

Comparison of CE-Chirp ABR and Click ABR methods in patients with bilateral sensorineural hearing loss

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Abstract

Objective: In this study, we aimed to compare ABR threshold values, V. wave latency times, amplitudes obtained using Click ABR and CE-Chirp ABR methods and procedural times of these tests in patients with bilateral hearing loss.

Methods: A total of 19 adult male patients were included in the study. ABR latency times with 10 dB decreases starting from 100 dB, V. wave latencies, V. wave amplitudes obtained using Click ABR and CE-Chirp ABR methods and procedural times were compared for both ears.

Results: Procedural time for CE-Chirp ABR test was found to be shorter than that of Click ABR test ($p=0.001$). For both ears, mean CE-Chirp ABR threshold values were more favorable than those of Click ABR test [(60.15±10.34 vs. 62.27±9.93) dB nHL, $p<0.006$]. For both ears, the threshold values of mean pure tone audiometry were estimated as following: 1 KHz (55.00±14.36 dB), 2 KHz (60.00±13.40 dB) and 4 KHz (63.48±10.57 dB). The corresponding values were calculated 62.27±9.93 dB nHL and 60.15±10.34 dB nHL using Click ABR and CE-Chirp ABR methods, respectively. Procedural time for CE-Chirp ABR test was shorter than that of Click ABR test [(24.89±4.74 vs. 28.63±4.98) min., $p=0.001$].

Conclusion: It has been determined that the use of CE-Chirp stimulus shortened ABR procedural time and provided responses closer to behavioral threshold values. In conclusion, we observed that CE-Chirp method was more advantageous than Click ABR method for the evaluation of the patients with bilateral sensorineural hearing loss.

Keywords: CE-Chirp ABR, Click ABR, bilateral sensorineural hearing loss.

Özet: Bilateral sensorinöral işitme kayıplı hastalarda CE-Chirp ABR ve Click ABR yöntemlerinin karşılaştırılması

Amaç: Bu çalışmada bilateral sensorinöral işitme kaybı olan hastalarda Click ABR ve CE-Chirp ABR yöntemleri ile elde edilen ABR eşikleri, V. dalga latans bulguları, amplitüd bulguları ve test sürelerinin karşılaştırılması amaçlanmıştır.

Yöntem: Bilateral sensorinöral işitme kaybı bulunan 19 yetişkin erkek hasta çalışmaya dahil edildi. Click ABR ve CE-Chirp ABR yöntemleri ile her iki kulakta 100 dB'den başlanarak 10 dB'lik düşüşlerle elde edilen ABR eşikleri, V. dalga latansları, V. dalga amplitüdüleri ve test süreleri karşılaştırıldı.

Bulgular: CE-Chirp ABR test süresi Click ABR test süresinden daha kısa bulundu ($p=0.001$). Her iki kulak için ortalama CE-Chirp ABR eşikleri Click ABR eşiklerinden daha iyi saptandı [(60.15±10.34 vs. 62.27±9.93) dB nHL, $p<0.006$]. Her iki kulakta ortalama *pure tone* audiometry 1 KHz eşikleri 55.00±14.36 dB, 2 KHz eşikleri 60.00±13.40 dB, ve 4 KHz eşikleri 63.48±10.57 dB olarak tespit edildi. Bu değerler, Click ABR ile 62.27±9.93 dB nHL, CE-Chirp ABR ile 60.15±10.34 dB nHL olarak ölçüldü. CE-Chirp ABR test süresi Click ABR test süresinden daha kısa bulundu [(24.89±4.74 vs. 28.63±4.98) dakika, $p=0.001$].

Sonuç: CE-Chirp uyaran kullanımının ABR test süresini kısalttığı ve davranışsal eşiklere daha yakın cevaplar sağladığı belirlenmiştir. Sonuç olarak bilateral sensorinöral işitme kayıplı hastaların değerlendirilmesinde CE-Chirp ABR yönteminin Click ABR yönteminden daha avantajlı olduğu gözlenmiştir.

Anahtar sözcükler: CE-Chirp ABR, Click ABR, bilateral sensorinöral işitme kaybı.

Evoked auditory brainstem responses (ABRs) are auditory evoked potentials emerging between 2–12 milliseconds after delivery of auditory stimuli.^[1,2] Click ABR method is the most frequently preferred and used method for ABR

recordings.^[2] In Click ABR measurements, the time interval for a sound wave to reach cochlear apex is prolonged. In an area of lower frequency, the peak point of the response becomes manifest milliseconds after the region of high fre-

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Received: February 27, 2018; **Accepted:** March 30, 2018

Online available at:
www.entupdates.org
doi:10.2399/jmu.2018001009
QR code:



quency. Therefore, cells of the basal membrane are not stimulated at the same time and as a result, depolarization of the nerve cells cannot be achieved at the same time.^[3,4] This condition may be described as the travelling time of the sound wave inside the cochlea or cochlear travel delay.

CE-Chirp stimulus has been developed to evaluate auditory brainstem responses and ensure synchronized stimulation of cochlea.^[5] Click-stimulus and CE-Chirp-stimulus have the same range of frequency spectrum ranging between 350 and 11,300 Hz.^[6] The difference between CE-Chirp and Click stimuli arises from delivery times of components with low, moderate and high frequencies so as to stimulate all areas of frequencies simultaneously.^[7] All components of high frequencies are sent later than the components with lower frequencies. Due to especially adjusted temporal distribution of its components, CE-Chirp stimulus simultaneously accesses into characteristic regions of the basal membrane. Since all cochlear regions are simultaneously depolarized by CE-Chirp stimulus, ABR waves with higher amplitude are obtained. CE-Chirp stimulus seems to be the most optimal model for an average human cochlea.^[8]

In this study, we compared ABR threshold values, V. wave latencies, V. wave amplitudes achieved and procedural times of Click ABR and CE-Chirp ABR methods in patients with bilateral sensorineural hearing loss.

Materials and Methods

Study design

The study has been conducted in accordance with the principles of the Helsinki Declaration and approved by the local Institutional Review Board (08.03.2016-119). Written informed consent was obtained from all subjects. This research study was realized between March and July 2016 in the Audiology Laboratory of Clinics of Ear-Nose-Throat of Izmir Military Hospital. As a result of pure-tone audiometry and tympanometry tests, 19 young men with bilateral sensorineural hearing loss were included in the study. Patients with lower IQs, psychiatric problems, patients who woke up before completion of the test which requires a state of sleep were not included in the study.

Outcome parameters

The patients with bilateral sensorineural hearing loss detected as an outcome of pure-tone audiometry and tympanometry applied were subjected to Click ABR and CE-Chirp ABR tests.

ABR test: Test electrodes were placed as follows: positive line was placed on the upper part of the forehead, ground line on the lower part of the forehead, one of the negative electrodes on the left mastoid and the other one on the right mastoid processes. ABR recordings were done using Interacoustics Eclipse Ep 15 ABR system (Interacoustics, Middelfart, Denmark). Test parameters were as follows: Rate: 20.1, Polarity: Alternating, HPF: 100 Hz, LPF: 3KHz and the type of signal delivered to the patient was selected (Click or CE-Chirp). Tests were started before using 100 dB click stimulus. Then with 10 dB decreases, ABR threshold values of both ears of each patient were determined. When required, 5 dB changes were made in sound intensities to identify V. Wave. Then, the same test method was repeated with CE-Chirp stimulus.

Statistical analyses

The data were analyzed using the IBM Statistical Package for Social Sciences v17 (SPSS Inc., Chicago, IL, USA). Parametric tests were applied to data of normal distribution and non-parametric tests were applied to data of questionably normal distribution. Data were expressed as mean±SD or median (interquartile range), as appropriate. All differences associated with a chance probability of .05 or less were considered statistically significant. ABR V. wave latencies and V. wave amplitudes achieved using each type of stimulus were compared using Wilcoxon Signed-Rank analysis. The lowest level of sound intensities (ABR thresholds) observed was statistically compared. Paired t-test method was used to compare procedural times of Click ABR and CE-Chirp ABR tests. The type of ABR method which yielded results closer to behavioral thresholds (pure tone audiometry 1, 2, 4 KHz regions) was investigated.

Results

Procedural time of CE-Chirp ABR test was longer than that of the Click ABR test (24.89±4.74 vs. 28.63±4.98 minutes, $p=0.001$). Mean CE-Chirp ABR threshold values of both ears were lower than those of Click ABR test (60.15±10.34 vs. 62.27±9.93 dB nHL, $p<0.006$) (**Table 1**). For both ears, the threshold values of mean pure tone audiometry were determined as following: 1 KHz (55.00±14.36 dB HL) 2 KHz (60.00±13.40 dBHL) and 4 KHz (63.48±10.57 dBHL). The threshold values were measured 62.27±9.93 dB nHL and 60.15±10.34 dB nHL using Click ABR and CE-Chirp ABR methods respectively (**Table 2**).

For both ears, lower threshold values were obtained using CE-Chirp ABR method when compared with Click ABR method (60.15 ± 10.34 vs 62.27 ± 9.93 dBHL). For right ears, CE-Chirp ABR threshold values (59.71 ± 9.6) were lower than threshold values measured using Click ABR test (62.65 ± 9.54) ($p=0.008$). For left ears, no statistically significant difference was found between threshold values obtained using Click ABR and CE-Chirp ABR tests ($p>0.05$) (Table 1 and Fig. 1).

Mean procedural time of CE-Chirp ABR test (24.89 ± 4.74 min.) was shorter than that of the Click ABR test (28.63 ± 4.98 min.) ($p=0.001$).

For right ears, CE-Chirp ABR threshold values were closer to pure tone average (PTA) 1 KHz and 2 KHz threshold values when compared with Click ABR threshold values. Click ABR threshold values were found to be closer to PTA 4 KHz threshold values relative to CE-Chirp threshold values (Table 2).

For both ears, CE-Chirp ABR threshold values were found to be closer to PTA 1 KHz and 2 KHz threshold values when compared with Click ABR threshold values. Click ABR threshold values were closer to PTA 4 KHz threshold values relative to CE-Chirp threshold values (Table 2).

Based on Wilcoxon signed-rank analysis, no statistically significant difference was found between the latencies of Click ABR and CE-Chirp ABR ($p>0.05$). However, at sound intensity levels of 70, 80, 90 and 100 dB, Click ABR latencies were longer than those of CE-Chirp ABR ($p<0.05$) (Fig. 2).

Table 1. Click ABR and CE-Chirp ABR threshold values.

Paired samples t-test	mean±SD	min-max	p-value
Click ABR threshold (right)	62.65±9.54	45–80	0.008
CE-Chirp ABR threshold (right)	59.71±9.6	40–75	
Click ABR threshold (left)	61.88±10.63	50–85	0.261
CE-Chirp ABR threshold (left)	60.63±11.38	45–80	
Click ABR threshold (right-left)	62.27±9.93	45–85	0.006
CE-Chirp ABR threshold (right-left)	60.15±10.34	40–80	

SD: Standard deviation

Wilcoxon Signed- Rank analysis was performed for the comparison between CE-Chirp ABR and Click ABR amplitudes and at sound intensity levels of 90 and 100 dB, Click ABR V. wave amplitudes were higher than CE-Chirp ABR V. wave amplitudes ($p=0.001$, $p=0.001$). At other sound intensity levels, no statistically significant difference was found between Click ABR and CE-Chirp ABR V. wave amplitudes ($p>0.05$) (Fig. 3).

Discussion

In our study, procedural time of CE-Chirp ABR test was longer than that of Click ABR test. Stuart et al. compared CE-Chirp ABR and Click ABR methods in 23 newborns, and similarly they reported shorter procedural times for Chirp ABR.^[9] New Zealand Ministry of Health National Screening Programme demonstrated that CE-Chirp ABR method yielded results nearly 3–5 minutes faster than Click ABR method.^[10] Cebulla et al. compared Click ABR and

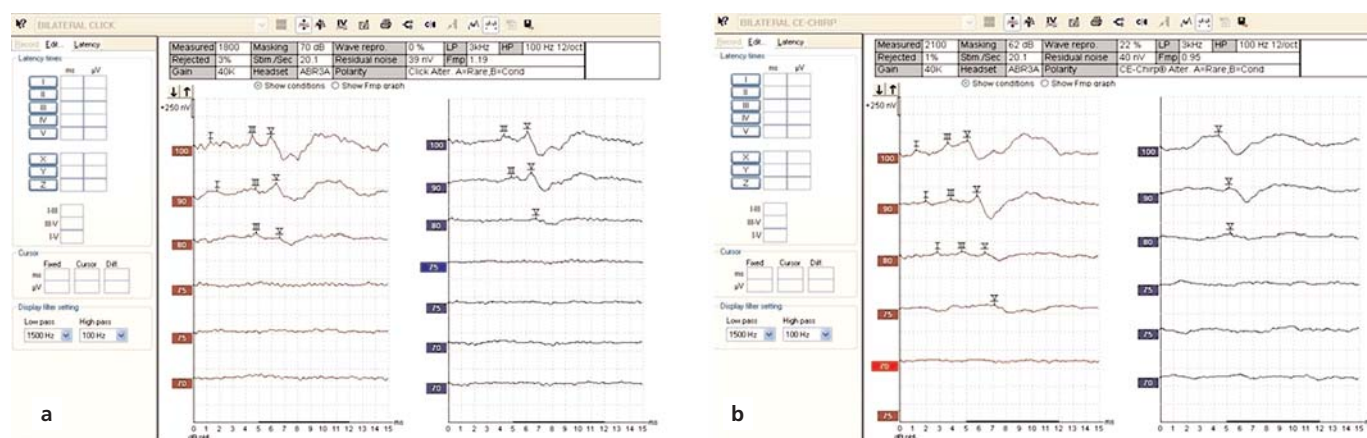


Fig. 1. The exemplary case where Click ABR (a) and CE-Chirp ABR (b) threshold values in patients with bilateral sensorineural hearing loss were compared. [Color figure can be viewed in the online issue, which is available at www.entupdates.org]

Table 2. The correlation between CE-Chirp ABR and Click ABR threshold and behavioral threshold values.

		Click ABR threshold (right)	p-value	CE-Chirp ABR Threshold (right)	p-value	
Right	Pure Tone 1 KHz threshold	52.06±14.04	62.65±9.54	0.004	59.71±9.6	0.031
	Pure Tone 2 KHz threshold	59.41±13.10		0.207		0.891
	Pure Tone 4 KHz threshold	62.94±10.62		0.884		0.119
		Click ABR threshold (left)	p-value	CE-Chirp ABR Threshold (left)	p-value	
Left	Pure Tone 1 KHz threshold	58.13±14.48	61.88±10.63	0.323	60.63±11.38	0.526
	Pure Tone 2 KHz threshold	60.63±14.13		0.728		1.000
	Pure Tone 4 KHz threshold	64.06±10.83		0.430		0.194
		Click ABR threshold (right-left)	p-value	CE-Chirp ABR threshold (right-left)	p-value	
Right-Left	Pure Tone 1 KHz threshold	55.00±14.36	62.27±9.93	0.006	60.15±10.34	0.048
	Pure Tone 2 KHz threshold	60.00±13.40		0.287		0.937
	Pure Tone 4 KHz threshold	63.48±10.57		0.466		0.041

CE-Chirp ABR methods in 96 newborns, and indicated that duration of Click ABR test was more prolonged relative to CE-Chirp ABR test.^[11]

Cho et al. compared the results of CE-Chirp ABR and Click ABR tests in 22 individuals with normal hearing acuity and 22 patients with sensorineural hearing loss.^[12] A correlation was found between PTA 0.5, 1, 2 and 3 KHz threshold values and threshold values of CE-Chirp ABR tests and also between Click ABR threshold values and PTA 1, 2, 3, 4 KHz threshold values. A correlation especially between CE-Chirp ABR threshold values and 0.5 KHz PTA threshold values were observed.^[12] In our investigation, we found CE-Chirp ABR threshold values closer to PTA 1, 2 KHz threshold values when compared with Click ABR threshold values, while Click ABR threshold values were

closer to 4 KHz behavioral threshold values. As literature reviews have indicated, CE-Chirp ABR and Click ABR methods were more frequently compared in patients with normal hearing acuity. In a study performed by Khorsand et al. in individuals with normal hearing acuity, CE-Chirp ABR threshold values were found to be 5 dB better than those of Click ABR.^[13] Our study has supported the assertion that CE-Chirp stimulus achieved more improved threshold values both in individuals with normal hearing acuity and also in patients with bilateral sensorineural hearing loss. In studies performed by Rodrigues et al. among individuals with normal hearing acuity, Ce-Chirp ABR wave amplitudes were found to be higher than those achieved by Click ABR at all levels other than 80 dB NHL (60, 40, 30, 20, 10 dB nHL).

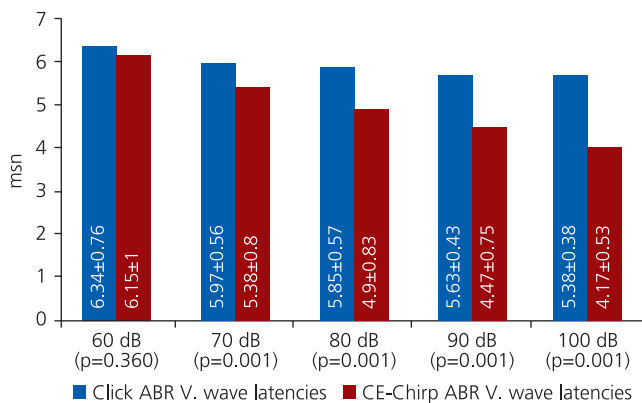


Fig. 2. Comparison of Click ABR and CE-Chirp ABR V. of the cases.

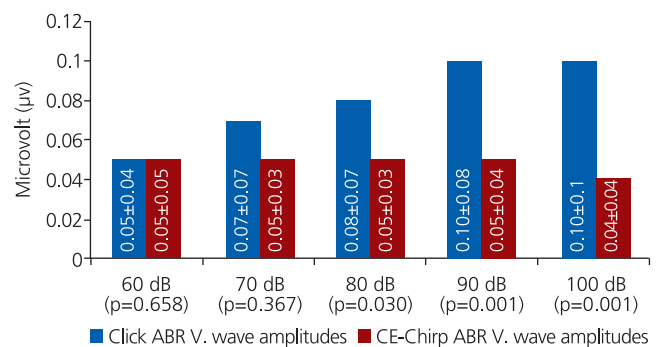


Fig. 3. Comparison of Click ABR and CE-Chirp ABR V. wave amplitudes of the cases.

Maloff et al. compared ABR results achieved using chirp or click stimuli, and they found greater AR V. wave amplitudes relative to Click ABR V. amplitudes especially at lower sound intensities.^[14] However, in our study, Click ABR V. amplitudes at 90 dB and 100 dB sound intensity levels were greater than CE-Chirp ABR V. wave amplitudes. In studies performed in individuals with normal hearing acuities, at higher sound intensity levels as 80 dB, Click ABR V. amplitudes were indicated to be greater than CE-Chirp ABR V. wave amplitudes.^[15,16] In our investigation at sound intensity levels below 90 dB, we found no statistically significant difference between Click ABR and CE-Chirp ABR V. wave amplitudes. As a result, CE-Chirp stimulus did not provide sound waves with higher amplitude in patients with sensorineural hearing loss, while they demonstrated characteristics of a V. wave at lower sound intensity levels. Soha et al. indicated that they had achieved more improved wave morphologies using chirp stimuli, rather than Click stimuli in 30 individuals with normal hearing acuity and 30 patients with moderate hearing loss.^[17]

Di Scipio and Mastronardi performed a study on the use of chirp stimuli for intraoperative monitorization.^[17] They indicated that intraoperative use of chirp ensured faster response with greater wave amplitudes, and as a result, they provided quicker feedback for the surgeon who performed the operation.

When we reviewed the literature, we have observed that the use of chirp stimulus has not been restricted only to ABR test, but it has been also used in compound action potentials and auditory steady state response (ASSR) tests. Chertoff et al. performed compound action potential tests in 16 adults with normal hearing acuities using click stimulus and chirp stimulus and reported that higher N1 wave amplitudes were obtained using chirp stimuli.^[18]

It has been indicated that inadequacies of CE-Chirp stimulus might be compensated with level-specific chirp stimulus. Kristensen and Elberling compared ABRs achieved with LS Chirp, CE-Chirp and Click stimuli.^[19] As a conclusion, they indicated that LS Chirp stimulus provided higher wave amplitudes relative to CE-Chirp ABR even at the level of 80 dB nHL.

Conclusions

As an outcome of this investigation, we found that duration of CE-Chirp ABR test was shorter than that of Click ABR test. For both ears, CE-Chirp ABR threshold values were

better than those of Click ABR test. In conclusion, in the evaluation of the patients with bilateral sensorineural hearing loss, we determined that CE-Chirp ABR method was more advantageous than Click ABR method. We believe that various types of chirp stimuli in ABR and other audiological electrophysiologic test methods may be used prevalently.

Conflict of Interest: No conflicts declared.

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Please cite this article as: Ceylan S, Gümüşgün A, Feratlar F. Comparison of CE-Chirp ABR and Click ABR methods in patients with bilateral sensorineural hearing loss. *ENT Updates* 2018;8(1):27–32.