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Original Research Article

Screening of Newborns and Infants for Hearing Assessment by Otoacoustic Emission Test in a Rural Area

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Abstract:

Background: Hearing is essential for speech, language, and cognitive development. In India, 4–6 out of every 1000 children are born with significant hearing impairment. Early identification and intervention are critical, particularly in rural areas where prevalence is higher and access to care is limited. OAE (Otoacoustic Emission) testing, including TEOAE (Transient Evoked Otoacoustic Emission) and DPOAE (Distortion Product Otoacoustic Emission) methods provide a simple, non-invasive tool for early hearing loss detection in neonates.

Methods: This cross-sectional study was conducted from November 2016 to September 2018 in rural areas of Chikkaballapur district, Karnataka. A total of 953 neonates and infants attending primary health centers were screened using a three-stage protocol. The first and second stages involved TEOAE/DPOAE testing and those who failed were subjected to BERA (Brainstem Evoked Response Audiometry) as a confirmatory test.

Results: Out of 953 screened neonates and infants, the prevalence of hearing loss was found to be 0.419%. The study demonstrated the effectiveness of the TEOAE/DPOAE screening protocol in early identification of congenital hearing loss.

Conclusion: OAE based screening is a reliable, feasible and efficient method for early detection of congenital hearing loss particularly in rural settings. Incorporating this method into UNHS (Universal Newborn Hearing Screening) programs can facilitate early diagnosis and timely intervention, promoting optimal speech and language development.

Keywords: Neonatal Hearing Loss, Transient Evoked Otoacoustic Emissions, Distortion Product Otoacoustic Emissions, Brainstem Evoked Response Audiometry, Newborn Screening.

Introduction

Hearing assessment is a crucial component in evaluating children with speech or hearing problems, as hearing loss has the highest incidence among pediatric disabilities and should be identified early for effective intervention.[1] Globally, hearing loss is the second leading cause of YLD (Years Lived with Disability), accounting for 4.7% of total YLD.[2] In India, approximately 6.3% of the population suffers from significant auditory loss,[3] with higher prevalence noted in rural areas compared to urban settings.[4] According to the 58th round of the National Sample Survey Organization (2002), 291 individuals per 100,000 population are affected by severe to profound hearing loss.[5]

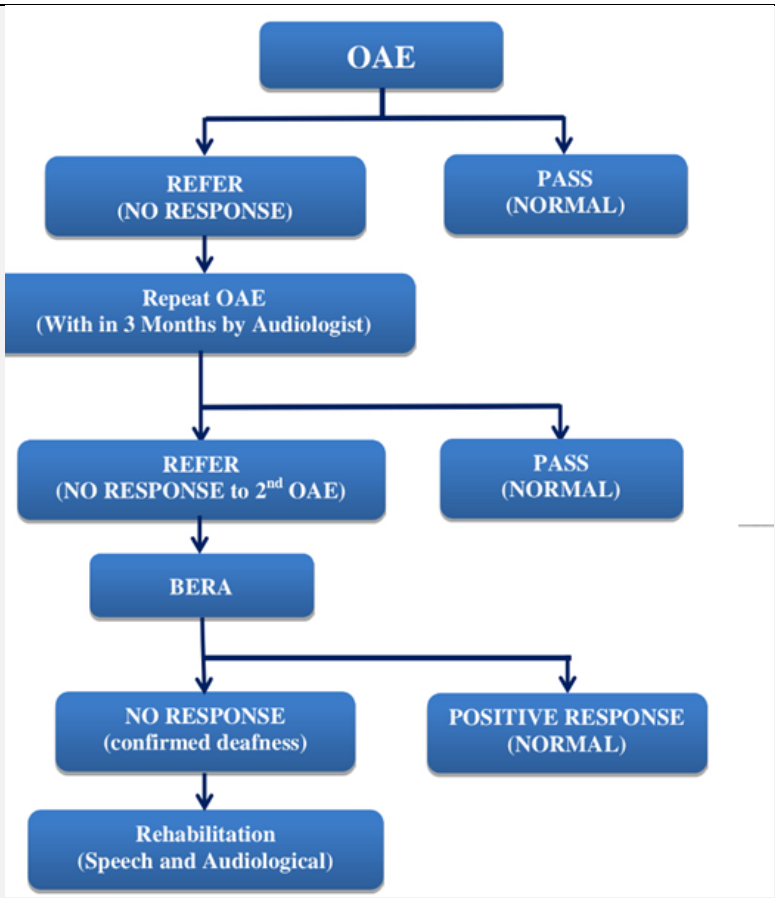
Timely assessment and referral of children with suspected hearing loss are essential. Informal tests like the whisper test often delay diagnosis and should be avoided. Instead, modern screening tools allow for early and accurate detection through both screening and diagnostic assessments.[1] Early identification, especially before six months of age, significantly improves language development in affected children.

OAEs are sounds of cochlear origin, which can be recorded by a microphone fitted into the ear canal. They are caused by the motion of the cochlea's sensory hair cells as they energetically respond to auditory stimulation. OAEs are non-invasive, objective indicators of cochlear (outer hair cell) function and are widely used in universal newborn hearing screening.[6] Two types of OAE used in our study are:

- **TEOAE (Transient Evoked Otoacoustic Emissions):** These are elicited using brief sounds like clicks and are useful for detecting cochlear function primarily in the 1000–4000 Hz range.
- **DPOAE (Distortion Product Otoacoustic Emissions):** These are evoked using two continuous tones and provide frequency-specific information, making them particularly helpful for monitoring hearing over time.

Both types are fast, painless and reliable for initial hearing screening. OAEs also assist in differential audiological diagnosis, monitoring treatment outcomes and guiding management strategies.[6] However OAEs cannot assess neural (retrocochlear) pathways.

To evaluate neural conduction pathways from the cochlea to the brainstem, BERA also known as ABR (Auditory Brainstem Response) is used. BERA is an objective electrophysiological test that records the brain's response to auditory stimuli (clicks or tone bursts). It is particularly useful for assessing infants, children with developmental delay or those uncooperative for behavioral testing. BERA helps to differentiate between sensory and neural hearing loss.



OAE Flow Chart

Aims and Objectives

This study evaluates the need for universal neonatal hearing screening in rural areas through a three-stage screening protocol using OAEs and BERA. It aims to assess the feasibility and importance of implementing comprehensive hearing screening programs in resource-limited rural settings.

Materials and Methods

Study Design: This cross-sectional study was conducted among neonates and infants attending PHCs (Primary Health Centres) in the rural areas of Chikkaballapur district. The study was carried out over a period of 23 months, from November 2016 to September 2018. All neonates and infants who presented to the PHCs during the study period were included as study subjects to assess the hearing using a three-stage screening protocol involving OAE and BERA.

Inclusion and Exclusion Criteria: The study included all neonates and infants attending the Primary Health Centres in the rural areas of Chikkaballapur district during the study period. However, neonates and infants with congenital defects of the ear, as well as those diagnosed with acute otitis media or otitis externa were excluded from the study to ensure accurate assessment of hearing through objective screening methods.

Sample Size Calculation: Sample size was calculated using the formulae –

$$N = \frac{Z a^2 P(1-P)}{D^2}$$

Where Z is a constant, Z = 1.96 for 95% confidence interval

P is the prevalence of neonatal hearing loss, P = 0.56%

D is precision which is 20% of P.

Based on this, the sample size was estimated roughly to be 335 neonates and infants. So considering this proportion, a minimum of 335 neonates and infants attending the Primary Health Centre of Kaiwara and Bagepalli, rural areas belonging to Chikkaballapur district were recruited based on the inclusion and exclusion criteria.

Data Collection Procedure: Data collection was carried out through a structured, three-stage hearing screening process among neonates and infants attending primary health centres in the rural areas of Kaiwara and Bagepalli in Chikkaballapur district. Prior to testing, parents or guardians were counseled on the importance of early detection and intervention for congenital hearing loss and informed written consent was obtained. A brief clinical history, particularly focusing on perinatal risk factors was taken, followed by a thorough ear examination including inspection of the external ear and otoscopic evaluation using a Welch Allyn otoscope. All eligible infants underwent Stage 1 screening using TEOAE/DPOAE (Transient or Distortion Product Evoked Otoacoustic Emissions) with the INTERACOUSTICS PORTABLE OTOREAD XP machine conducted in a quiet room with the infant in a supine position preferably asleep. Infants who failed this initial test (result: "REFER") were recalled within three months for Stage 2 screening, which included a repeat OAE test after ENT evaluation. Those who failed the second screening were referred for Stage 3 testing with BERA performed by a qualified audiologist at M. S. Ramaiah Medical College and Hospital using the Interacoustics Eclipse BERA system. Data on test outcomes were systematically recorded for both ears throughout all stages.

Statistical Analysis: Descriptive and inferential statistical analyses were performed using SPSS version 18.0 and R version 3.2.2. Continuous variables were summarized as mean ± standard deviation (min–max), while categorical variables were expressed as frequencies and percentages. Significance was assessed at the 5% level. The chi-square test or Fisher's exact test was applied for categorical data, depending on cell size with assumptions of normal distribution of dependent variables, random sampling and independence of observations. Statistical significance was denoted as suggestive (+) for p-values between 0.05 and 0.10, moderate for $p \leq 0.05$, and strong for $p \leq 0.01$. Microsoft Word and Excel were used for generating graphs and tables.

Results

Table 1: Demographic Profile of Mothers and Infants

Variable	Category	Frequency (n)	Percentage (%)
Maternal Age	19–24 years	460	48.3%
	25–29 years	461	48.4%
	30–35 years	32	3.4%
Mode of Delivery	Normal	903	94.8%
	Caesarean	50	5.2%
Gender of Neonates	Female	478	50.2%
	Male	475	49.8%

Table 1 provides an overview of maternal and neonatal demographics. Most mothers were between 19 and 29 years old, with a nearly equal distribution across age groups. Normal delivery was predominant. Gender distribution was also balanced

Table 2: Age Distribution of Neonates

Age Group	Female (n/%)	Male (n/%)	Total (n/%)
<1 month	71 (14.9%)	65 (13.7%)	136 (14.3%)
1–2 months	133 (27.8%)	117 (24.6%)	250 (26.2%)
2–6 months	182 (38.1%)	192 (40.4%)	374 (39.2%)
7–12 months	92 (19.2%)	101 (21.3%)	193 (20.3%)
Total	**478 (100%)**	**475 (100%)**	**953 (100%)**

Table 2 details the age-wise distribution of neonates by gender. The majority of neonates were in the 2–6 months age group consistent across both genders.

Table 3: Outcome of OAE Screening

Screening Stage	Pass (n/%)	Refer (n/%)	Total (n/%)
1st OAE	779 (81.7%)	174 (18.3%)	953 (100%)
2nd OAE	170 (97.7%)	4 (2.3%)	174 (100%)
Final OAE	949 (99.6%)	4 (0.4%)	953 (100%)

Table 3 summarizes results across two stages of OAE screening. Initial referrals were 18.3%, which dropped to 0.4% after re-screening and confirmatory testing, indicating high test specificity

Table 4: BERA Testing Outcome

Category	No. of Patients	Percentage (%)
BERA Done	4	100.0%
Hearing Loss Found	4	100.0%
Normal (No BERA)	949	99.6%
Not Responded Cases	4	0.4%

Table 4 shows that BERA confirmed hearing loss in all four referred cases. There were a few cases with no follow-up data (N/R) spread over several months.

Table 5: Correlation Between OAE and BERA

Test	Done (n/%)	Pass (n/%)	Refer (n/%)
1st OAE	953 (100%)	779 (81.7%)	174 (18.3%)
2nd OAE	174 (100%)	170 (97.7%)	4 (2.3%)
BERA	4 (100%)	0 (0.0%)	4 (100.0%)

Table 5 illustrates a perfect correlation between second-stage OAE referrals and confirmed hearing loss on BERA, validating the stepwise screening process.

Table 6: Correlation of Maternal Factors with Final Hearing Diagnosis

Variable	Final Diagnosis - PASS (n/%)	REFER (n/%)	Total (n)	P-Value
Maternal Age				0.553
19–24 years	457 (48.2%)	3 (75%)	460	
25–29 years	460 (48.5%)	1 (25%)	461	
30–35 years	32 (3.4%)	0 (0%)	32	
Mode of Delivery				0.194
Caesarean	49 (5.2%)	1 (25%)	50	
Normal	900 (94.8%)	3 (75%)	903	

Table 6 investigates maternal factors such as age and mode of delivery in relation to final hearing outcomes. No statistically significant associations were found

Table 7: Correlation of Neonatal Factors with Final Hearing Diagnosis

Variable	Final Diagnosis - PASS (n/%)	REFER (n/%)	Total (n)	P-Value
Age of Neonates				0.010*
<1 month	136 (14.3%)	0 (0%)	136	
1–2 months	246 (25.9%)	4 (100%)	250	
2–6 months	374 (39.4%)	0 (0%)	374	
7–12 months	193 (20.3%)	0 (0%)	193	
Gender				0.624
Female	475 (50.1%)	3 (75%)	478	
Male	474 (49.9%)	1 (25%)	475	

Table 7 examines the correlation between neonatal factors and final diagnosis. A significant association was found between age (particularly 1–2 months) and likelihood of referral, whereas gender showed no statistical correlation.

Discussion

In our rural OAE-based newborn hearing screening initiative, the prevalence of hearing loss stood at approximately 4.19 per 1,000 live births, confirmed via BERA. A study in Maval Taluka, Maharashtra by Joshi et al. recorded a prevalence of 3.54 per 1,000.[7] Gupta & Kumar reported 1.4 per 1,000 in Jodhpur using a DPOAE→BERA two-stage protocol among mainly urban, high-risk neonates.[8] In Mangalore, Reddy et al., found 0.96 per 1,000 cases of confirmed hearing loss after rescreening 950 newborns.[9]

Our initial referral rate of 18.8% at first-stage OAE reduced to 0.6% after repeat testing and ultimately to 0.4% post-BERA. In Chennai, Nair et al., conducted a two-step TEOAE–DPOAE protocol among 404 neonates, noting 10.9% (TEOAE) and 11.3% (DPOAE) first-stage referral rates-validating the importance of multi-stage approaches.[10] Internationally, Zhang et al., reported a 17.9% initial referral rate and a final confirmed prevalence of 2.25 per 1,000 in rural China using a DPOAE→AABR protocol.[11]

Our protocol aligns with global best practices. Gangadhara et al., screened 14,226 neonates in Shimoga using three-stage OAE followed by BERA, identifying 11 cases (~0.8 per 1,000) of hearing loss, confirming the method's utility at scale. Suligavi et al., screened 800 neonates in Bagalkot via TEOAE and ABR, finding a 0.25% prevalence.[12] High-risk screening in Gulbarga by Tegnoor & Naaz further reinforced risk associations with 8 out of 500 high-risk infants testing positive.[13]

Consistent risk factors like prematurity, low birth weight and NICU stay were observed across studies.[8,14] Our integration of screening with immunization visits effectively improved follow-up compliance, a strategy also beneficial in Zhang's rural Chinese study.[11]

India's NPPCD (National Programme for Prevention and Control of Deafness) endorses a model of community level OAE screening, repeat testing during immunization visits and referral for BERA at tertiary centers.[15] Our program mirrors this successful national model, reinforcing the importance of decentralized, community-based screening tied to existing health services.

Conclusion

The study reveals a 0.419% prevalence of neonatal and infant hearing loss in the rural areas of Kaiwara and Bagepalli, aligning with national statistics of 4–5 per 1000 births. Using a three-stage screening protocol involving OAE and BERA, it demonstrates that OAE is a feasible and effective tool for UNHS (Universal Newborn Hearing Screening) in rural settings. Despite challenges such as limited awareness and healthcare access in these areas, universal screening is essential, as selective screening may miss up to half of infants with sensorineural hearing loss. Early detection through UNHS enables timely intervention, leveraging advancements in diagnostic and rehabilitative audiology, and should be systematically implemented even in rural regions to reduce the burden of hearing impairment.

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