

# Comparison of auditory steady state response (ASSR) & auditory brainstem response (ABR) hearing thresholds in young children

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## Author's Contribution

<sup>1</sup> Conception, synthesis, planning of research and manuscript writing

<sup>2</sup> Interpretation and discussion

<sup>3,4</sup> Data analysis, interpretation and manuscript writing

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## A B S T R A C T

**Objective:** Hearing loss (HL) with a local prevalence of 5.7%, is the commonest childhood disability, requiring Early Hearing Detection and Intervention (EHDI) programs to reduce the disability burden. Knowing the degree, type and configuration of HL is prerequisite for appropriate amplification, with Automated Auditory Brainstem Responses (ABR) being commonly used for this purpose, however Auditory Steady State Response (ASSR) has been recently introduced in the region. This study was conducted to compare ABR to ASSR, as an early diagnostic tool in children under five years of age.

**Methodology:** This cross-sectional comparative study was performed at the Auditory Verbal Institute of Audiology and Speech (AVIAS) clinics in Rawalpindi and Islamabad, from December 2016 to September 2017. It included thirty-two cases (n=32) who visited AVIAS clinics for hearing assessment and conformed to the investigative protocol using non probability convenient sampling technique, and subjected to both ABR and ASSR for comparative purposes. Correlations were calculated between the thresholds obtained by ABR and ASSR.

**Results:** N=32 children (64 ears) with male female ratio of 2.2:1 and mean age of 33.50±17.73 months were tested with ABR and ASSR for hearing thresholds and correlation coefficient between 2KHz, 4KHz ASSR and average of both with ABR was calculated to be 0.92 and 0.90 and 0.94 respectively.

**Conclusion:** ASSR provides additional frequency specific hearing threshold estimation compared to C-ABR, essentially required for proper setting of amplification devices.

**Keywords:** Brainstem evoked response audiometry, auditory brainstem response, Hearing loss.

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## Introduction

Hearing loss with a local prevalence of 5.7%<sup>1</sup> and 13.6% in 5-15 years old school children,<sup>2</sup> being the commonest childhood disability, results in a high burden on economies like Pakistan.<sup>3</sup> Importance of Early Hearing Detection and Intervention (EHDI) programs cannot be over emphasized, since even a delay in intervention up to first year of life results in detrimental effects on communication and psychosocial development of the child.<sup>4</sup> Oto-acoustic emissions (OAE) and Automated Auditory Brainstem Responses (ABR) are being used for objective hearing screening of new-born, and those failing

hearing screening are referred for further diagnostic evaluations.<sup>5</sup> Rehabilitation of hearing impaired demands timely detection & intervention through appropriate amplification, for which pre requisites like the degree, type and configuration of HL before 6 months of age are absolutely essential.

ABR and Auditory Steady State Responses (ASSR) are objective electrophysiological tests to detect hearing sensitivity. Click evoked ABR (C-ABR) is recorded as a far field transient response with the help of electrodes

mounted on the scalp. It has been in use since long for objective hearing evaluation. Neural synchrony is needed to record ABR by the use of abrupt onset stimulus such as click. However, this abruptness of the onset of the stimulus implies broadness of the stimulus spectrum.<sup>6</sup> Thus C-ABR lack the ability to provide useful frequency specific knowledge about hearing thresholds and due to transducer limitations for producing high intensity abrupt onset stimulus, it is poor in differentiating between severe and profound hearing losses,<sup>7</sup> indicating a clear need for better techniques to manage the technical limitations of C-ABR. Therefore the focus shifted to the use of slowly rising frequency specific stimulus to evoke auditory potentials such as Tone Burst to produce reliable threshold estimates within 15dB of behavioral thresholds.<sup>8</sup> However, low frequency tone burst evoked response waveforms are less distinct and difficult to identify through visual inspection,<sup>9</sup> as low frequencies have to travel to the apical end of the cochlea to evoke the response thus loss of neural synchrony is observed and thus poorer wave morphology was observed and also transient nature of the response limits the assessment of multiple frequencies. ASSR seems to cater to these issues. These are rhythmic brain potentials noted in response to ongoing periodic stimulus. In ASSR, multiple frequency tones called carrier frequency, are amplitude/frequency/mixed modulated with respect to distinct tones called modulating tone, and simultaneously presented. Detection is automatic through statistical methods resulting in robustness of the technique. ASSR might have more important usage compared to C-ABR assessment of state of arousal and supra-threshold hearing in anesthetized state, in addition to auditory threshold measurements.<sup>10</sup>

ASSR is a new technique rarely being used in the country while C-ABR is a widely used technique. The widespread clinical application of ASSR demands a thorough comparative study of the two techniques. Therefore, the current study was designed to compare Auditory Brainstem Response (ABR) to Auditory Steady State Response (ASSR) as an early diagnostic tool in children under five years of age. This study is important because no such study has come up from this part of the world.

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## Methodology

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This cross-sectional study was conducted at Auditory Verbal Institute of Audiology and Speech (AVIAS) clinics, located in Islamabad and Rawalpindi. Data collection was conducted in a span of 10 months from Dec 2016 to Sept 2017. The Study population consists of n=32 patients selected by convenience sampling, and from both the genders, under the age of 5 years who visited AVIAS clinics for hearing assessment. Patients having any other disability and/or those in whom ABR and/or ASSR could not be performed were excluded from the study. Both ABR and ASSR were performed on the same visit in a quiet room with patient in deep sleep with syrup chloral hydrate given per orally in a dose of 50 mg/kg body weight. Electrode placement included high forehead (Fpz) for recording, left mastoid (M1) for reference and right mastoid (M2) for ground after skin sites prepared by rubbing with Nu prep skin preparation gel to keep impedance under 5kohm, followed by electrode placements. Additionally, it was ensured that impedance difference between reference and recording electrode was under 1kohm so that effective common mode rejection ratio was achieved.

PATH Medical's Sentiero Advanced Instrument was used to perform all ABR and ASSR tests and data was transferred to a laptop for reporting purpose using PATH medical's software Mira. The ABR reporting and wave marking was done by the researcher himself and reviewed by colleague audiologists. For ABR, click stimulus at a rate of 10 clicks per second was used with a time window of 12ms and click stimulus presented 3000 times with response averaging, while for ASSR, frequency modulated tones at 80Hz was used to evoke ASSR test and recording done at four stimulus frequencies including 500 Hz, 1 KHz, 2 KHz and 4 KHz. However, where needed responses on 250 Hz, 6 KHz and 8 KHz were also recorded.

Test results having no response on 2 KHz or 4 KHz ASSR or C-ABR were excluded from the sample for this study, because correlation coefficient cannot be calculated between them without making assumptions. The data was organized and SPSS 20 (Statistical Package for Social Studies) was used for statistical analysis. Correlation coefficients between 2 KHz and 4

KHz ASSR and the average of both with click evoked ABR (C-ABR) hearing thresholds were calculated. The results obtained were then compared with local and international literature.

## Results

With a view to compare C-ABR to Auditory Steady State Response (ASSR) as an early diagnostic tool in children under five years (60 months) of age, hearing threshold estimation with ABR and ASSR was done followed by statistical analysis of the test results. Total sample population included 32 children (64 ears) with a male female ratio of 2.2:1. Their age range was 4 to 60 months with a mean age of  $33.50 \pm 17.73$  months (table 1) with maximum population  $n=10$  (31.25%) in the age group of 12-24 and 48-60 months each (table 1 and 2).

**Table 1: Demographic Data of Study Population (n=32)**

<b>Gender</b>	Male	22 (56%)
	Female	10 (44%)
<b>Age (Months)</b>	Minimum	4
	Maximum	60
	Mean	33.50
	Median	37.00
	Standard Deviation	17.73

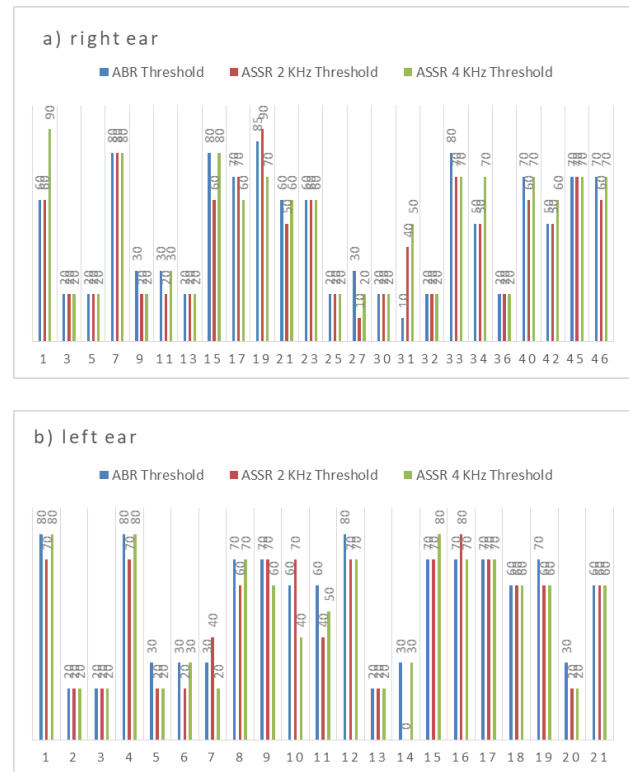
Note: Multiple modes exist. Only the smallest value is shown.

**Table 2: Distribution of Age & Gender: Age Group \*Gender Cross Tabulation (n=32)**

Age Group (Months)	Female		Male		Total		Cum %age
	No	%	No	%	No	%	
0-12	1	33.33	2	66.67	3	9.37	9.37
12-24	3	30.00	7	70.00	10	31.25	40.62
24-36	1	50.00	1	50.00	2	6.25	46.87
36-48	2	28.57	5	71.43	7	21.88	68.75
48-60	3	30.00	7	70.00	10	31.25	100
Total	10		22		32		

No: Absolute frequencies  
%: Relative frequencies

A total of 64 ears were tested and out of these 64 ears 18 were excluded from data analysis since no response to C-ABR was observed up till the limits of the equipment and thus no comparison could be made with ASSR thresholds, thus leaving behind a total of  $n=46$  cases on which data analysis was performed. Figure 1, shows the ABR and ASSR thresholds of the study population.



**Figure 1: Auditory Thresholds of study population of a) right ear (n= 25 ears) b) left ear (n=21 ears)**

Pearson correlation calculated for C-ABR thresholds with 2kHz ASSR, 4kHz ASSR and the average of both was found to be 0.92 and 0.90 and 0.94 respectively (Table 3).

**Table 3: Pearson Correlation coefficients between ABR and 2 KHz and 4 KHz ASSR (n=46 ears)**

		ASSR (2 KHz)	ASSR (4 KHz)	ASSR avg.
<b>ABR threshold</b>	Pearson Correlation	.918*	.904*	.938*
	Sig. (2-tailed)	.000	.000	.000
	N	46	46	46

\* Correlation is significant at 0.01 level (2 tailed).

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## Discussion

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In infants and children frequency specific thresholds of hearing are important for better amplification and ASSR with its multiple frequency testing facility provides an opportunity for estimation of frequency specific thresholds of hearing in babies.<sup>11</sup> ASSR has shown comparable results to pure tone audiometry in adults.<sup>12</sup> Since hearing thresholds obtained by C-ABR is closely related behavioral thresholds in 2 KHz – 4KHz frequency region, this study calculated how well the 2 KHz and 4 KHz ASSR hearing thresholds correlate to those obtained by C-ABR. N=46 ears were tested with ABR and ASSR for hearing thresholds and correlation coefficient between 2 KHz, 4 KHz ASSR and average of both with C-ABR was calculated to be 0.92 and 0.90 and 0.94 respectively. These results are consistent with previous studies. In a similar study by Vander Werff KR et al, conducted on infants and young children with significant correlation of 0.97 was found for C-ABR with 2 KHz and 4 KHz ABR.<sup>13</sup> In contrast in a study Luts H et al, found correlation of 0.77, between ABR and ASSR thresholds at 2 KHz frequency.<sup>11</sup> Also Celik O et al, found strong correlation between ABR and ASSR thresholds at 4 KHz, however the correlation at other frequencies were not strong.<sup>14</sup>

It is important to point out that out of total of n=64 ears, n=18 ears were excluded from data analysis, since no response to C-ABR was present till the limit of the equipment and these were cases in which ASSR showed responses at least at the low frequencies (250 Hz, 500 Hz, 1 KHz). This is an important result and have also been reported by other studies.<sup>15</sup> This information about residual hearing is not only beneficial in selection of a particular intervention such as hearing aids or cochlear implants but also help fitting process of hearing aids. The stimulus used to evoke ASSR have narrower frequency spectrum thus gives more frequency specific information about hearing thresholds than the tone burst or click evoked ABR.

ASSR can be recorded binaurally at multiple stimulus frequencies simultaneously thus it takes less time to complete than tone burst ABR,<sup>16</sup> and completes procedure before the child wakes up or the sedation wears off. Also, statistical measures are applied to generate results in ASSR, eliminating the possibility of

error made in ABR that depends on marking of waves by audiologist. Another benefit of ASSR over ABR reported by many studies is that due to the nature of stimulus used in ASSR it can be used as a tool to demonstrate benefit of amplification.<sup>17</sup> Previously many studies focused to evaluate role of click evoked ABR for this purpose, but since abrupt onset of click stimulus cause distortion when presented with free field speakers. A digital hearing aids process such stimulus differently, C-ABR is not used for aided response evaluation except in cases with bone conduction hearing implants (BAHA).<sup>18</sup>

However, Click evoke ABR has its own diagnostic importance. ABR evoked thorough clicks of alternate polarity may help in identifying retro-cochlear pathologies and also the morphology of ABR waveform can lead to the site of lesion. Thus, ABR should be performed as part of complete audiological test battery for infants and young children. In difficult to test children where behavioral observation audiometry is not conclusive, ABR is the investigation which can detect the sensitivity of the ear, being useful for early detection.<sup>19</sup> Song et al, in their study to screen newborns with ASSR and DPOAE, concluded that ABR can be substituted with ASSR for screening,<sup>20</sup> while Celik O et al, concluded that ASSR is not a reliable for screening purposes, but as a complementary diagnostic investigation.<sup>14</sup>

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## Conclusion

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ASSR provides additional frequency specific hearing threshold estimation compared to C-ABR, which is essential in infants and children with hearing loss for provision of amplification devices.

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