Comparison of 500Hz Tonebursts and 500Hz octave Chirps for Cervical Vestibular Evoked Potentials.

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Abstract- The Cervical-Vestibular evoked Myogenic potential(c-VEMP) is a biphasic surface potential recorded from the belly of Sternocleidomastoid muscle (SCM) followed by presenting a short loud sound. Various studies have been done with different stimulus to obtain better VEMP responses. The present study is aimed at comparing the c-VEMP responses (amplitude and latencies) of 500 Hz tone burst with 500Hz octave chirp (360-720Hz). c-VEMP was administered on 60 ears from 30 subjects. After preparation, responses were recorded presenting 500Hz Tone bursts and 500Hz octave chirps. P1-N1 amplitude, P1 and N1 latencies for both stimuli were noted. The chirp was observed to produce significantly larger amplitude and early latencies than tone burst ($p<0.01$). This study was in search of a stimulus that will produce larger and better response to be used in clinics , Chirp qualifies to be one. Further studies on larger sample size and age groups are required to make generalizations.

Index Terms- Chirp, tone burst, c-VEMP

I. Introduction

The cervical-Vestibular Evoked Myogenic Potential(c-VEMP) is a biphasic surface potential recorded from the belly of Sternocleidomastoid muscle (SCM) followed by presenting a short loud sound. Vestibulo-collic reflex which is the basis for the recording of c-VEMP starts with the activation of Saccule through loud sound. This saccular activity is carried through inferior vestibular nerve and ends in the inhibition of the ipsilateral SCM. It is first described by Colebatch et al in 1994(1). Since then for almost 25 years, it has been extensively studied and clinically used in diagnosis of vestibular disorders.

There is not one best stimulus for c-VEMP yet. Colebatch used clicks to elicit c-VEMP and studies in upcoming years suggested tone bursts with various frequencies from 250 to 4000Hz with different rise/fall and plateau times. Saccule, one of two otolith organs has been found to have frequency tuning and responses have been better at frequencies at approximately 500-1000Hz(2). 500Hz tone bursts with many studies suggesting it, have become the commonly used stimulus in clinics. Studies done with various rise/fall and Plateau times to produce larger amplitudes suggest rise/fall time of 2ms(3)and plateau times of 2ms(4),

Chirp, comparatively new stimulus was developed to compensate for the travelling wave delay in cochlea and have been studied since early 1990s. Much of its application was in recording a better auditory brainstem responses (ABR). In 2010, Elberling et al(5) developed octave band chirps to be used to elicit ABRs. After 20 years since c-VEMP was first described, Wang et al(6) compared the c-VEMP responses using Chirps (200-10,000Hz), also called as CE-Chirps, Clicks and tone bursts. Özgür et al (Özgür et al., 2015) used narrowband chirps (500-4000Hz) and compared it with clicks and Tone bursts. Since saccule tuning is better at 500 Hz, Walther et al(8) designed a chirp (250-1000Hz) centered at 500Hz and compared with clicks and tone bursts.

The present study is aimed at comparing the c-VEMP responses (amplitude and latencies) of 500 Hz tone burst with 500Hz octave chirp (360-720Hz).

II. Materials and Methods

Subjects

C-VEMP was administered on 60 ears from 30 subjects (M-15; F-15). The mean age of the subjects was 22±2 years. No history of balance related issues were reported. All subjects underwent tympanometry and only those subjects who had normal tympanograms were included in this study. Written informed consent was obtained from all subjects.

C-VEMP administration

The subjects were asked to sit in supine position on a chair. Electrode sites - forehead, upper-half of SCM and sternum were cleaned with Nuprep gel and disc electrodes are placed with ten20 conductive paste and electrode were secured in place with Micro pore tape. They were instructed to turn opposite to the side of stimulation until lateral margin of SCM is visible to naked eye. The active, reference and ground electrodes were placed on upper-half of SCM, sternum and forehead respectively and stimulus was presented through ER3C-10Ω. The C-VEMP was recorded using Neurosoft's Neuro-Audio instrument. Rarefaction 500Hz Tone bursts with 2-2-2 cycles and 500Hz octave chirp were delivered at 100dBnHl(124dBSPL) at rate of 5/sec. The filter was set between 30 and 2000Hz. The subjects were provided with visual cues via laptop monitor to maintain enough muscle stretch and were given rest between recordings. The two stimuli were altered randomly to avoid any fatigue related bias. Two recordings were made to check replicability. After completion of recording, P1 and N1 were marked. The study related data – P1-N1 amplitude, P1 and N1 latencies for both tone bursts and chirps were noted.

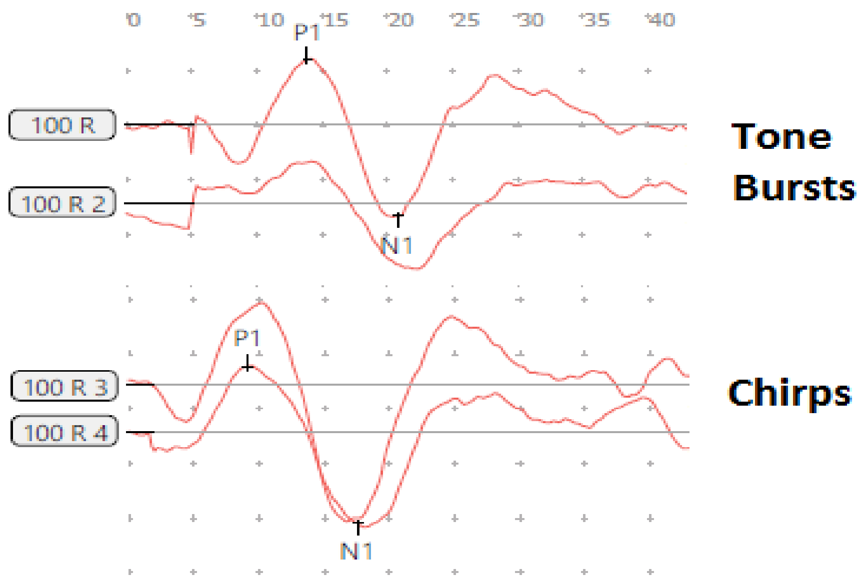

Figure 1: The c-VEMP responses for Tone bursts and Chirps.

III. Statistics

All statistical analyses were done using SPSS software for windows, version 20. Mean values and standard deviation (SD) were calculated. The distribution of the results was analyzed using the Shapiro–Wilk test. Normal distribution was observed. The test for stability of chirps and tone bursts evoked amplitudes was performed by means of correlation analysis (Pearson correlation coefficient). Paired t-test was done to test the significant differences between corresponding datasets which revealed a significance of 5%.

IV. Results & Discussion

A group of 30 healthy subjects (M-15; F-15) whose mean age was 22±2 years were involved in this study. No history of balance related issues were reported. c-VEMP was administered with two stimuli- 500Hz tone bursts and 500 Hz octave chirp (360-720Hz). The mean latencies and amplitudes for both stimuli are presented in Table 1.

	P1 (ms)	N1 (ms)	Amplitude (µV)
Tone Bursts	16.4 ± 2.99	22.36 ± 3.28	68.45 ± 28.11
Chirps	12.61 ± 3.06	18.71 ± 2.78	70.15± 25.45

Table 1: The mean latencies and amplitudes for both stimuli .

The chirp stimulus has been observed to have larger amplitudes and early latencies than tone bursts. The mean amplitude of tone bursts and chirps are 68.45 ± 28.11µV and 70.15± 25.45µV respectively and is provided in Figure 2.

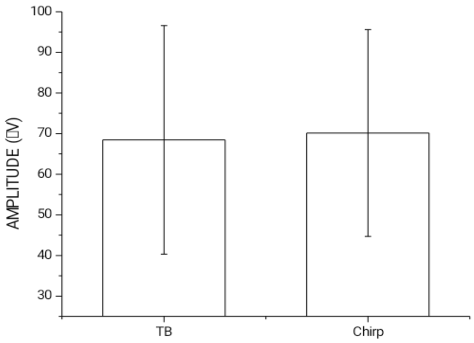

Figure 2: The mean amplitude of tone bursts and chirps

The mean P1 and N1 latencies for tone bursts are 16.4 ± 2.99ms and 22.36 ± 3.28ms respectively. The mean P1 and N1 latencies for chirps are 12.61 ± 3.06 ms and 18.71 ± 2.78ms respectively and are provided in Figure 3. There is a mean difference of 3.8ms for P1 and 3.6ms for N1. Both Amplitude and latencies of VEMP for Chirps are significantly better ($p<0.01$) than tone bursts.

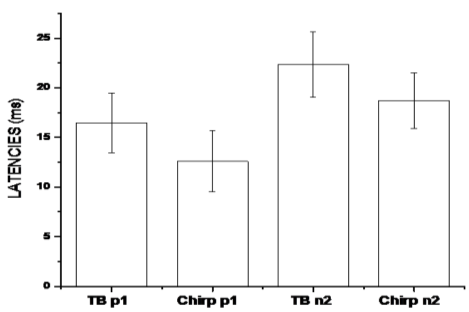

Figure 3: The mean P1 and N1 latencies for tone bursts and Chirps.

V. Discussion

c-VEMP are non-invasive procedure administered to assess the function of saccule and inferior vestibular nerve. It is a sound evoked myogenic potential recorded from the SCM. Since it was first described, there have been many attempts and studies to find optimum parameters for c-VEMP recording. Starting from the sitting position, stimulus parameters and recording parameters have been modified and studied. Among the various stimulus parameters, the type of stimuli and its spectrum have been studied extensively, looking forward a stimulus that will produce larger amplitude, thus making the process of recording and diagnosis easier. The present study is one such effort to verify and support the findings of previous studies on chirp and document the better band of frequencies of chirp for c-VEMP testing.

The earlier studies have used chirps of different bands- 200-10,000Hz by Wang et al(6); 500-4000Hz by Özgür et al(7) and 250-1000Hz by Walther et al(8). All these studies compared the c-VEMP responses of chirp with clicks and 500 Hz tone bursts. Studies that have compared tone bursts of different octave frequencies concluded that 500Hz tone bursts produce larger waveforms. Hence, 500 HZ tone bursts are used extensively in clinics. In this present study, we used 500 Hz tone bursts and 500 Hz octave Chirp (360-720Hz) and compared amplitudes and latencies of both.

We recorded significantly larger amplitudes for chirps than tone bursts of same intensity (100 dBnHL/124 dBSPL). This is in correlation with studies by wang et al(6) and walther et al(8). This difference in amplitude can be explained using the frequency content of the stimulus as one of the factors. Tone bursts are single frequency short stimulus, while chirps have frequencies of particular band.

The latencies of c-VEMP for chirp have been observed to be earlier than for tone bursts and these results are in accordance with previous studies on chirp. There was previously no study done to explain these early latencies. This early latencies and larger amplitudes cannot be explained using the travelling wave theory as in auditory brainstem response testing using chirps. Chirps are stimulus developed based on various travelling delay models and most appropriate one was designed by Elberling et al(5). zakaria et al(9) designed a chirp with no onset/offset temporal adjustment and compared its c-VEMP with tone bursts of 500Hz. He found no significant differences between the two and concluded that the early latencies are due to stimulus design and not related to any physiological factors as in cochlea.

VI. Conclusion

The study was an attempt to find a better stimulus than 500Hz Tone bursts widely used in clinics. The results of this study clearly show significant differences between the responses elicited by stimuli. The chirps have been observed to produce better and early responses than tone bursts. The results of this study supports the view of replacing the tone bursts currently used in clinics worldwide with frequency specific chirps for easy peak identification and better analysis. The samples involved in this study were less and further studies on larger sample size and age groups are required to make generalizations.

Ethics Committee Approval: The approval of local Institutional Review board
has been obtained **.**

Informed Consent: Written informed consent has been obtained from all participants.

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