

# Comparison of hearing thresholds of patients with advanced, and very advanced sensorineural type hearing loss using tone-evoked ABR

## İleri ve çok ileri derece sensörinöral (S/N) işitme kaybı olan hastaların işitme eşiklerinin tonal ABR ile karşılaştırılması

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### Abstract

**Objective:** In the present study, thresholds of airway tone-burst auditory brainstem response (ABR), and pure-tone audiometry were compared, and correlations between threshold values obtained with classical audiometric methods, and pure-tone airway hearing in individuals with advanced, and very advanced sensorineural (S/N) hearing loss were investigated.

**Methods:** Eighty patients with advanced and very advanced S/N hearing loss were included in the study. Pure-tone air conduction thresholds of advanced, and very advanced S/N hearing loss patients detected at 500, 2000 and 4000 Hz frequencies were compared with tone-burst ABR threshold values.

**Results:** Our study population consisted of males with a mean age of 21.8±3.45. Mean differences between thresholds of tone-burst, and pure-tone audiometry were detected to be 4.75 dB, 6.25 dB, and 4.87 dB at stimulus frequencies of 500 Hz, 2000 Hz, and 4000 Hz, respectively.

**Conclusion:** In conclusion, in patients with S/N hearing loss, a strong correlation is found between pure-tone audiometry thresholds, and electrophysiological thresholds obtained at 500, 2000, and 4000 Hz with tone-evoked ABR wave-V. Tone-ABR can be used as a reliable test in the diagnosis of patients with hearing loss in conditions where pure-audiometry cannot be performed.

**Keywords:** Pure-tone audiometry, advanced sensorineural type hearing loss.

### Özet

**Amaç:** Bu çalışmada hava yolu tonal ABR ile saf ses hava yolu işitme eşiklerinin karşılaştırılması yapılarak; klasik odyometrik yöntemlerle ileri ve çok ileri derece sensörinöral (S/N) işitme kaybı olan kişilerin tonal ABR ile elde edilen eşiklerinin korelasyonu araştırılmıştır.

**Yöntem:** İleri ve çok ileri derece S/N işitme kaybı olan 80 hasta çalışmaya dahil edildi. Saf ses ölçümlerinde ileri ve çok ileri derecede sensörinöral işitme kaybı hastaların 500, 2000 ve 4000 Hz’te elde edilen saf ses hava yolu eşikleri ile tonal-ABR eşik değerleri arasında karşılaştırma yapıldı.

**Bulgular:** Çalışmaya alınan hastaların yaş ortalaması 21.8±3.45 olarak saptandı ve tüm hastalar erkekti. Tonal ABR ve saf ses eşikleri arasında 500 Hz uyaran için ortalama fark 4.75 dB, 2000 Hz uyaran için 6.25 dB ve 4000 Hz uyaran için fark 4.87 dB bulunmuştur.

**Sonuç:** Sonuç olarak ileri derece S/N işitme kaybı olan bireylerde saf ses odyometri eşikleri ile 500, 2000 ve 4000 Hz tonal ABR V.dalga ile elde edilen elektrofizyolojik eşikler arasında güçlü bir korelasyon vardır. Tonal ABR, saf ses odyometri yapılamadığı durumlarda, işitme kaybı olan hastaların tanısında güvenilir bir test olarak kullanılabilir.

**Anahtar sözcükler:** Saf ses odyometri, ileri derecede sensörinöral işitme kaybı.

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Hearing is one of the important functions which enables adaptation, and communication of the organism with its environment. Sensorineural hearing (S/N) is realized with the aid of cochlear cilia, and neurons, pathways up to the cerebral cortex, and their integration. Interference to the functions of one of these components for various reasons leads to S/N hearing loss. As etiological factors of this interference genetic (syndromic, non-syndromic), congenital infections (rubella, CMV), infections (rubeola, measles, toxoplasmosis, syphilis), ototoxicity, exposure to noise, and presbiacusia have been suggested.<sup>[1]</sup>

Frequently, and prevalently applied first test for the detection of hearing sensitivity in adult patients is pure-tone audiometry. Pure-tone audiometry detects the type, and severity of the hearing loss. In the detection of airway hearing threshold, the average of the airway hearing thresholds at 500-1000 Hz, and 2000 Hz is taken into consideration.<sup>[2]</sup> Data which can be obtained using pure-tone audiometry are related to the hearing thresholds, the laterality, and the type of the hearing loss, and the frequencies affected.<sup>[3]</sup> Although this test is not one of the objective hearing tests, it is an indispensable audiologic test in the orientation of diagnostic, follow-up, and therapeutic processes.

Evoked auditory brainstem potentials is an objective test which is used for the determination of hearing thresholds in pediatric cases who cannot comply with pure-tone audiometry tests or in adults, and children who make simulation or cannot show cooperation on the test for any reason (ie. mental retardation). Auditory brainstem response (ABR) audiometry is a battery of tests, which enable objective evaluation of auditory potentials stemming from the structures at a level of VIII cranial nerve, and lower brainstem following acoustic stimuli. In the determination of hearing threshold, ABR provides information about the peripheral hearing sensitivity. In ABR, tonal stimulus is the most important stimulus in obtaining frequency-specific response.

In the present study, thresholds of airway tone-burst ABR, and pure-tone audiometry were compared, and correlations between threshold values obtained with classical audiometric methods, and pure-tone airway hearing in individuals with advanced and very advanced S/N hearing loss were investigated.

## Materials and Methods

This study was performed between May 2005 and June 2007 in the Laboratory of Evoked Auditory Potential of Ear-Nose and Throat Department of G llhane Military

Medicine Academy (GATA). Among 85 patients with advanced and very advanced S/N hearing loss, only 5 cases with a history of operation were not included in the study. Demographic, and clinical data of the patients were recorded. The study was approved by the ethics committee. The patients were firstly subjected to pure-tone audiometry, then tone-burst ABR (tone-ABR) test was performed, and hearing threshold values were estimated. Patients with completely healthy eardrums as detected by otoscopic examinations were included in the study. In every patient with suspect retrocochlear pathologies, CT was used to rule out this possibility. Classical audiometric tests were performed by IAC AC-5 model clinical audiometry equipment. For ABR analysis, Nicolet Compact Auditory model electrodiagnostic system was used.

For the retrieval of tone-ABR recordings, 4 mm-diameter silver electrodes were used. During testing, active, and ground electrodes were placed on the forehead, and reference electrode on the ipsilateral mastoid cortex. Electrode impedances were attentively kept under 5 K . All cases were sedatized with 0.01 mg/kg IM midazolam (Dormicum) during enrolment. Tone-burst stimuli with alternant polarity were used. Rise/fall/plateau times of tonal stimuli were selected as 1-8-1 ms. ABR pure-tone average, and duration of analysis were determined, and set at 2000 ms, and 20 ms, respectively. During tests EEG upper, lower cut-off values of filter settings were selected as 30, and 3000 Hz, and duration of analysis as 25 ms. Tone-burst ABR stimuli were delivered at frequencies of 500, 2000, and 4000 Hz. High-pass, and low-pass ABRs were filtered at frequencies of 30, and 1500-3000 Hz, respectively.

Pure-tone air conduction thresholds of advanced and very advanced S/N hearing loss patients detected at 500, 2000 and 4000 Hz frequencies were compared with tone-ABR threshold values. Pure-tone audiometry tests of the same individual were performed twice in the same ambient conditions using threshold values.

Recorded test data were subjected to statistical analysis. Mean values, and standard deviations were calculated. Mean values for gender, age of the patients, recordings for right, and left ears were compared using Student's t test. Since ABR threshold values were different, and scattered noncompliant with normality of distribution, nonparametric statistical tests were used. The correlation between tone-ABR, and pure-tone audiometry thresholds was analyzed using Spearman's rank order test.

## Results

Ages of the patients included in the study ranged between 18, and 26 years. Our study population consisted of males with a mean age of  $21.8 \pm 3.45$ .

To determine threshold of tone-ABR, wave-V was evaluated. In 58 (72.5%) patients with very advanced hearing loss as detected by pure-tone audiometry, stimuli at a high intensity (90 dB nHL) did not elicit any response in auditory-evoked brainstem audiometry (wave-V could not be detected). In 20 patients with very advanced S/N hearing loss, stimuli at 90 dB nHL yielded a response. One (1.25%) patient responded to stimuli at an intensity of 80 dB nHL, and frequency of 500, 2000 Hz, while another patient yielded a response to stimuli at an intensity of 80 dB nHL, and frequencies of 500, 2000, and 4000 Hz. The wave-V was distinctly recognized, and defined at a level of 90 dB nHL which was determined as the threshold value. Mean absolute latencies of wave-V of the patients with very advanced hearing loss (75-90 dB) when the patient was exposed to a stimulus at a level of 90 dB nHL were determined as  $11.06 \pm 1.40$  ms,  $8.80 \pm 0.50$  ms, and  $8.60 \pm 0.70$  ms, at frequencies of 500 Hz, 2 kHz, and 4 kHz, respectively.

When all patient population was considered, mean differences between thresholds of tone-burst, and pure-tone audiometry were detected to be 4.75 dB, 6.25 dB, and 4.87 dB at stimulus frequencies of 500 Hz, 2000 Hz, and 4000 Hz, respectively.

Spearman's rank test was used to analyze the correlation between thresholds of tone-ABR, and pure-tone audiometry at stimulus frequencies of 500-2000, and 4000 Hz, then correlation coefficients between thresholds were calculated for each frequency. p values showed statistically significant and strong correlation ( $p=0.945$ ;  $p=0.962$ ;  $p=0.985$ ) (Table 1).

## Discussion

Since evaluation of hearing using behavioral audiometry is based on patients' self-reported information, it is a subjective

test. It is not possible for an individual to evaluate his/her actual behavioural threshold completely, and exactly independent from one's feelings. Though its application is more difficult, and time consuming than other tests, in conditions where determination of threshold is complicated with other factors, ABR is a valid, and objective method for the measurement of hearing thresholds.

Stapells et al. detected that when compared with pure-tone audiometry thresholds tone-ABR thresholds were 10-20 dB nHL higher in individuals with normal hearing acuity, while in individuals with sensorineural hearing loss this increment was 5-15 dB nHL.<sup>[4]</sup> In our study, in patients with very advanced S/N hearing loss, a difference of 4-6 dB nHL was found.

Durgut et al. detected differences of 13, 7, 8 dB between thresholds of tone-burst ABR, and pure-tone audiometry applied at 500, 2000, and 4000 Hz, respectively in individuals with normal hearing acuity, while the corresponding differences in patients with sensorineural hearing loss were 13,7, and 8 dB.<sup>[5]</sup> They did not include patients with very advanced hearing loss in their study. In our study the respective differences were 4.75, 6.25, and 4.87 db, respectively.

Kisat et al. compared pure-tone audiometry thresholds with tone-burst ABR thresholds with rise/fall/plateau times of 1-1-1, 1-2-1, 1-4-1, and 1-8-1 ms duration in 10 individuals with normal hearing acuity, and 21 patients with sensorineural hearing loss. They noted a 3-18 dB difference between thresholds of tone-burst ABR, and pure-tone audiometry. They detected that as the frequency increased, the difference between thresholds of ABR, and pure-tone audiometry decreased, and especially when tone-ABR stimuli with 1-8-1 ms were used. However in higher frequencies, thresholds of ABR, and pure-tone audiometry were close to each other. In patients with sensorineural hearing loss, and flat audiograms, they detected that difference between thresholds of pure-tone audiometry, and tone- burst ABR ranged between 2.5, and 25 dB. They observed better outcomes in lower frequencies.<sup>[6]</sup>

In many studies, consistent results have been obtained regarding differences between the thresholds of tone burst ABR, and pure-tone audiometry. The results retrieved have demonstrated differences owing to the diverse methodologies used.

Generally, the longer is the rise/fall, and plateau times of tone burst stimuli, the frequency range generated in the cochlea induced by these stimuli narrows proportionally.

**Table 1.** Correlation between thresholds of tone-ABR, and pure-tone audiometry at stimulus frequencies of 500-2000, and 4000 Hz.

	500 Hz	2000 Hz	4000 Hz
Tone-ABR (dB nHL)	89.75	89.75	89.87
Pure-tone audiometry (dB HL)	85	83.5	85
p value	0.945	0.962	0.985

Therefore stimulus tends to stimulate cochlea within a narrow band of frequencies, and thus selectivity for frequency predominates. Because of weakness of synchronized activities induced by these types of stimuli, the amplitudes of pre-determined responses, and their detection rates decrease. However, tone-burst stimuli with relatively shorter rise/fall times evoke better synchronized responses. Since these types of stimuli induce wider spectral scattering, they are subjected to interference from other frequencies. Consequently, wave recognizability is increased, at the risk of decreased frequency-specificity.<sup>[7,8]</sup> Besides studies performed have detected that response latency is prolonged in proportion with increased rise/fall times.<sup>[9-11]</sup> In our study, among patients with advanced hearing loss, number of recognizable waves increased without a marked prolongation of latency.

## Conclusion

In conclusion, in patients with S/N hearing loss, a strong correlation is found between pure-tone audiometry thresholds, and electrophysiological thresholds obtained at 500, 2000, and 4000 Hz with tone-evoked ABR wave-V. Tone-ABR can be used as a reliable test in the diagnosis of patients with hearing loss in conditions where pure-audiometry cannot be performed.

**Conflict of Interest:** No conflicts declared.

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