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Sweep frequency impedance measures in Australian Aboriginal and Caucasian neonates

Venkatesh Aithal [a,b,*], Joseph Kei [b], Carlie Driscoll [b], Andrew Swanston [c], Michio Murakoshi [d], Hiroshi Wada [e]

[a] Audiology Department, Townsville Hospital and Health Service, Douglas, Australia
[b] Hearing Research Unit for Children, School of Health and Rehabilitation Sciences, University of Queensland, Brisbane, Australia
[c] Department of ENT, Townsville Hospital and Health Service, Douglas, Australia
[d] Department of Mechanical Engineering, Kagoshima University, Kagoshima, Japan
[e] Department of Intelligent Information System, Tohoku Bunka Gakuen University, Sendai, Japan

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ABSTRACT

Objective: Despite high prevalence of otitis media in Aboriginal children, the acoustic–mechanical properties of their outer and middle ear during the neonatal period remain obscured. The objective of this study was to compare the acoustic–mechanical properties of outer and middle ear using Sweep Frequency Impedance (SFI) measures between Australian Aboriginal and Caucasian neonates.
Methods: SFI data from 40 ears of 24 Aboriginal neonates (16 males, 8 females) with mean gestational age of 39.57 weeks (SD = 1.25) and 160 ears of 119 Caucasian neonates (57 males, 62 females) with mean gestational age of 39.28 weeks (SD = 1.25) serving as controls were analysed. SFI data in terms of resonance frequency (RF) and mobility of the outer and middle ear (ΔSPL) were collected from neonates who passed a test battery that included automated auditory brainstem response, distortion product otoacoustic emissions test and 1000-Hz tympanometry. SFI data were analysed using descriptive statistics and analysis of variance.
Results: There was no significant difference in mean gestational age, age of testing and birth weight between the Aboriginal and Caucasian neonates. The mean resonance frequencies for the outer ear (mean RF1 = 264.9 Hz, SD = 58.6 Hz) and middle ear (mean RF2 = 1144 Hz, SD = 228.8 Hz) for Aboriginal neonates were significantly lower than that of Caucasian neonates (mean RF1 = 295.3 Hz, SD = 78.4 Hz and mean RF2 = 1241.8 Hz, SD = 216.6 Hz). However, no significant difference in the mobility of outer ear (ΔSPL1) and middle ear (ΔSPL2) between the two groups was found. Middle ear resonance was absent in 22.5% (9 ears) of Aboriginal ears but present in all Caucasian ears.
Conclusions: This study provided evidence that despite passing the test battery, Aboriginal neonates had significantly lower resonance frequencies of the outer and middle ear than Caucasian neonates. Furthermore, 22.5% of Aboriginal neonates showed no middle ear resonance, indicating the possibility of subtle middle ear issues not detected by the test battery. Reasons for the different acoustic-mechanical properties between the two ethnic groups remain unclear and require further investigation.

1. Introduction

Australian Aboriginal children have a high prevalence of otitis media (OM) compared to Caucasian children [1–6]. OM is reported to start within the first few months of life in Aboriginal infants and children. In a prospective otoscopic study of young infants in three Aboriginal communities, Rebgetz et al. [1] and Douglas and Powers [4] found that, by one year, up to two thirds of infants had at least one perforated ear drum. Peak incidence of ear drum perforation occurred at around 18 weeks and 50 weeks. In another study, Foreman [5] found that of 425 ears examined in Aboriginal infants and young children, only 5 ears (1.2%) were normal and 420 ears (98.8%) had evidence of abnormality.

In a longitudinal study, Boswell and Nienhuys [3] used pneumatic otoscopy, 226 Hz tympanometry and auditory brainstem response audiometry (ABR) to detect OM in 30 Aboriginal infants and 16 Caucasian infants. They reported that 95% of Aboriginal

* Corresponding author at: Consultant Clinical Audiologist, Department of Audiology, IMB 79, Townsville Hospital and Health Service, 100 Angus Smith Drive, Douglas 4814, QLD, Australia. Tel.: +61 744332765/+61 439755065; fax: +61 7 47962751.
E-mail addresses: venkatesh.aithal@health.qld.gov.au, sreedeviaithal@hotmail.com (V. Aithal).

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infants compared to only 30% of Caucasian infants showed signs of OM with acute infection by eight weeks after birth. They also reported that once OM started early in life, it became persistent despite treatment in Aboriginal infants.

In another longitudinal study, Lehmann et al. [7] monitored middle ear function in 100 Aboriginal and 180 Caucasian infants from birth to two years of age using transient evoked otoacoustic emission (TEOAE) test, 226-Hz tympanometry and otoscopic examinations by an otolaryngologist. They found that TEOAEs were present in 90% (46/51) of Aboriginal and 99% (120/121) of Caucasian neonates aged less than one month. However, the percentage of TEOAEs present dropped to 62% (21/34) for Aboriginal and 93% (108/116) for Caucasian infants aged 1–2 months. These authors also noted that Aboriginal infants who failed TEOAEs at age 1–2 months were 2.6 times more likely to develop OM subsequently than those who passed. However, such prediction was not demonstrated in Caucasian infants with a failed TEOAE outcome at age 1–2 months [7].

In a recent study, Aithal et al. [15] studied 211 infants (54 Aboriginal, 157 Caucasian) referred through a newborn hearing screening program in Queensland, Australia. They reported higher prevalence of middle ear pathology in Aboriginal infants (44.4%) compared to Caucasian infants (28.7%). They also reported significantly higher prevalence of conductive hearing loss in Aboriginal infants (37.9%) compared to Caucasian infants (17.8%). Additionally, Aboriginal infants showed poor resolution of conductive hearing loss over time with 66.7% of Aboriginal infants reviewed showing persistent conductive hearing loss compared to only 17.9% of Caucasian infants.

In summary, the studies on Aboriginal infants have indicated that they are more likely to have OM during the neonatal period and that they are more likely to have recurrent OM later in life compared to their Caucasian peers. The findings of these studies were derived from standard tests which included otoscopy, 226-Hz tympanometry, ABR, 1000-Hz tympanometry (HFT) and TEOAE test. Nevertheless, these tests do not provide detailed information about the acoustic–mechanical properties of outer and middle ear in neonates. Sweep frequency impedance (SFI), an advanced technology, has shown promising results in analysing the acoustic–mechanical behaviour of outer and middle ear in normal neonates [8,9]. In view of the high prevalence of OM and conductive hearing loss in Aboriginal infants during the first few months of life, it is very important to study the acoustic–mechanical properties of the outer and middle ear system in these neonates.

SFI measures the resonance frequency (RF) and mobility of the outer and middle ear in terms of changes in sound pressure level (ΔSPL) [10–12]. According to Murakoshi et al. [9], the resonance that occurs in the low-frequency region (e.g., 250–300 Hz) may be associated with the movement of the elastic external ear canal wall of neonates, while the resonance that occurs in the higher frequency region (e.g., 1100–1300 Hz) may be associated with the movement of the middle ear components. These acoustic–mechanical properties have the potential to detect outer and middle ear dysfunction in neonates.

Nonetheless, to date, there have been no studies that have investigated differences in the acoustic–mechanical properties of the outer and middle ear system between Aboriginal and Caucasian neonates using SFI measures. The research question is: Are there any significant differences in the acoustic–mechanical properties of the outer and middle ear between Aboriginal and Caucasian neonates? The objective of the present study was to compare SFI findings measured at ambient pressure between Australian Aboriginal and Caucasian neonates who passed a test battery containing HFT, distortion product otoacoustic emission (DPOAE), and automated auditory brainstem response audiometry (AABR) screening tests.

2. Material and methods

2.1. Participants

The present study included 24 Aboriginal and 119 Caucasian neonates who passed all three tests in a test battery that consisted of AABR, DPOAE and HFT. All neonates had uneventful birth history with no medical complications and risk factors for hearing loss [13]. This study was approved by the Human Research Ethical Committee of Townsville Hospital and Health Service and the University of Queensland Behavioural and Social Sciences Ethical Review Committee. Parents provided written consent for neonates to be included in the research project.

Table 1 shows the case details of Aboriginal and Caucasian neonates who passed the test battery. Data obtained from 40 ears (21 right and 19 left) of 24 Aboriginal neonates (16 males and 8 females) and 160 ears (84 right and 76 left) of 119 Caucasian neonates (57 males and 62 females) were analysed. The results of independent sample *t*-test showed no significant differences in gestational age [t (141) = 0.304, $p > 0.05$], age at time of testing [t (141) = 0.222, $p > 0.05$], and birth weight [t (141) = 0.885, $p > 0.05$] between Aboriginal and Caucasian neonates.

2.2. Procedure

Otoacoustic emissions (OAEs) and AABR are currently used for hearing screening in neonates. However, successful recording of OAEs and AABR require both healthy inner ear and normal or near normal middle ear function. While passing AABR indicates global normal auditory function, AABR is not sensitive to subtle middle ear and cochlear conditions [14,15]. Hence a pass in AABR screening may not always assure normal middle ear function. Although OAEs are useful for assessing the function of the conductive pathway, the OAE results may be affected by physiologic and ambient noise [16]. HFT or DPOAE test alone does not appear to be effective in detecting middle ear disorders [17]. While use of a single test alone may not be accurate in detecting middle ear disorders, Aithal et al. [18] advocated the use of a battery of tests which may provide greater assurance of an efficient conductive pathway. In the present study, a test battery consisting of AABR, HFT and DPOAE tests was employed to check for conductive conditions. However, it is acknowledged that it is not an ideal gold standard for detecting conductive disorders.

Table 1
Case details of Aboriginal and Caucasian neonates who passed test battery. Results of *t*-test showed no significant difference in gestational age, age at time of testing, and birth weight.

	Aboriginal	Caucasian	*t*	Df	*p* value
Number of neonates	24	119			
Males	16	57			
Females	8	62			
Number of ears	40	160			
Right ear	21	84			
Left ear	19	76			
Gestational age (weeks)					
Mean	39.57	39.28			
SD	1.25	1.25	0.304	141	NS
90% range	36.4–41.3	37–41			
Age at time of testing (hours)					
Mean	50.49	45.16			
SD	18.10	19.70	0.222	141	NS
90% range	23.2–83.2	19–85			
Birth weight (grams)					
Mean	3470.00	3484.90			
SD	414.90	470.00	0.885	141	NS
90% range	2643–4230	2730–4040			

NS = not significant.