)** and **hypoplasia (12%)** contributing equally to the total.
CONCLUSION: This study emphasizes the diverse range of inner ear malformations contributing to pediatric SNHL. A multidisciplinary diagnostic approach is essential to optimize treatment, improve auditory and vestibular outcomes, and enhance the quality of life for affected children.

Key Words: SNHL, hearing loss.

INTRODUCTION

Sensorineural hearing loss (SNHL) is a hearing impairment caused by damage to the inner ear or auditory nerve, affecting sound perception and speech understanding. The Vindhya Region, with its rural and underserved healthcare infrastructure, has a higher prevalence of SNHL due to limited access to early diagnostic and treatment facilities, socioeconomic constraints, and lack of awareness. Untreated SNHL leads to delayed speech and language development, cognitive and social impairments, and emotional and psychological challenges. Early detection through newborn hearing screening, advanced diagnostics like imaging, and interventions such as hearing aids, cochlear implants, and speech therapy are crucial.

Congenital SNHL is more common in developing regions, affecting 1- out of every 1,000 live infan ts.

In the Vindhya area, a study of 250 preschool children with hearing impairment found that 21.6% ha d sensorineural hearing loss.

This suggests a high frequency of SNHL among young children in the area.

Diagnosing sensorineural hearing loss (SNHL) in resource-limited settings is challenging due to limited access to diagnostic tools, lack of early screening programs, and limited expertise and training. Insufficient awareness and education about the signs of hearing loss and treatment options, cultural factors, stigmatization, and financial barriers can lead to underreporting and neglect of SNHL in children.. Multidisciplinary care, involving audiologists, otolaryngologists, speech therapists, and educators, is often lacking in resource-limited settings, leading to fragmented care and delayed interventions.

Radiological evaluation is crucial in diagnosing the underlying causes of sensorineural hearing loss (SNHL), especially in pediatric populations. It helps in identifying anatomical anomalies and their possible causes, such as congenital anomalies, structural abnormalities, vestibular pathologies, and acquired pathologies. It also guides treatment and management, allowing for personalized intervention, surgical planning, and vestibular rehabilitation. Regular radiological assessments are essential for monitoring disease progression and assessing the effectiveness of treatment plans. Early detection of ototoxic effects from medications or infections can prevent further hearing damage and improve long-term outcomes. Early diagnosis of complex conditions, such as syndromic hearing loss, can enable timely genetic counseling and family planning. Radiological evaluation also raises awareness and early detection, allowing for early intervention and educational programs to reduce stigma around hearing impairments.

This study aims to identify cochlear, vestibular, and semicircular canal diseases in pediatric patients with sensorineural hearing loss in Vindhya, aiming to improve early detection and management techniques, patient outcomes, and healthcare infrastructure development.

METHODS

- This was a **prospective, observational** cohort study done **at Shyam Shah Medical College & associated Sanjay Gandhi Memorial Hospital** in **department of Otorhinolaryngology & Head and Neck surgery, Rewa(M.P.)** carried out from September 2023-September 2024 with a Sample Size of 25 patients in the age group of 1-15 years.

The patient's history, prenatal and postnatal exams, and developmental milestones were assessed.

Once **sensorineural hearing loss (SNHL)** was diagnosed through **audiological testing** (such as **pure-tone audiometry**, **auditory brainstem response (ABR)**, or **otoacoustic emissions (OAE)**), further **higher radiological investigations** like **High-Resolution Computed Tomography (HRCT)** and **Magnetic Resonance Imaging (MRI)** were employed to understand the underlying anatomical and structural causes.

Inclusion Criteria:

1. **1–15 years** of age (population with SNHL).
2. Written informed consent obtained from parents or legal guardians for participation in the study and the use of radiological images and audiological data for research purposes.

3. Confirmed diagnosis of **sensorineural hearing loss** (through audiological testing such as pure-tone audiometry, auditory brainstem response, or otoacoustic emissions).
4. Patients who have undergone **radiological evaluation** (e.g., CT and MRI) as part of the clinical workup for SNHL.
5. Patients who are residents of the **Vindhya region**, ensuring a localized study population.

Exclusion Criteria:
1. Patients outside the age range (1–15 years) are excluded from the study.
2. Patients whose parents or guardians do not provide informed consent for participation in the study.
3. Patients with conductive hearing loss or mixed hearing loss (combination of sensorineural and conductive components) are excluded, as the study specifically targets SNHL.
4. Patients who have not undergone complete radiological evaluation (CT or MRI) or those with incomplete imaging records are excluded.
5. Patients whose hearing loss is caused by recent trauma or acute infections (e.g., meningitis, labyrinthitis) and who do not have a history of congenital or hereditary SNHL are excluded, as they might require different management.
6. Patients with speech or developmental delays that are not related to hearing loss (e.g., neurological disorders not associated with SNHL).

OBSERVATION

TABLE 1DEMOGRAPHIC DSITRIBUTION OF STUDY POPULATION

AGE GROUP	MALE(N=14)	FEMALE(N=11)	TOTAL(N=25)
1-5 years	5(20%)	3(12%)	8(32%)
6-10 years	6(24%)	4(16%)	10(40%)
11-15 years	3(12%)	4(16%)	7(28%)
TOTAL	14(56%)	11(44%)	25(100%)

The study includes a higher percentage of males (56%) compared to females (44%).The age group with the most participants is 6–10 years, with a 40% share of the study population. The 1–5 years and 11–15 years age groups have 32% and 28% of the participants, respectively**.**

TABLE 2 DURATION OF HEATING LOSS IN STUDY POPULATION

Duration of SNHL	N=25	Percentage(%)
< 1 year	8	32%
1-5 years	10	40%
6-10 years	5	20%
>10 years	2	8%
Total	25	100%

40% of participants have had SNHL for **1–5 years**, which is the most common duration in this study population.**32%** of participants were diagnosed with SNHL for **less than 1 year**, indicating that a large portion of the study population has been recently diagnosed.**20%** have had SNHL for **6–10 years**, and only **8%** have been dealing with SNHL for more than **10 years**.

TABLE 3 COCHLEAR ABNORMALITIES IN STUDY POPULATON

Cochlear Abnormalities	Number of patients	Percentage(%)
Mild	6	23 %
Moderate to severe	2	9%
Cochlear nerve Deficiency	5	18%
Aplastic Cochlear Pathology	2	6%
Hypoplastic Cochlear Pathology	2	9%

100% of the study population (N = 25).**Cochlear Abnormalities**:Include **mild (23%)** and **moderate to severe abnormalities (9%)**, totaling **32%** of the study population. **Cochlear Nerve Deficiency**: Accounts for **18%** of the study population.**Aplastic Cochlear Pathology**:Present in **6%** of patients (approximately 2 participants).**Hypoplastic Cochlear Pathology**:Found in **9%** of patients (approximately 2 participants).

TABLE 4 VESTIBULAR ABNORMALITIES IN STUDY POPULATION

Vestibular Abnormalities	Number of patients(N=24)	Percentage (%)
Enlarged vestibular aqueduct	4	16%
Vestibular Hpoplasia (Underdeveloped)	2	8%

Enlarged vestibular aqueduct (EVA), the most common vestibular anomaly, present in **16% (4 patients)**. Vestibular hypoplasia affects **8% (2 patients)**, characterized by an underdeveloped vestibular system.

TABLE 5 SEMICIRCULAR CANAL ABMORMALITIES IN STUDY POPULATION

Semicircular canal Abnormalities	Number of patients(N=5)	Percentage (%)
Aplasia (Absence of SCC)	2	8%
Hpoplasia (Underdeveloped SCC)	3	12%

Aplasia: Represents **8% of patients** (**2 patients**) with a complete absence of one or more semicircular canals. Typically leads to severe vestibular dysfunction and balance issues. **Hypoplasia:** Accounts for **12% of patients** (**3 patients**), indicating underdeveloped semicircular canals.May cause mild to moderate balance disturbances **.**Overall, **20% of the study population** (**5 patients**) exhibits semicircular canal anomalies.

RESULTS

Male participants represented 56% of the study population, making up the majority of participants. Female participants comprised 44% of the study population.

1–5 years (32%, N=8):Early childhood shows a substantial number of participants, likely because congenital or early-onset causes of SNHL (e.g., genetic factors, perinatal infections) are often diagnosed in this age group.

6–10 years (40%, N=10): The largest age group, representing **40%** of the study population. This may reflect the cumulative identification of SNHL as children enter school, where **speech and language delays**, **academic difficulties**, or **social challenges** become more noticeable.

11–15 years (28%, N=7): This adolescent group forms the smallest age cohort in the study, with **28%** of participants.

Mild cochlear abnormalities were observed in **23%** of patients (6 out of 25).Moderate to severe abnormalities contributing to **9%** of patients (2 out of 25). **32%** of the study population had combined form of cochlear abnormality. **18%** of patients had **Cochlear Nerve Deficiency** (5 out of 25). **Aplastic Cochlear Pathology** occurred in **6%** of patients (2 out of 25). **Hypoplastic Cochlear Pathology** was observed in **9%** of patients (2 out of 25).

Among the 25 patients in the study, **vestibular abnormalities** were noted in a total of **6 patients (24%)**. **Enlarged Vestibular Aqueduct (EVA) was** present in **4 patients (16%)**, making it the most prevalent vestibular anomaly observed in the study. **Vestibular Hypoplasia was** identified in **2 patients (8%)**, characterized by an underdeveloped vestibular system.

Among the **25 patients** in the study, **semicircular canal abnormalities** were noted in **5 patients. Aplasia of Semicircular Canal refers to complete absence and** was seen in **2%** of the study population which contributed to **8%. Hypoplasia** which refers to underdeveloped Semicircular Canal was seen in **3 patients ,** making **12%** of the study population.

DISCUSSION

The higher percentage of males (56%) in the current study aligns with global and regional patterns of male predominance in pediatric SNHL. This higher male predominance could reflect inherent gender-based susceptibility to sensorineural hearing loss (SNHL), or it might be due to referral patterns or health-seeking behaviors specific to the Vindhya region. According to **Saurabh et.al** 1, males were more frequently reported with SNHL than females in rural and semi-urban regions.

The lower proportion of females may be influenced by sociocultural factors in the region, where healthcare access or prioritization for female children might differ. Similar findings were observed in a study done by **Christian k. Pederson et.al** 2. According to a study by **Villavisanis DF et.al** 3**,** certain genetic conditions linked to SNHL, such as *POU3F4*-related X-linked hearing loss, predominantly affect males.However, many non-syndromic forms of genetic SNHL showed no significant gender bias. In a study done by **Haile et.al** 4 , male predominance was noted in low- and middle-income countries

1–5 years (32%, N=8):This age group highlights the importance of early audiological screening and intervention to improve outcomes. The **32% prevalence in 1–5 years** observed in the Vindhya region is consistent with findings that early childhood is a critical period for identifying congenital or early-onset SNHL. Similar results were found by Simon R et.al5 and Mir Mohm.et.al6 indicating hearing loss was most commonly identified in children aged **1–5 years** .

6–10 years (40%, N=10): School-age children might also have more structured healthcare access due to school health programs. The **6–10 years age group** accounted for the largest proportion of cases (approximately 40–45%) in studies, aligning with the school-going population where **speech delays** or **academic struggles** often lead to diagnosis.

11–15 years (28%, N=7): Late identification of SNHL in this group could result from **progressive or acquired hearing loss** (e.g., infections, trauma, ototoxicity) or earlier cases not diagnosed in younger years due to limited healthcare access. The age of the children ranged from 9 to 18 years, and the mean age was 15.74 years. Adolescents are less likely to receive timely diagnosis due to reduced parental monitoring compared to younger children. 7

According to this study, cochlear abnormality was present in 32% (8 patients) out of 25 patients. Mild cochlear abnormlity was 23% and moderate abnormalities 9%,cochlear Nerve Deficiency was 18% ,aplastic cochlear pathology was in 6% and lastly hypoplastic cochlear pathology was 9% . A study by **Sennaroglu et.al** 8 depicted mild cochlear abnormality was seen in 43.5 %, moderate cochlear abnormality was observed in 17.4 % cases, ~30.4% showed cochlear nerve deficiency and 30.4 % had aplastic cochlear pathology .

Ahmad Daneshi et.al 9 found incomplete partition type-I, 19 (17.8%) patients; incomplete partition type-II, 31 (29%), common cavity, 17 (15.9%), cochlear hypoplasia, 17 (15.9%), and isolated enlarged vestibular aqueduct (isolated EVA), 23 (21.5%) patients. EVA was the coexisting anomaly in 27(25.2%) subjects .

Vestibular abnormalities were detected in 6 of the 25 participants in the research (24%).

Enlarged Vestibular Aqueduct (EVA) was 16%, 2 patients (8%) had vestibular hypoplasia.

A research published in the **European Journal of Pediatrics**10 found that EVA is one of the most c ommon inner ear defects in children with SNHL, accounting for roughly 11.9% of cases.

Another study in **OtolaryngologHead & Neck Surgery** discovered that the prevalence of EVA vari ed depending on the diagnostic criteria utilized, with the Cincinnati criteria identifying 44% of indiv iduals with EVA, compared to 16% recognized by the Valvassori criterion 11. A study by **Eshrak Hassanein et.al** in the Journal of International Advanced Otology reveled that vestibular hypoplasia is a common CT finding in children with SNHL, accounting for up to 25% of cases. 12.

The research discovered semicircular canal anomalies in 5 of the 25 individuals, with 2% with total absence and 8% having hypoplasia, suggesting undeveloped canals**. Satar B et.al** 13 identified 15 patients with congenital absence of the semicircular canals. Among these, 9 patients had CHARGE association, a syndrome known to include SCC anomalies. Research published in JAMA Otolaryngology–Head & Neck Surgery 14 examined the prevalence of SCC hypoplasia in children with SNHL.

The study discovered that 76% of the children had bilateral severe to profound SNHL, with a signifi cant proportion showing SCC hypoplasia.This highlights the relationship between SCC underdevelo pment and substantial hearing impairment.

CONCLUSION

This study gives useful insights into the radiological examination of pediatric sensorineural hearing loss (SNHL) in a cohort of 25 patients from the Vindhya region.

HRCT and MRI imaging are critical in chidren as well

as juvenile SNHL patients, particularly in Vindhya, which has limited access to modern diagnostic t echniques. The results highlight the value of thorough radiological imaging, including high-resolution CT (HRCT) and MRI, in detecting the underlying etiologies of SNHL, especially when clinical examination and audiological testing alone may not offer clear answers. It emphasizes on congenital inner ear abnormity as a major cause, impacting balance and coordination. Additionally highlighting the need for vestibular system assessment in young SNHL patients.

Recognizing related abnormalities in syndromic situations, such as CHARGE syndrome, can help w ith early genetic counseling and family assistance.

Early detection of problems can lead to effective treatment plans, such as hearing rehabilitation and vestibular therapy.

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