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Comparing Newborn Hearing Test Batteries: TEOAE and A-ABR – Pilot Study

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Abstract

The aim of the newborn hearing screening programme is early detection of hearing loss. Transient evoked otoacoustic emissions (TEOAE) and automised auditory brainstem response (A-ABR) are effective, objective and valuable test batteries for newborn hearing screening, and they should be used together. The purpose of this study is to determine which test battery is more accurate and can be used as the gold standard. A total of 933 newborn children were included in this study, of which 602 were girls and 331 boys. 622 of them were screened with TEOAE, while 311 with A-ABR. 31 of the newborn screened with A-ABR and 27 of those screened with TEOAE were referred in the hearing screening programme. The results showed that out of 933, 17 subjects had hearing loss. The hearing loss rate was 1.8%; 12 of the newborn screened with A-ABR and 5 of those screened with TEOAE had hearing loss.

Keywords: Hearing loss, TEOAE, ABR, newborn hearing screening.

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1. Introduction

Permanent hearing loss varies in different countries. For example hearing loss incidence is 1 newborn in every 1,500 births in the USA, 1 newborn in every 2,000 births in Sweden, 1 newborn in every 800 births in Israel, 1 or 2 newborn in every birth in Turkey [1]. Early identification of hearing loss is important to decrease or prevent the consequences of hearing impairment in future communication skills and in the academic life of a baby [2]. The newborn hearing screening programme goal is the early detection of hearing loss [3]. Transient evoked otoacoustic emissions (TEOAE) and automised auditory brainstem responses (A-ABR) are used in the newborn hearing screening programme [4].

TEOAE is frequency dispersive and can be measured in the external ear canal. TEOAE can record normal hearing [5]. TEOAE is an objective and non-invasive measurement method, generated from the outer hair cells (OHCs). When TEOAE is present, hearing thresholds are about 30–40 dB HL. There are many cautions in the absence of TEOAE. It arises from middle ear dysfunction or sensorineural hearing loss. Absence of TEOAE should not be interpreted as hearing loss. Presence of TEOAE should be interpreted as good hair cells function. However, TEOAE never determines exact hearing thresholds. The presence of TEOAE alone cannot indicate that hearing sensitivity is normal, because TEOAE is a response of the cochlea. If dysfunction is in the auditory nerve or low brainstem, TEOAE is measured as normal [3].

The otoacoustic emission (OAE) test determines the cochlear status, specifically hair cell function. This information can be used to screen hearing (particularly in neonates, infants, or individuals with developmental disabilities). The information can be obtained from patients who are sleeping or even comatose, because no behavioural response is required. Sounds are emitted in response to an acoustic stimulus of very short duration, usually clicks, but can be tone bursts [6].

ABR audiometry is the most common application of auditory evoked responses. The ABR test measures the hearing nerve's response to sounds. The A-ABR test is often ordered if a newborn fails the hearing screening test given in the hospital shortly after birth or for older children if there is a suspicion of hearing loss that was not confirmed through more conventional hearing tests [7, 8].

A-ABR is a tool that evaluates the auditory system [3]. A-ABR with clicks is commonly used in the newborn hearing screening programme [4].

In Turkey, if a newborn has a risk factor in terms of hearing loss, we use A-ABR for hearing screening, whereas if the newborn has no risk factor, we use TEOAE or A-ABR.

The risk factors of hearing loss in newborn are premature birth (gestational<34 weeks), low birth weight (<1,500 g), genetics factors, TORCH infections, neurological disorders, hyperbilirubinemia, craniofacial anomalies and some syndromes associated with hearing loss, APGAR<7 at min [9].

Both A-ABR and TEOAE are used in newborn hearing test. The purpose of this study is to determine which test battery is more accurate and can be used as the gold standard.

2. Materials and Methods

2.1. Individuals

We conducted a retrospective study to compare the TEOAE and A-ABR methods between March 2015 and March 2017, using Mustafa Kemal University Research Hospital Audiology Database. A total of 933 newborn were included in this study of whom 602 were girls and 331 were boys. Of these newborn, 622 were screened with TEOAE, while 311 were screened with A-ABR. Of the newborn referred for the hearing screening programme, 58 had been screened with A-ABR and 50 had been screened with TEOAE. All the participants referred were diagnosed for whether they had hearing loss or not. Diagnostic test batteries (diagnostic ABR, diagnostic OAE and tympanometry) were applied to

all the referred newborn between 3 and 6 months of age. Of those screened with A-ABR, 12 had hearing loss, whereas 5 of the newborn screened with TEOAE had hearing loss. Ten of them were boys and seven were girls. All the newborn children had risk factor screened with A-ABR.

A-ABR and TEOAE test batteries were applied to the newborn in the 0–14 days' age. Informed consent was obtained from the parents and ethical approval was obtained from the Mustafa Kemal University Ethical Council.

2.2. Audiological Evaluation

A total of 622 newborn were screened with TEOAE, while 311 of them were screened with A-ABR. All the newborn children that had applied to the Mustafa Kemal University Hospital Audiology department were included. Hearing screening tests were made through TEOAE or A-ABR. Hearing test was made with diagnostic ABR, diagnostic OAE and tympanometry. So if the patient has hearing loss, it means the test battery is more accurate.

TEOAEs and ABR tests were compared with each other and the more accurate of them was examined.

Some of the babies that were included in this study were tested with TOAEs and some of them with A-ABR. Each baby who was referred to the hearing screening tests was tested with diagnostic ABR, diagnostic TEOAEs and tympanometry to check for hearing loss. The similarity between the diagnostic tests and A-ABR or TEOAEs means the greater reliability of the test. All the tests were made by only one audiologist.

2.3. Statistical Analyses

We performed the analyses using the SPSS statistical software. Descriptive measures are summarised as frequency and percentage (*n*%). The chi-squared test was used to compare the differences between TEOAEs and ABR tests. Probability values of less than 0.05 were considered as significant.

3. Results

It was found that 622 subjects were examined with TEOAE test and 311 with A-ABR test. We found that 58 of newborn screened with A-ABR and 50 of newborn who screened with TEOAE were referred in the hearing screening test. Twelve of the newborn screened with A-ABR had hearing loss, while five of the newborn screened with TEOAE had hearing loss. Totally 17 subjects had hearing loss and 916 were healthy (Table 1). The hearing loss rate is 1.8% (17/933). Ten of them were boys and seven were girls (Table 1).

Table 1. Hearing screening test results

Test protocol	**TEOAE**		**A-ABR**	
	n (933)	%	*N* (933)	%
	622	66.6	311	35.4
Test results	*n* (622)	%	*N* (311)	%
Refer	50	8,1	58	18.64
Pass	572	91.9	253	81.35
Hearing loss	*n* (50)	%	*N* (58)	%
Had hearing loss	5	10	12	20.68
Did not have hearing loss	45	90	46	79.32

We noticed that newborn babies with hearing loss had the hearing loss risk factor. Some of them had two and more risk factors. We recorded that nine of them had intensive care unit history, five of their parents had consanguineous marriage, five of them had hyperbilirubinemia, one of them had low birth weight (1,500 g), two of them were premature, one of them had Down syndrome and one of them had a cleft palate. One of the newborn's mothers had herpes zoster virus during pregnancy.

4. Discussion

We conducted this study to determine which test battery is more accurate and can be used as the gold standard. We found that A-ABR is more accurate compared to TEOAE, but for more reliable results, both of them should be used together.

Hearing loss is the most important defect for emotional, social, speech, language development and academic success. Emotional, social, speech, language development and academic success depend on normal hearing. Therefore, hearing screening tests must be done for all newborn babies to prevent emotional, social, academic, speech and language defects. The average age of identification of hearing loss is delayed, because both parents and doctors do not diagnose that the baby has hearing loss [10, 11]. Ideally, if the baby has hearing loss, using proper hearing aid is begun by the age of 6 months [10]. Therefore, objective test batteries must be used to determine hearing loss.

The true time for hearing screening is before discharge from the hospital after birth. Two methods have been used for hearing screening: TEOAE and A-ABR [10].

TEOAE is generated from OHCs. If everything is normal from auricle to cochlea, TEOAE is present and the amplitude is robust [3].

A-ABR is informed from the auricle to brainstem. If the baby has normal hearing, results of A-ABR show that the baby has passed the test. This means that everything is normal from the auricle to the brainstem in these babies [3].

We found that A-ABR is a more accurate test battery than TEOAE. Two test batteries should be used for newborn hearing screening. We generally use TEOAE in newborn without risk factor and A-ABR in newborn with risk factor.

A-ABR gives important information about central hearing screening. The disadvantages of the A-ABR test are consumption expense, long time required for TEOAE and the baby should be sleeping in the test [1, 12]. The advantages of TEOAE are simple, easy screening, requires little time for testing and the baby's being quiet is enough [12]. The disadvantages of TEOAE are it is affected by external ear and middle ear diseases.

Auditory neuropathy (AN) is a hearing disorder characterised by the preservation of the OHC function, despite the absence of ABRs. TEOAE is present but A-ABR is absent in patients with AN [13]. Therefore, AN cannot be diagnosed only by TEOAE. Using A-ABR and TEOAE together is more reliable in AN for the newborn hearing screening programme.

Rouev et al. [10] preferred A-ABR to identify hearing-impaired infants. They found the sensitivity of A-ABR to be 100% and specificity 98.87%. A-ABR is a better screening test for newborn infants, because A-ABR has a high tolerance of noise and allows flexibility in screening location and timing.

Brass et al. [14] found the sensitivity of TEOAE to be 100% and specificity 98.1%. They declared that TEOAE is effective and efficient for identifying hearing loss in the newborn.

Connolly et al. [15] defined that several screening protocols should be used to minimise the cost and screening failures. TEOAE followed by A-ABR on the same day prevents missing AN diagnosis.

Norton et al. [5] reported that TEOAEs easily measure newborn infants with and without the risk factor for hearing loss.

Cacace and Pinheiro [16] reported that TEOAE and A-ABR provide valuable information about the auditory system integrity and sensitivity. Using both test batteries is suited for the newborn.

Ghirri et al. [2] reported that TEOAE is an adequate test battery. It is objective, economic and rapid. A-ABR is necessary to identify AN. In addition, it is important to reduce the number of false positive test results.

Korres et al. [17] found that A-ABR and TEOAE are useful in newborn hearing screening. However, the lower referral rate obtained by A-ABR and its potential to recognise babies at risk for AN, and central pathology should be considered.

We found the hearing loss incident to be 1.45% in this study.

This rate changes from country to country. This rate is 1:1,500 in the USA, 1: 2,000 in Sweden, 1: 800 in Israel and 2: 1,000 in Turkey [1].

We conducted this study in Hatay, Turkey. In this region there are a lot of consanguineous marriages. Because of consanguineous marriages, this incident is higher than in other regions of Turkey and in other countries.

Cancer, cardiac problems, stomach intestine disease, psychological problems, hypertension and hearing loss problems are commonly seen in populations in which consanguineous marriage rates are high [18, 19]. In the healthy newborn, hearing loss rates are between 0.1% and 0.6% [20]. Genc *et al.* [1] reported that profound sensorineural hearing loss rates are 0.20%. Ovet *et al.* [20] defined this rate as 0.1%.

5. Conclusion

TEOAE and A-ABR are effective, objective and valuable test batteries for newborn hearing screening. A-ABR and TEOAE should be used together in all newborn babies. The first assessment should be applied in the first month of birth for early diagnosis in children who have hearing loss; children who are doubtful of have hearing loss should be followed. Children with hearing loss should be counselled about hearing loss rehabilitation centres.

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