Measuring Vestibular Evoked Myogenic Potential Using Two Different Procedures

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Abstract: Latest developments in technology has equipped the clinician's ability to evaluate otolithic function through VEMP testing. The present study was taken up to investigate the changes in the VEMP parameters while recording VEMP response with visual feedback system to control EMG. VEMP testing was administered on 20 participants between 20-40 years of age. The study results showed no statistically significant difference in amplitude and latency of cVEMP and oVEMP responses with and without visual feedback system. However, with visual feedback system standard deviations were observed to be reduced for both cVEMP and oVEMP responses. Hence we can conclude that using the visual feedback system to monitor the muscle contraction in otological disorders is easier and more reliable than testing without visual feedback.

Keywords: Otolithic organ, VEMP, latency, amplitude, muscle, visual feedback.

INTRODUCTION

Development in technology has equipped audiologists to assess otolithic function through Vestibular evoked myogenic potential (VEMP) testing. VEMP is a short latency myogenic potential that is generated when the vestibular system is stimulated with high intensity sounds. There are two types of VEMPs, Cervical VEMP (cVEMP) and Ocular VEMP (oVEMP) which are responses to high intensity sound stimulation from the otolithic organs; the saccule and the utricle.

cVEMP are responses acquired from the anterior neck muscles, specifically from the sternocleidomastoid (SCM) muscles. Research on animals has demonstrated the ability of high intensity air conduction sounds to activate primary irregular otolithic afferents in the saccular maculae of cats [1,2], guinea pigs [3-5], and squirrel monkeys [6]. Recent research has shown that high intensity sound activates both the utricle and saccule [7,8]. The response evoked in the SCM with high intensity sounds is assumed to travel *via* a disynaptic pathway where the saccular hair cells project to the lateral vestibular nucleus into the brainstem *via* inferior vestibular nerve. From there the pathway is thought to project through the spinal cord *via* the vestibulospinal tract, and synapse with SCM moto-neurons to elicit a response. The cVEMP response is a short latency biphasic waveform with significant positive and negative peaks at 13 and 23 ms respectively, recorded from the averaged EMG on the ipsilateral tonically contracted SCM to the stimulated ear [9,10]. Recent research interest is on oVEMP testing, recorded from inferior extraocular muscles of the eye. oVEMP response is recorded from either bone conduction or air conduction stimuli from extraocular muscles. The oVEMP response is known to represent vestibular function intermediated by a vestibulo-ocular pathway (otolith) from the portion, just inferior to each eye [11-13]. This development in the oVEMP testing may supplement conventional testing in difficult to test population and may also enable to access the unreachable information about the vestibular system.

Based on an increasing amount of evidence in human research, the VEMP test is now a universally accepted test of saccular, utricular, and vestibular nerve function. To record cVEMP and oVEMP response, muscle contraction is very important. VEMP amplitude depends upon the amount of tonic contraction of muscle. A direct correlation has been reported between the tonic muscle tension and the cVEMP amplitude [14,15]. Moreover, cVEMP amplitude is directly related to the intensity of the stimulus and the amount of muscle contraction [10]. Both the VEMP responses differ from neural potential, as it requires tonic muscle contraction from modulation of the background EMG activity [16].

Clinically, VEMP testing is interpreted based on the latency and amplitude parameters. In many otological disorders, amplitude plays a major role in the diagnosis, while the latency remains unaltered. In

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neurological disorder the latency and the amplitude plays a major role in the diagnosis. Amplitude is dependent on contraction of muscle and so it is necessary to monitor muscle contraction during recording period of cVEMP and oVEMP testing. Hence the current study was taken up to see if there is any change in cVEMP and oVEMP parameter while recording using visual feedback system to control EMG.

METHOD

A total number of 20 participants (20 ears) within the age range of 20 to 40 years (mean age 25.6 years) were included in the present study, with equal number of males and females. cVEMP and oVEMP recording was done only on the left ear. This study commenced with the clearance from the Manipal university institutional ethics committee and the participants were recruited with informed consent. All the participants had hearing thresholds ≤15 dBHL for air and bone conduction. All the participants also had 'A' type tympanogram with the acoustic reflexes present at 500Hz and 1 kHz at normal sensation levels. None of the participants had history or complaint of otological or gross neurological deficits, occupational noise exposure, symptomatic spondylitis, diabetes, high blood pressure or ototoxicity.

Instrumentation

GSI-61 audiometer was used to estimate air and bone conduction hearing threshold. It was also used to find out uncomfortable level. GSI Tympstar was used to record Tympanometry and Reflexometry. The cVEMP and oVEMP recordings were done using IHS Smart EP Version: 3.92.

Procedure

The pure tone thresholds of each of the participants were obtained from 250 to 8000Hz and 250 to 4000Hz for air and bone conduction respectively. The TDH-50 supra-aural headphone was used to obtained air conduction and a B-71 bone vibrator was used to obtain bone-conduction pure-tone thresholds. All thresholds were tracked using the modified Hughson and Westlake procedure for air and bone conduction threshold. The uncomfortable level for 500 Hz was also checked for in all the participants. The conductive pathology was ruled out in all the participants using Tympanometry and Reflexometry using 226Hz probe tone. Initially tympanometry was performed followed by acoustic reflex threshold measurement.

cVEMP and oVEMP was administered on the participants who fulfilled the above criteria. For recording of both the types of VEMP, Ear-Tone 3A earphone was used to deliver the 500Hz short duration tone burst stimuli at 100dBnHL. A total of 200 sweeps were averaged using 5.1 repetition rate for both VEMP recording. Filter setting for cVEMP was kept 30-1500Hz and for oVEMP 1-1000Hz. Rarefaction stimulus was used for cVEMP and oVEMP with amplification of 50,000 and 30,000 respectively. All the above tests were carried out in a sound treated room. Electrode placing sites were cleaned using Nuprep skin preparing gel followed by placing the electrodes using the Ten-20 conduction paste. The electrode impedance at each electrode site was ≤3K ohm. The electrode impedance was verified prior to every recording. For cVEMP electrodes were placed at midpoint of sternocliedomastoid muscle of the side being stimulated (non-inverting electrode), sternoclavicular junction (inverting electrode) and forehead (ground electrode). The following electrode montage was used for oVEMP recording with the Non-inverting electrode (+) placed on the contralateral side of the inferior oblique muscle, the Inverting electrode (-) positioned 1-2 cm beneath the non-inverting electrode over the cheek and the ground electrode was placed on the forehead.

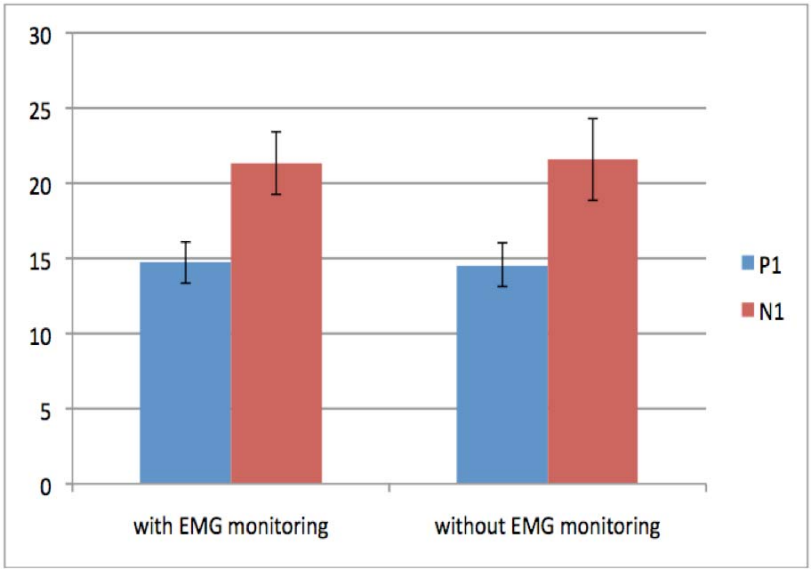
For recording of cVEMP, the participants were trained to turn their heads towards opposite side of the test ear to contract the SCM muscle. All participants underwent cVEMP and oVEMP recording twice, with and without EMG monitoring. EMG monitoring was done using integrated visual feedback system. To record the cVEMP, the EMG activity was monitored between 50 - 150 µv. Another way to record cVEMP was without visual feedback system where the participants were instructed to maintain the contraction of SCM muscle at approximately 40-45 degree angle. For oVEMP recording, the participants were made to look upward at a fixed target of >2m with the eyes, at a perpendicular visual angle of roughly 30-35 degree above horizontal. While recording oVEMP responses, the participants were asked to keep their eye gaze fixed on the target throughout the test. Participants were instructed to avoid extraneous activities of head, jaw and eye while the VEMP recording was going on. oVEMP was also recorded using integrated visual feedback system where the EMG was monitored between 5-50 µv for all the participants. During the recording visual feedback was provided to maintain the contraction of muscle within the given range.

For cVEMP, latency (P1&N1) and peak to peak amplitude was taken for analysis. And for oVEMP, response latency of N1 andP1 as well as peak to peak amplitude was considered. Non parametric Wilcoxon signed rank test was administered to check for the significant difference in latency and amplitude between the two different recording methods for cVEMP as well as oVEMP testing.

RESULTS

Descriptive analysis was performed to obtain mean and standard deviation for cVEMP and oVEMP response. It can be observed from the Graph **1** that mean latency of cVEMP for P1 peak was 14.72 and 14.49 ms with and without visual feedback system respectively. The mean latency of N1 peak was 21.34 and 21.58 ms with and without visual feedback system respectively. It was observed that peak to peak amplitude with visual feedback system was 44.68μv as compare to without visual feedback system where it was observed to be 38.34μv. From the Graph **1**, it is evident that standard deviation observed was more or less same for cVEMP response with and without visual feedback system.

In the Graph **2** it can be observed that latency of N1 and P1 remained the same for oVEMP response with and without visual feedback system. oVEMP latency of N1 was 10.82 and 10.67ms, with and with visual



Graph 1: Showing mean and standard deviation of P1 and N1 latency for cVEMP with and with EMG monitoring.

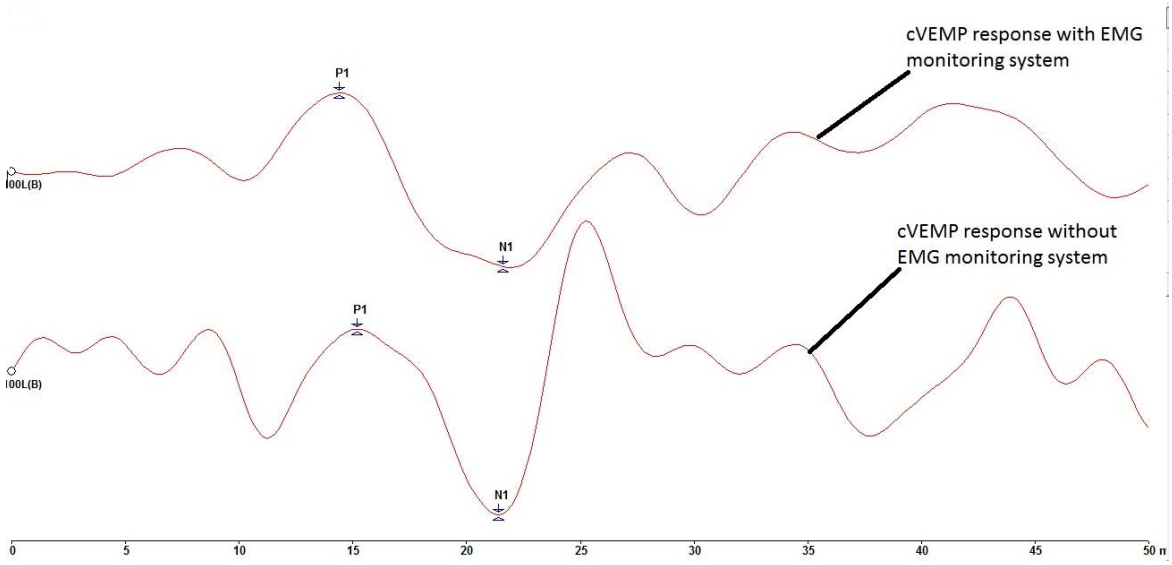
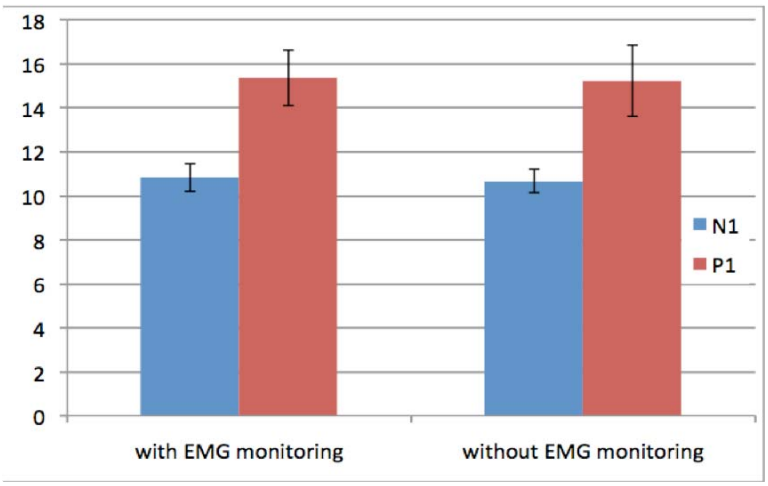


Figure 1: Showing cVEMP response with EMG monitoring and without EMG monitoring system.



Graph 2: Showing mean and standard deviation of N1 and P1 latency for oVEMP with and with EMG monitoring.

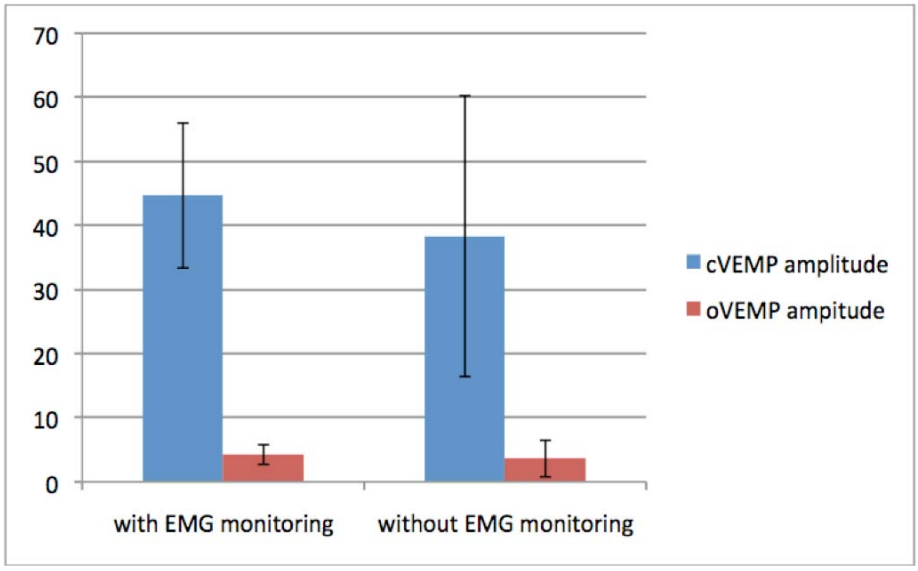
feedback system respectively. Latency of P1 was observed to be 15.35 and 15.22ms with and without visual feedback system respectively. Standard deviation observed was more or less same for oVEMP response with and without visual feedback system.

From the Graph **3** it is evident that with use of EMG monitoring system, cVEMP as well as oVEMP peak to peak amplitude is more compared to without use of visual feedback. However, in peak to peak amplitude, there was more standard deviation for cVEMP without using integrated visual feedback system. And with integrated visual feedback system, the standard deviation was reduced with increased peak to peak amplitude. Similar finding was also observed in oVEMP response.

Wilcoxon signed rank test showed that there was no significant difference (Z= -1.336, P=0.181 and Z= -0.313, p=0.755) in latency of cVEMP response with and without visual feedback system for P1 and N1 latency respectively. There was no significant difference (Z= -1.374, p= 0.170 and Z= -0.306, p= 0.760) observed for oVEMP latency of N1 and P1 respectively. Peak to peak amplitude for cVEMP and oVEMP also showed no significant difference (Z= -1.755, p=0.079 and Z= -1.457, p= 0.145) between the two procedures.

DISCUSSION

Present study did not show any significant changes in latency and peak to peak amplitude for cVEMP and oVEMP response with and without monitoring of EMG



Graph 3: Showing mean and standard deviation of peak to peak amplitude of cVEMP and oVEMP with and with EMG monitoring.

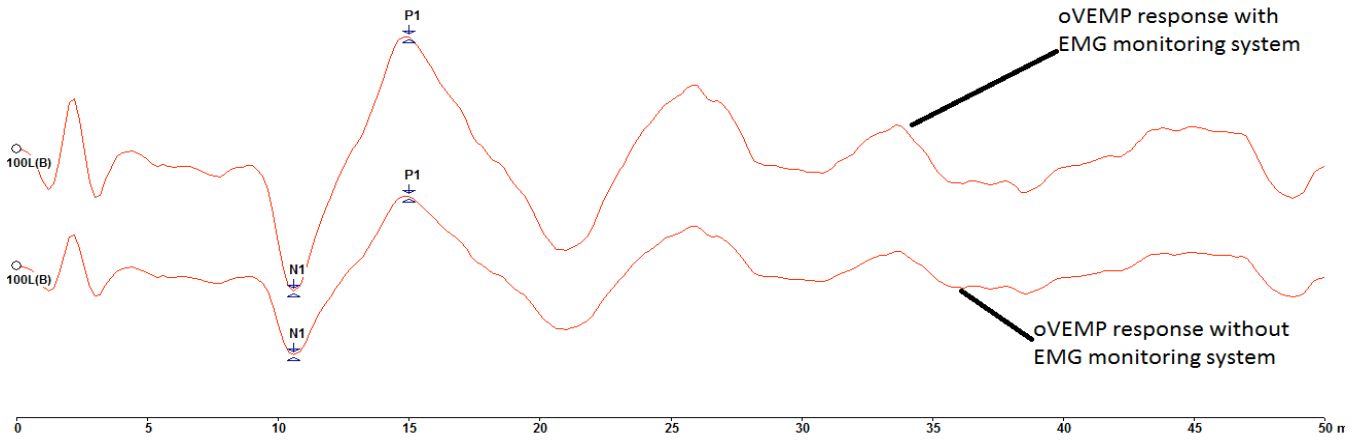


Figure 2: Showing cVEMP response with EMG monitoring and without EMG monitoring system.

activity. Standard deviation of peak to peak amplitude was observed to be less with monitoring EMG activity than without EMG monitoring.

Many studies have reported that, one of the critical parameter to record VEMP response is tonic state of the SCM muscle [9,17]. Thus, it is essential to control the level of tonic EMG which would appear to be a pre-requisite to accurately interpretation of VEMP responses. Akin *et al*. [15] reported that during unilateral activation of the SCM muscle the EMG target levels were obtained.They also stated thatas the target level increased there was increase in amplitude. They also suggested that target EMG of 30 μV to 50 μV was optimal for clinical recoding of VEMP. These views were attributed to reduced tonic EMG variable for the age range between 18-34 yearsin their study. In addition, they also reported that a positive correlation was obtained along with the tonic EMG level for click as well as the tone burst stimuli. Since VEMP amplitude is considered as a parameter employed to interpret the response clinically, the effect of the tonic EMG level on the amplitude of VEMP response is important. Nevertheless, there was no significant difference observed on the latency parameter for cVEMP response even though EMG activity was increased. Similar findings have been reported where in the amplitude of the VEMP responses correlated positively with both click-stimulus level as well as the EMG level, whereas the latency of the VEMP responses were found to be independent of both the factors [9,17,18]. Therefore, a possible prerequisite for the accurate interpretation of VEMP amplitude could be controlling the level of tonic EMG.

The VEMP software provides visual feedback of the muscle contraction to assist correct muscle contraction throughout the entire test. Hence with and without integrated visual feedback, peak to peak amplitude values are more or less same. Hence it is recommended that VEMP response can be reliably recorded without integrated visual feedback system. Also it is important to maintain the same amount of muscle contraction throughout test. Hence as the standard deviation is high in without using visual feedback condition, it is recommended to do VEMP testing using EMG monitoring. With the help of the monitoring of muscle contraction, one may comment on the peak to peak amplitude in otological patients.

CONCLUSION

VEMP response can be reliably recorded with and without visual feedback system. In view of high standard deviation when visual feedback was not used, it is recommended to go for VEMP testing using EMG monitoring. Using the monitoring of muscle contraction in otological disorder is easier and more reliable.

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