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RESEARCH ARTICLE

Observing frequency following response in recording of 500 Hz tone burst-evoked auditory brainstem response

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Abstract

Background and Aim: Frequency following response (FFR) is a neural response with multiple origins. The purpose of current study is to record FFR with alternative and single polarity 500 Hz tone burst stimuli in the setting of auditory brainstem response (ABR).

Methods: The population of this observational study consists of 21 adults (n=42 ears) with a mean age of 22.43 (SD=1.51), with 8 out 21 (38%) being female. The participant shows normal results in otoscopy, tympanometry, acoustic reflex, pure tone audiometry, speech recognition threshold, and speech discrimination score. They underwent ABR with a click and various polarities of 500 Hz tone burst stimuli.

Results: First, latencies of ABR waveform with the alternative polarity of click and tone burst were compared and then with changing the polarity to single polarity, FFR was recorded in 24 ears (about 57%) using the 500 Hz tone burst stimuli. The results showed that in some patients changing the polarity caused a better morphology.

Conclusion: In some cases, FFR can be recorded in ABR setting. In addition, because of large amplitude, they fade away ABR waveforms.

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Introduction

Frequency following response (FFR) is a neural response with multiple cortical and subcortical origins [1,2] usually recorded by a stimulus with frequencies less than 2000 Hz and rise and fall time over 5 ms. Using this stimulus improves frequency selectivity [3]. FFR does not have widespread clinical use because of high variability even in normal hearing persons [4] and difficult separation from stimulus artifact and cochlear microphonic (CM). However, this response could provide good information about pattern encoding [5], pitch understanding [6,7], phased locked function and temporal envelope of auditory stimulus [8,9], binaural hearing and nonlinear properties of cochlea [3].
Although FFRs could be recorded during auditory brainstem response (ABR), which was reported in few cases [10,11], most of the knowledge about this subject is related to clinicians' experience, suggesting the possibility of recording FFR with tone burst-evoked ABR with single polarity and low-frequency stimulus.
The purpose of present study was to evaluate

Table 1. Latencies of ABR waveforms for alternative polarity of click and 500 Hz tone burst

	click						500 Hz tone burst					
	latencies			Inter peak latencies			latencies			Inter peak latencies		
	I (n=42)	III (n=42)	V (n=42)	I-III	III-V	I-V	I (n=12)	III (n=18)	V (n=42)	I-III	III-V	I-V
Mean	1.37	3.47	5.38	2.09	1.90	4.00	2.36	4.76	6.89	2.31	2.21	4.49
SD	0.10	0.14	0.13	0.12	0.10	0.15	0.41	0.27	0.30	0.24	0.84	0.48

this possibility. It may be important because the recording of low-frequency ABR is very common and presence of FFR could mislead clinicians in detecting ABR waveforms. It has to be noted that it is not clear that recorded FFR could be used for reliable and valid estimation of auditory thresholds.

Methods

The population of this observational study consists of 21 adults (n=42 ears) with a mean age of 22.43 (SD=1.51), with 8 out 21 (38%) being female. They had normal function in auditory evaluation including otoscopy, tympanometry, acoustic reflex, pure tone audiometry, speech recognition threshold, and speech discrimination score.

First, they were evaluated by click and 500 Hz tone burst-evoked ABR (Interacoustics, EP25, Denmark) with an alternating polarity. Electrodes were placed on the forehead (active) and mastoid (passive). Latencies of waveforms I, III, and V and interpeak latencies (I-III, III-V, and I-V) were tested at 80 dBnHL. The stimulus presented via headphone at a rate of 17.3 Hz. Then, the polarity was adjusted to be condensed and rarified and tone burst stimuli were tested again. The reason for using this electrode array was an evaluation of the probability of recording FFRs in usual ABR montage. Presence of FFRs was confirmed by repeating the test and visual observation of repeating sinusoidal waveform that has slightly larger amplitude than usual ABR waveforms.

Results were analyzed by SPSS 19. Latencies of click and tone burst-evoked ABR were compared with paired t-test and ratio of observed FR response were evaluated by descriptive analysis.

Results

The latencies of click and 500 Hz tone burst-evoked ABR for alternative polarity showed in Table 1. As can be seen, latencies have a statistically significant difference ($p<0.05$). Using 500 Hz tone burst stimuli, only 12 and 18 ears (out of 42) had a wave I and III, resectively, but all of them had wave V. The variability in tone burst-evoked ABR was higher than click-evoked ABR while tone burst-evoked ABR had poorer morphologies. FFRs were recorded at 24 ears (about 57%) by changing the polarity in 500 Hz stimuli (Fig. 1) and FFRs were recorded in both ear. In other participants, FFRs were not recorded bilaterally but changing the polarity caused better morphologies of ABR in some cases (Fig. 2).

Discussion

In most of the participants, FFRs were recorded in usual setting of ABR. In some cases, changing the polarity only made a small change in latencies of ABR waveforms. In all participant, ability or inability of recording FFRs was identical for both ears.

The presence of FFRs in the recording of ABR was previously mentioned in [11,12] and it was named “ringing” because of repeated waveforms [10]. FFR is also recorded at speech evoked ABR [13,14].

The importance of this result relies on the extensive usage of low-frequency tone burst-evoked

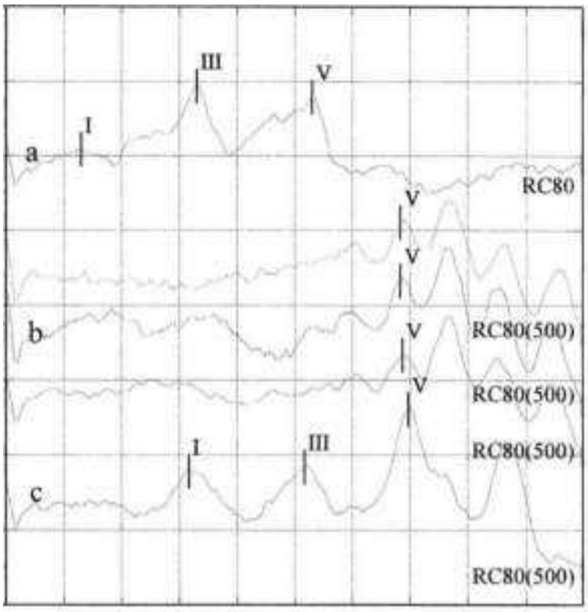

Fig. 2. A sample of a) click evoked ABR, and recording of 500 Hz tone burst evoked ABR with b) alternating and c) single polarities.

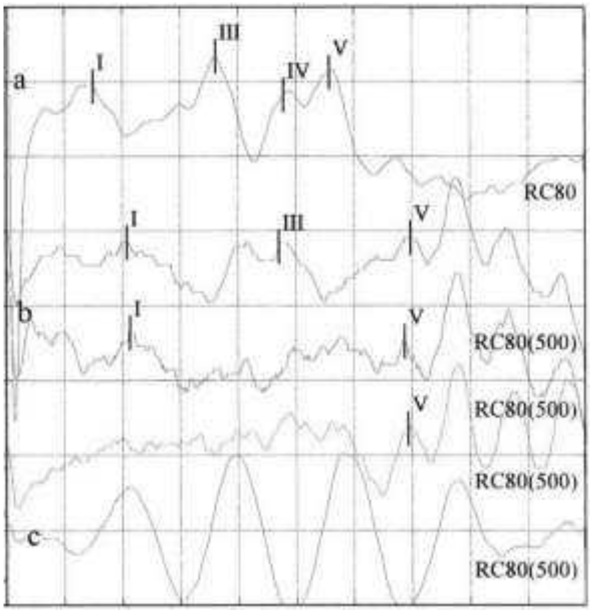

Fig. 1. A sample of a) click-evoked ABR, b) 500 Hz tone burst evoked ABR, and c) Frequency following response (FFR).

ABR for auditory threshold estimations. Presence of any kind of response that may jeopardize the real ABR waveforms is a critical issue to be considered. The results of this study show that using the wrong polarity may result in the wrong threshold in more than half of patients. However, FFR and ABR have different morphologies that reduce the chance of mistake for more experienced clinicians. As shown in Figures. 1 and 2, they have a considerable difference in amplitude, morphology, and latency of waveforms.

The value of recorded FFRs (with this setting) for a valid and reliable estimation of auditory thresholds is unclear. To the best of author's knowledge, there is little knowledge about this subject that mostly involves clinical experience. The origins of this response are also unclear. Usual FFRs have multiple origins including CM [3,15]. Because of lower latencies of recorded waveforms, this response may have more involvement of CM. If this assumption is true, recording of this response could be beneficial in auditory dyssynchrony/neuropathy cases. It also suggests that using non-cephalic electrodes may decrease the involvement of CM [11,12].

Conclusion

In some cases, FFR can be recorded in ABR setting. Because of their large amplitude, they fade away ABR waveforms. This effect must be noted in the recording of low-frequency tone burst-evoked ABR.

Conflict of Interest

The authors declare that they have no conflict of interest.

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