COMPARISON OF RECTIFIED VERSUS UNRECTIFIED METHOD OF CVEMP IN INDIVIDUALS WITH MENIERE'S DISEASE

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Reg. No.: 12AUD012

A Dissertation Submitted in part fulfillment of final year

Master of Science (Audiology)

University of Mysore

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MANASAGANGOTHRI, MYSORE – 570 006

MAY, 2014

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This is to certify that this dissertation entitled '**Comparison of rectified versus unrectified method of cVEMP in individuals with Meniere's disease'** is a bonafide work submitted in part fulfillment for the degree of Master of Science (Audiology) of the student Registration No: 12AUD012. This has been carried out the under guidance of a faculty of this institute and has not been submitted earlier to any other university for the award of any diploma or degree.

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This is to certify that dissertation entitled '**Comparison of rectified versus unrectified method of cVEMP in individuals with Meniere's disease'** has been prepared under my supervision and guidance. It is also certified that this dissertation has not been submitted earlier to any other university for the award of any diploma or degree.

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This is to certify that this master's dissertation entitled '**Comparison of rectified versus unrectified method of cVEMP in individuals with Meniere's disease'** is the result of my own study under the guidance of Dr. Sujeet kumar Sinha Lecturer in Audiology, Department of Audiology, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier to any other university for the award of any diploma or degree.

Mysore

May, 2014 Register No: 12AUD012

ACKNOWLEDGEMENT

GRATITUDE IS ONE OF THE LEAST ARTICULATE OF THE EMOTIONNS,

ESPECIALLY WHEN IT IS DEEP.

-FELIXFRANKFURTE

I WOULD MAINTAIN THET THANKS ARE THE HIGHEST FROM OF THOUGHT, AND THAT GRATITUDE IS HAPPINESS DOUBLEDBY WOUNDER.

-G.K. CHESTERTON

First of all, I would like to thank God 'THE SUPREME POWER'…. All the efforts wouldn't have resulted in success, if not for this guiding spirit.

वक्रतुण्ड महाकाय सुर्यकोटि समप्रभ
निर्विघ्नं कुरु मे देव सर्वकार्येषु सर्वदा
कर्पूरगौरं करुणावतारं
संसारसारम् भुजगेन्द्रहारम् ।
सदावसन्तं हृदयारविन्दे
भवं भवानीसहितं नमामि ॥

I express my sincere gratitude and thankfulness to my giuide, Dr. Sujeet Kumar Sinha, thank you sir for being the best guide in this world. In spite of our short coming and late coming you tried so hard to help us. The intense amount of concentration you had during the time of correcting our drafts were beyond imagination.. sir, without you we would never have completed our dissertation on time… THANKS A LOT SIR from all three of us. Sir, Kindly forgive me for all the mistakes and inconvenience I had caused you. Few quotes for an ideal teacher and guide like you.

IDEAL TEACHERS ARE THOSE WHO USE THEMSELVES AS BRIDGES OVER WHICH THEY INVITE THEIR STUDENTS TO CROSS, THEN HAVING FACILITATED CROSSING, JOYFULLY COLLAPSE, ENCOURAGING THEM TO CREATE BRIDGES OF THEIR OWN

NIKAS KAZANTZAKIS

THE TEACHER WHO IS INDEED WISE DOES NOT BID YOU TO ENTER THE HOUSE OF HIS WISDOM BUT THEIR LEADS YOU TO THE THRESHOLD OF YOUR MIND

-KAHIL GIBRAN

My sincere thanks to Dr. Ajith Kumar U., HOD, Dep. Of Audiology, AIISH, for permitting me to use the department facilities for my data collection. Especially permission during the weekends was really helpful sir.

My sincere thanks to Dr. S.R. Savithri, Director, AIISH, for permitting me to conduct this study.

I thank all my teachers for making me who I am today.. right from Nursery to M.Sc. All have helped me to achieve success.

I would like to thank MY PARENTS AND MY BROTHERS for making me who I am today. For showing me the right path. For believeing in me always. For Supporting me in all my endeavors.. never saying no to my requests. I would like to thank my sweet BHABHI who always helps me for everything. And I would like to thank my little cute sweetheart, my nephew ATIKSH (om/omu), whenever I am tensed or sad I remember your words 'BUA TIYA HUAAA...' the way you say ir brings smile on my face.

MUMMY, PAPA, DEEPAK BHAIYA, JAYANT BHAIYA, BHABHI, OM Thank you from bottom of my heart. I will always have deep sense of gratitude for having influenced my life in the best way possible. Thank you sooooooooooo much.

My special thank to the one who always motivates me, who is the source of my energy and my happiness.

Friends are the most important aspect of person's life…. So I thank all my friends who stand with me throughout the journey of AIISH and special thanks to **Roju, Mammo, Swathi, Suhani, Kanchan, Pari di..,** you guys are the one who made my journey easy. I would like to thanks to my dearest classmate. You guys are the best.

Last but not least I thank everyone who helped me directly or indirectly.

THANK YOU ONE AND ALL ☺

TABLE OF CONTENTS

LISTS OF THE TABLES

LISTS OF FIGURES

Chapter-I

INTRODUCTION

Meniere's disease is an idiopathic inner ear disorder characterized by episodic vertigo, hearing loss, aural fullness and tinnitus. Committee on Hearing and Equilibrium of the American Academy of Otolaryngology-Head and Neck surgery, (1995) as "the idiopathic syndrome of endolymphatic hydrops." The age of onset of symptoms in Meniere's disease varies from 4 years old children to 90 years old individuals (Paparella, 1991). The peak incidence of Meniere's disease is in the 40–60 years age group (Paparella, 1985). The prevalence of Meniere's disease is 15 out of every 100,000 individuals reported in USA and 157 out of every 100,000 individuals reported in UK (Minor, Schessel & Carey, 2004). There is no single feature from the history, physical examination, or diagnostic test that establishes the diagnosis of Meniere's disease with certainty. The tests which are utilized generally for the evaluation are EcochG, ENG, CHAMP and cVEMP.

EcochG has been widely used in the diagnosis and monitoring of Meniere's disease. For the diagnosis of Meniere's disease amplitude of summating potential (SP) or the ratio of SP to AP (action potential) is utilized. The assumption is that the cochlear hydropes changes the position of the basilar membrane which in turn affects the magnitude of cochlear potentials (Schimdt, Eggermont & Odenthal, 1974). Though there is lot of variation in the findings of different studies done by different authors, Ferraro and Tibbilis (1999) reported that 60% of the individuals with Meniere's disease had elevated SP to AP ratio. However, most of the clinics make use of extra tympanic of electrode

placement method to record EcochG. Though this method is noninvasive, has an inherent shortcoming of being able to record recognizable SP in only 40% of normal individuals owing to poor signal to noise ratio (Sinha, 2006; Sinha & Vanaja, 2009).

Chochlear hydrops analysis masking procedure (CHAMP) is another technique which has been utilized for the diagnosis of Meniere's disease. It is based on the assumption that changes in the cochlear responses due to hydrops may bring down the suppressing effect of masking noise (Don & Tanka, 2005). However there have been equivocal findings regarding the sensitivity and specificity of cochlear hydrops analysis masking procedure. Don & Tanka, (2005) reported 100% sensitivity and 100% specificity. De valck, Claes, Wuyts, & Heyning, (2007) reported 31% sensitivity and 28% specificity and they concluded that CHAMP has little value in diagnosis of Meniere's disease.

Another test which has been utilized for the diagnosis of peripheral vestibular disorder is Electronystagmography (ENG). ENG is a diagnostic test to record the corneoretinal potentials through involuntary movements of the eye caused by a condition known as nystagmus. ENG is a test which is mainly concerned with the ocular connections of the vestibular nuclei, which are responsible for production of eye deviations constituting the slow phase of the vestibular nystagmus (Kirtane, 2009). The major problem with the ENG is that it assesses only the horizontal canal of the vestibular system. Since vestibular system is a complex structure and involves many anatomical structures, different tests are required to assess the different anatomical structures of the vestibular system.

Recently for the assessment of the otolith organs (utricle & saccule) a new test vestibular evoked myogenic potential has been introduced. There are two variations of the vestibular evoked myogenic potentials; one is called as cervical vestibular evoked myogenic potentials and other is called as ocular vestibular evoked myogenic potentials.

Cervical vestibular evoked myogenic potential (cVEMP) is neurophysiologic assessment technique which is used to assess the function of saccule and its innervating structures. It was first described by Bickford, Jacobson, and Cody (1964). cVEMP have been proposed as a reliable clinical test for saccular and /or inferior vestibular nerve function (Cloebatch, 2001).

The cVEMP has been used for the diagnosis of various diseases like vestibular neuritis (Ochi, Ohasi and Watanabe, 2003), superior canal dehisense syndrome (Bradtberg, Bergenius and Tribukait, 1999), acoustic neuromas (Murofusi, Shimizu, Takegoshi and Cheng, 2001; Murofushi, Matsuzaka and Mizuno,1998; Streubel, Cremer, Carey, Weg, and Minor, 2001; Suzuki, Yamada, Inoeu, Kashio, Saito and Nakanishi, 2008), noise induced hearing loss (Fakharnia, Sheibanizadeh, Jafari and Hoseini, 2009), audiovestibular neuropathy (Kumar, Sinha, Singh, Bharti and Berman, 2007), Multiple Sclerosis (Murofushi, Shimizu, Takegoshi and Cheng, 2001) and Cerebellopontine angle tumor (Iwasaki, Takai, Ito and Murofushi, 2005).

cVEMP can be recorded using two types of averaging method rectified and unrectified. It has been shown that responses are more clearly seen with unrectified rather than rectified method of recording of cVEMP (Bickford, Jacobson and Cody, 1964). Lee, Kim, Son, Lim, Banc & Kang (2008) reported that the mean amplitudes and the mean inter-aural difference ratio were significantly smaller for the rectified method compared

to the unrectified. There have been equivocal findings regarding the reliability of both the rectified and unrectified method of recording cVEMP (Kim, Hong, Lee, Yi, & Lee, 2008; Isaredisaikal et,al. 2008). However, Unrectified averaging detect signal effectively, but does not detect modulation of overall background activities. Conversely rectified averaging is less sensitive to signals added to background activity.

Need of the study:

- Vestibular system contains multiple of anatomical structures, different tests are required to assess the different structures. cVEMP is the only test which assess the saccule function of vestibular system.
- cVEMP have been used as a test battery for the diagnosis of Meniere's disease (Colebatch et al., 1994; Bath et al., 1998; Rauch et al., 2004b). The sensitivity of the cVEMP in the diagnosis of Meniere's disease varies from 50% to 67% (de Waele et al. 1999; Murofushi et al. 2001; Ohki, et al. 2002; Rauch et al. 2004; Ribeiro et al. 2005; Kuo et al. 2005; Akkuzu et al. 2006; Chen & Young 2006; Lin et al., 2006). Authors have utilized either a rectified or unrectified averaging method for their study. There is dearth of study on comparison between rectified and unrectified in the individual with Meniere's disease.
- There is also dearth of information on association between the rectified versus unrectified method of recording cVEMP and the sign and symptoms the client exhibit.

Aim of the study

- To investigate the difference between rectified and unrectified method of cVEMP in normal hearing individual and individuals with Meniere's disease.

Objectives of the study

- To compare the rectified and unrectified method of cVEMP in normal hearing individual and individual with Meniere's disease.
- To compare the rectified and unrectified method of cVEMP in individuals with Meniere's disease.
- To compare the rectified and unrectified method of cVEMP results between normal hearing individuals and individuals with Meniere's disease.
- To correlate finding of cVEMP using rectified and unrectified method with caloric test results in individuals with Meniere's disease.

Chapter-II

REVIEW OF LITERATURE

Meniere's disease is an inner ear disorder characterized by fluctuating low frequency sensorineural hearing loss, vertigo, aural fullness and tinnitus. The pathophysiology which has been indicated in individuals with Meniere's disease is the endolymphatic hydrops. Meniere's disease affects all the anatomical structures of the inner ear i.e. it affects the utricular macula, saccular macula as well as the hair cells the semicircular canals. Various test such as pure-tone audiometry, Electrocochleography, Caloric test, cochlear hydrops analysis masking procedure, glycerol tests etc. has been utilized for the diagnosis of Meniere's disease.

Since the vestibular system contains multiple anatomical structures one particular test cannot assess the entire vestibular system. Particularly the assessment of the otolith organs in past has always been difficult. Recently cervical vestibular evoked myogenic potential has been introduced as a tool for the assessment of function of the saccule and its innervating structure. The Cervical Vestibular Evoked Myogenic Potentials (cVEMP) is an inhibitory potential which can be recorded from the tonically contracted ipsilateral sternocleidomastoid muscle (SCM) in response to a loud monaural click or tone-burst. It is characterized by a biphasic response with a positive peak namely P13 (latency at around 13 ms) and a negative peak namely N23 (latency at around 23 ms) (Colebetch, Halmygi & Skuse, 1994). Robertson & Ireland (1995) reported that the VEMP p13-n23 originates from the saccule and may travel along the inferior vestibular nerve to the vestibular nuclei.

From the inferior vestibular nucleus the pathways underlying the VEMP traverse downward, primarily along the lateral vestibulospinal tract to the motor neurons within the eleventh (accessory) cranial nerve that innervate selected muscles in the neck (Todd, Cody & Banks, 2000).

Applications of cervical vestibular evoked myogenic potentials in various peripheral vestibular disorders

1) Vestibular neuritis:

Vestibular neuritis is characterized by prolonged severe vertigo with an acute onset. It is not accompanied by any cochlear symptom or any other neurological symptoms as reported by Murofushi, Halagyi, Yavor and Colebatch (1996).

Studies have reported abnormal findings on cVEMP in individuals with vestibular neuritis. Zhang et al., (2010) recorded cVEMP in 216 patients diagnosed with vestibular neuritis (104 males and 112 females) in the age range of 10 years to 64 years with the mean age of 38.4 years. Rectified method of cVEMP was used and result showed that eight cases had abnormal cervical vestibular evoked myogenic potentials. cVEMP response were absent in 6 ears and 2 ears had low amplitude. The authors concluded that the cVEMP is a useful tool in the detection of vestibular nerve pathology in vestibular neuritis.

It has also been reported that cVEMP examination provides one more electrophysiological test to enable location of the lesion site of vestibular neuritis. Chen et al., (2000) recorded cVEMP in 8 patients diagnosed with vestibular neuritis (6 males and 2 females) in the age range of 12 to 65 years with the mean age of 42 years. Unrectified

method of cVEMP was used for recording cVEMP. Result revealed that 7 of 8 patients had bilateral normal response. Only one patient had absent response. They concluded that vestibular neuritis is considered to mainly affect the superior division of the vestibular nerve and cVEMP facilitate information regarding site of lesion.

Lin et al. (2011) recorded cVEMP in 20 subjects diagnosed with unilateral vestibular neuritis (9 male and 11 female) in the age range 21 to 62 years with the mean age of 45 years. Unrectified method was used to record cVEMP and result revealed that 15 patients had clear cVEMP responses and 5 patients (25%) showed abnormal cVEMP responses, including absent, reduced, and delayed responses. The authors concluded that cVEMP is a major tool in the inner ear monitoring system and are useful for identifying the affected branches of vestibular nerve in cases of vestibular neuritis.

It has been reported that recovery of cVEMP responses as an indication of recovery of inferior vestibular nerve function in vestibular neuritis. Murofushi et al. (2006) recorded cVEMP in 13 patients with vestibular neuritis (7 male and 6 female in the age range of 28-82 years). Unrectified recording was utilized to record cVEMP. The results of the study revealed that for 4 participants cVEMP response recovered to the normal range. The authors concluded that Inferior vestibular nerve functions could recover in patients with vestibular neuritis and it can be shown by recovery in cVEMP responses.

Ochi et al. (2003) monitored and evaluated cVEMP in eight patients (three male and five female) in the age range of 21–73 years. Unrectified recording cVEMP was used and result showed recovery in the cVEMP responses. The authors concluded that cVEMP can be use as a major tool in the monitoring of vestibular neuritis (Inferior nerve).

It has been stated that cVEMP plays a major role to differentiate saccular and utricular abnormality in vestibular neuritis. Manzari et al., (2012) recorded oVEMP and cVEMP in 59 patients diagnosed with probable vestibular neuritis. Patients comprised 21 males (age range, 25–83 years; mean age, 55 years) and 38 females (age range, 10–80 years; mean age, 54 years). Unrectified method of cVEMP recording was done and result revealed that asymmetrical cVEMP response and symmetrical oVEMP response. The authors concluded that cVEMP can be used to differentiate saccular from utricular function.

2. Benign Paroxysmal Positional Vertigo (BPPV)

BPPV is a peripheral vestibular disorder where semicircular canal is involved. It is characterized by short duration of vertigo and nystagmus roused by critical movement of the head relative to gravity. Vertigo and nystagmus caused by free floating otoconial particle in the endolymph of the semicircular canal.

It has been reported that cVEMP enables to know the involvement of saccule in individuals with BPPV. Talaat et al. (2013) recorded cVEMP in a group of normal hearing individuals and another group with BPPV. The Normal hearing group included 100 participants (45 males, 55 females) with no neuro-otological symptoms. BPPV group included 112 subjects (52 males, 60 females) diagnosed with unilateral BPPV. cVEMP was recorded using unrectified method for both the groups . Result revealed bilateral normal response in normal hearing individual except one had delayed P13 while in BPPV group 23 individuals had abnormal (delayed) cVEMP response. The authors concluded

that cVEMP may be a more sensitive tool for detection of early mild effects of pathological disorders causing dual affection of the utricle and saccule.

It has been reported that cVEMP is an important tool to diagnose the otolith dysfunction incase of BPPV. Lee et al. (2013) recorded cVEMP in 36 patients diagnosed with BPPV. Two groups were formed first group had 16 individuals patients diagnosed with recurrent BPPV and other group included 20 individuals diagnosed with Non recurrent BPPV (4 males and 16 females). cVEMP was recorded using rectified method and result reveled abnormal cVEMP responses in 5 out of 16 (31.3%) subjects in the recurrent group and 2 (10%) out of 20 subjects in the non-recurrent group. The authors concluded that the incidence of abnormalities in cVEMP or in recurrent BPPV patients is significantly higher than that in non-recurrent BPPV patients.

It has been stated that in benign paroxysmal positional vertigo (BPPV), vestibular evoked myogenic potentials (VEMPs) help to better define the extent of saccular damage and the patient's prognosis. Longo et al. (2012) recorded cVEMP in 23 subjects affected by BPPV. Unrectified method was used and result showed altered VEMP response in 14 ears (30.4%). They were absent in five (10.9%) affected ears and in two (4.3%) non-affected ears. In the affected ear the latency of p1 was higher than 17.09 ms (mean + 2 SD) in two cases (4.3%) and the latency of n1 was higher than 24.32ms (mean + 2 SD) in three cases (6.5%). In the contralateral ear p1 latency was prolonged in one case (2.2%) and n1 latency in three cases (6.5%). The authors concluded that Cervical VEMP helped to better define the extent of saccular and inferior vestibular neural damage and the prognosis of BPPV patients.

It has been stated that cVEMP responses are affected by age. Hong et al. (2008) recorded VEMP in 62 individuals diagnosed with BPPV (41 female and 21 male) in the age range of 20 to 80 years with the mean age of 53.9 years. Unrectified method was used and result showed that 16 individuals showed abnormal VEMP response in BPPV. Abnormal responses varied 54.8%, 43.5%, and 11.3% in 20-29, 40-49, and 60-69 age groups respectively. The authors concluded that interpretation of cVEMP findings need to take into account age related changes in VEMP response.

It also has been stated that cVEMP cannot differentiate individuals with BPPV from healthy individuals. Singh et al. (2014) recorded cVEMP in 30 participants diagnosed with BPPV (16 male and 14 female) in the age range of 30-60 years with the mean age of 42.3 years and 30 normal participants with matched age and gender with the BPPV group. Unrectified method of cVEMP was used and result revealed that no significant difference in cVEMP response between normal participants and participants diagnosed with BPPV. The authors concluded that cVEMP is not sensitive to changes in the peripheral vestibular system that associated with BPPV.

3. Auditory Neuropathy (AN)

Auditory neuropathy is characterized by mild to moderate hearing loss accompanied by difficulty in speech discrimination. Auditory electrophysiological test findings shows absent or severely distorted auditory brain stem responses (ABR) with presence of otoacoustic emissions and cochlear microphonics.

Sheykholeslami et al. (2005) recorded cVEMP in a group of 3 individuals with auditory neuropathy. Rectified method was utilised to record cVEMP to a 500 Hz tone

burst stimulus in individuals with auditory neuropathy. The authors reported that the cVEMP responses were absent bilaterally in all the three subjects with auditory neuropathy. The authors concluded that the inferior vestibular nerve was affected in all the three individuals and cVEMP can be used as a tool to identify the inferior vestibular nerve involvement in individuals with auditory neuropathy.

Kumar et al. (2007) recorded unrectified cVEMP in 10 subjects (20 ears) with auditory neuropathy. The results of the study revealed an abnormal cVEMP results (prolonged latency or absent cVEMP or reduced amplitude) in 16 out of 20 ears in individuals with auditory neuropathy. The authors suggested that the term 'acoustic neuropathy' should be used to indicate those patients in whom only the acoustic nerve is affected, and the label 'vestibuloacoustic neuropathy' should be applied to those patients who also show involvement of the vestibular system.

It has been stated that cVEMP helps to diagnosed inferior vestibular nerve involvement in case of vestibular neuropathy. Akdogan et.al, (2008) recorded cVEMP and caloric test in 3 patients (aged 3 years, 4 years and 5 years) were taken for this study caloric test and cVEMP using unrectified method was carried out and result revealed normal bilateral caloric result for all three patients and cVEMP was absent in both the ears in one patient, second patient cVEMP was present in right ear and in third patient cVEMP was present in both the ears the authors concluded that vestibular nerve may be assessed by cVEMP and early rehabilitations may be planned if necessary in auditory neuropathy patients.

Sinha et al. (2013a) recorded rectified vestibular evoked myogenic potentials in three subjects diagnosed with auditory neuropathy. Sinha et al. reported that the cVEMP

responses were absent in all the individuals with auditory neuropathy. Similar findings were reported by Sinha et al. (2013b) in a group of 11 subjects with auditory neuropathy.

4**. Noise Induced Hearing Loss (NIHL)**

Madappa, (2009) recorded cVEMP using unrectified method in individuals diagnosed with noise induced hearing loss. Two groups were taken for this study. One group consisted of 30 subjects with normal hearing and no exposure to noise in the age range of 26 – 50 years with the mean age of 39.33 years. Second group consisted of 30 subject diagnosed with noise induced hearing loss in the age range of 29-49 years with the mean age of 42.40 years. Result reveled that responses were present in 51 ears and absent in 9 ears in control group and it was present in 35 ears and absent in 22 ears in experimental group. The author concluded that concluded that cVEMP enable to evaluate the function of saccule in individual diagnosed with noise induced hearing loss.

Fakarnia et,al (2009) recorded cVEMP using unrectified method in 30 male diagnosed with noise induced hearing loss and 30 males matched control participants. Results revealed that there was no significant difference in unilateral weakness between the two groups. There was a significant difference in mean latencies of P13 in the right and left ears between the two groups. The difference in mean latencies of N23 was noted only in right side. There was no significant difference in the amplitude of p13-n23 complex. They concluded that in individual with noise induced hearing loss the pars inferior of vestibule is susceptible for damage.

Kumar et al, (2010) recorded cVEMP using unrectified method in 30 individuals (55 ears) diagnosed with noise induced hearing loss in the age range of 30-40 years. Results revealed that cVEMP responses were absent in 16 ears, latency of p13 & n23 was

prolonged and peak to peak amplitude was reduced in 19 ears and cVEMP results were normal in 20 ears. The authors concluded that there are possibilities of vestibular deficits in individuals with noise induced hearing loss.

Akin et al. (2012) recorded cVEMP in 14 normal hearing individuals and 43 individuals with noise induced hearing loss. The authors reported that 33% of the participants with NIHL had abnormal cVEMP responses whereas cVEMP was present in all the subjects with normal hearing. The authors concluded that in individuals with NIHL there could be damage to the saccule and its innervating structures. Wang et al. (2006) recorded cVEMP in 29 subjects with acute acoustic trauma. Wang et al. (2006) reported that in 21 out of 29 subjects cVEMP was absent.

5. Meniere's Disease

Meniere's disease is characterized by aural fullness, fluctuating hearing loss, recurrent attack of vertigo and tinnitus (Hamann & Arnold, 1999). It has been stated that The cVEMP response do not correlate with the stage of MD, but there was a trend toward clinical disease progression with greater IAD ratios. Wang et al. (2012) recorded cVEMP in 79 patients with unilateral definite MD (24 males and 55 females) in the age range of 19 to 75 years, with a mean age of 48.3 years. Out of 79 patients 42 patients classified into stage I, 23 patients into stage II, 11 patients into stage III, and 3 patients into stage IV. The results of VEMP testing were abnormal in 30 patients. The mean ± SD IAD ratio was 0.24 ± 0.21 in stage I, 0.25 ± 0.19 in stage II, 0.34 ± 0.23 in stage III, and 0.20 ± 0.22 in stage IV. A comparison of the IAD ratio and the stage of MD revealed no relationship but the trend was the greater the clinical stage, the more the IAD ratio increased. The

authors concluded that the cVEMP response and caloric test results did not correlate with the stage of MD, but there was a trend toward clinical disease progression with greater IAD ratios.

It has been stated that cVEMP using 500 Hz would be clinically useful in the diagnosis of MD. Kim-Lee et al. (2009) recorded cVEMP in 39 subjects diagnosed with unilateral or bilateral Meniere's disease. Out of 39 participants, 20 participants had definite Meniere's disease group (total 24 ears) and 19 participants had probable Meniere's disease (total 26 ears). Unrectified method was used for recording cVEMP and the results revealed that cVEMP were present in 83% of affected ears of the definite Meniere's group. The cVEMP peak amplitudes in normal ears were elicited most efficiently after stimulation at 0.5 kHz, consistent with previous studies. In contrast, in the Meniere's ears, the cVEMP were most reliably elicited at a tone burst stimulation frequency of 1 kHz. The author concluded that frequency peak amplitude cut-off value would be clinically useful in the diagnosis of Meniere's disease.

It has been stated there is a relationship between the degree of endolymphatic hydrops revealed by magnetic resonance imaging (MRI) and cVEMP results. Katayama et al., (2010) recorded cVEMP in 40 subjects with Meniere's disease. Among 40 subjects 19 subjects had definite Meniere's disease 6 patients had probable Meniere's disease. 3 subjects had cochlear Meniere's disease. Eight patients (14 ears) were diagnosed as having delayed endolymphatic hydrops. 13ears had no hydrops, 10 ears had mild hydrops, and 26 ears had significant hydrops in the vestibule. In the cochlea, 13 ears had no hydrops, 16 ears had mild hydrops, and 20 ears had significant hydrops. Unrectified method of cVEMP recording was done and result revealed that cVEMP was present in 21

ears and was absent in 28 ears. In 13 ears with no vestibular hydrops on the MRI, cVEMP was present in 10 ears and was absent in 3 ears. In 36 ears with vestibular hydrops on MRI, cVEMP was present in 11 ears and was absent in 25 ears. In subjects with vestibular hydrops on the MRI, the percentage of absent cVEMP was significantly high. All five patients who had extremely large vestibular hydrops showed no response of cVEMP. In 13 ears with no cochlear hydrops on the MRI, cVEMP was present in 9 ears and was absent in 4 ears. In 36 ears with cochlear hydrops on MRI, cVEMP was present 12 ears and was absent in 24 ears. In patients with cochlear hydrops on the MRI, the percentage of absent cVEMP was high. The authors concluded that cVEMP can be used to examine endolymphatic hydrops, especially in the vestibule.

Egami et al. (2013) recorded cVEMP in 114 patients (53 male and 61 female) with the mean age 50.5 years in the age range of 15–76 years. Unrectified method of recording was used and result revealed that 34 (29.8%) showed abnormal click-cVEMP only on the affected side (decreased responses in 8 patients; absent responses in 26 patients), whereas 34 (29.8%) showed normal responses on both sides. burst- cVEMP in the 32 patients (28.1%) who showed no response to click-cVEMP on either side. Among them, 23 patients (20.2%) showed abnormal burst-cVEMP responses solely on the affected side (decreased responses in 7 patients; absent responses in 16 patients), whereas 18 patients (15.8%) showed normal responses on both sides. The remaining 3 patients (2.6%) showed absent burst-cVEMP responses on both sides and 2 patients showed abnormal burst-cVEMP responses solely on the intact side. Overall, 57 of the 114 patients were classified into the appropriately identified with cVEMP group, resulting in an abnormality of cVEMP of 50.0%. The authors concluded that the sensitivity and specificity of cVEMP

was 50.0% and 48.9%. So cVEMP may give additional information as part of a diagnostic test battery for detecting vestibular abnormalities in MD.

Young et al. (2003) recorded cVEMP in 40 patients with unilateral definite Meniere's disease (23 males and 17 females) in the age range of 19 to 68 years with the mean age of 43 years. Among 40 ears 5 ears were in stage 1, 12 were in stage 2, 17 were in stage 3 and 5 were in stage 4. Rectified method of recording was done and result revealed that out of 6 ears in stage 1 the VEMP response were normal in 5 eras and augmented in 1, out of 12 in stage 2 the VEMP responses were normal in 7, augmented in 2, depressed in 1 and absent in 2. Out of 17 ears in stage 3 10 had normal, 4 had expressed and 3 had absent response and in stage 4 the VEMP response were normal in 2, depressed in 1 and absent in 2 ears. Comparing the inter aural ratio in each stage showed significant difference. The authors concluded that the inter aural ratio of VEMP correlated with the stage of MD and can be used as an important tool diagnose the stage of MD.

It has been stated that pattern of cVEMP abnormalities may enable us in differential diagnosis of Meniere's disease from other peripheral vestibular pathologies. Rachael et.al, (2010) recorded cVEMP from rectified and unrectified sternocleidomastoid EMG using air Conduction click stimuli, Bone Conduction forehead taps and a triggered tendon hammer. Two group were taken in this study 35 normal individuals with the mean age of 47.1 (control group) and 77 individual diagnosed with unilateral Meniere's disease (Experimental group). Experimental group classified into definite, probable, or possible Meniere's disease. And they further classified into disease stage (1-4). Result revealed that cVEMP responses were present for all control groups for all modalities of stimuli. In

clinically definite unilateral Meniere's disease (60 individual) the prevalence of unilateral cVEMP abnormalities were 40.0%, 22.8%, and 10.7% for click, minitap and tendon-hammer evoked cVEMP. The abnormalities for AC alone was more (33.3%) followed by BCV stimuli (26.7%). The authors concluded that predominance of abnormalities in cVEMP responses to AC sound is characteristics of Meniere's disease and indicative of saccular involvement.

To summarise, the cVEMP is useful in the diagnosis of various peripheral vestibular disorders such as vestibular neuritis, BPPV, auditory neuropathy, Noise induced hearing loss and Meniere's disease. cVEMP has been recorded using both rectified and unrectified method in the peripheral vestibular disorders. Studies have either utilized either rectified or either unrectified method to record cVEMP in vestibular disorders. However, none of the studies have compared the two methods in peripheral vestibular disorders.

Chapter-III

METHOD

The present study was conducted with an aim to compare rectified and unrectified method of cVEMP in individuals with Meniere's disease and normal individuals. The study also aimed at correlating the caloric test results with rectified and unrectified cVEMP results in individuals with Meniere's disease. To achieve the aim of the present study cVEMP was carried out in individuals with normal hearing and individual with Meniere's disease using rectified and unrectified method.

Participants

Two groups of participants were taken for this study.

Experimental group

Total 15 participants participated in this study. Out of 15 participants 11 were males and 4 were females. The age range of subject was 18 years to 45 years with a mean age of 38.40 years.

Control group

Total 15 participants participated in this study. Out of 15 participants 12 were males and 3 were females. The age range of subject was 18 years to 45 years with a mean age of 39.53 years.

Participant's selection criteria

Participant selection criteria for control group

- ❖ All the participants had hearing sensitivity within normal limits as defined by hearing thresholds within 15 dB HL at octave frequencies between 250 Hz to 8000 Hz for air conduction and between 250 Hz and 4000 Hz for bone conduction.

- ❖ The participants did not have any presence or history of middle ear problem.
- ❖ They did not have any symptoms of vestibular problem.
- ❖ They did not have any evidence of retrocochlear pathology based on ABR.
- ❖ The participants had uncomfortable level of more than 95 dB HL for speech.
- ❖ The participants did not have any history of otological or neurological problem.
- ❖ The participants did not have any neuromuscular problems in body and neck region.

Participant selection criteria for experimental group

- ❖ All the participants were diagnosed as Meniere's disease, based on American Academy of Otolaryngology–Head and Neck Surgery (1995) and a report from Otorhinolaryngologist.
- ❖ The participants did not have any history or presence of conductive hearing loss.
- ❖ All of the participants had hearing thresholds within minimal to severe degree.
- ❖ They did not show any evidence of retrocochlear pathology based on ABR.
- ❖ The participants had uncomfortable level of more than 95 dBHL for speech.
- ❖ There did not have any presence or history of relevant neurological dysfunction.
- ❖ They did not have history or presence of any neuromuscular problems in body and neck region.

Instrumentation

- ❖ Calibrated two channel audiometer (Orbiter-922 V-2x, G N Otometrics, Taastrum, Denmark) with TDH-39 headphones (Telephonics, 815 Broad Hollow Road, Farmingdale, New York) and B-71 bone vibrator (Radioear, KIMMETRICS,

22050 Mohawk Drive, Smithsburg, MD 21783) were used to estimate air conduction and bone conduction threshold respectively.

- Calibrated GSI-Tympstar (GSI VIASYS Healthcare, Wisconsin, USA) was used for tympanometry and reflexometery.
- IHS Smart EP version 4.3.02 US Bez (Intelligent Hearing System , Florida, USA) instrument was used for recording of the cVEMP and Calibrated Eartone 3-A insert earphone was used to deliver the stimuli.

Test environment

All the testing of the present study was done in a sound treated room as per guidelines in ANSI S3.1 (1991). Pure tone audiometry was done in double room set up while the Immittance evaluation, recording of auditory brain stem response and cVEMP were carried out in a single room. The rooms were electrically shielded.

Procedure:

Case history: A detailed case history was obtained from all the participants regarding vestibular problems, middle ear problems, neurological problems.

Otoscopic examination: All the participants went for Otoscopic examination to rule out presence of wax or any infection in the ear canal.

Pure tone audiometry: Pure tone thresholds were obtained at the octave frequencies between 250 Hz to 8000 Hz for air conduction and between 250 Hz to 4000 Hz for bone conduction through modified Hughson Westlake procedure (Carhart and Jerger, 1959).

Uncomfortable loudness level: UCL was obtained in both the ears for air conducted speech stimuli using ascending method.

Immittance: Immittance was carried out with a probe tone frequency of 226 Hz. Ipsilateral and contralateral acoustic reflexes thresholds were measured for 500, 1000, 2000, and 4000 Hz for both the ears.

Auditory brainstem response: Auditory brainstem response (ABR) testing was done to rule out retrocochlear pathology. Auditory brainstem responses were recorded with a click stimulus of 0.1 msec duration, presented at 90 dB nHL at a repetition rate of 11.1 and 90.1. The filter used was from 100 Hz to 3000 Hz and responses were analysed in a 10 msec time window.

Cervical Vestibular Evoked Myogenic potential (cVEMP): Cervical Vestibular Evoked Myogenic potential testing was carried out in a sound treated room.

Rectified method of cVEMP: The site of electrode placement was prepared using skin preparation gel. Silver chloride disc electrode was used for recording. Absolute electrode impedance and inter electrode impedance were maintained below 5000 ohms and 2000 ohms respectively. Participants were instructed to sit turn their head to the opposite side of the ear in which stimulus was presented, so as to activate ipsilateral sternocleidomastoid (SCM) muscle; participants were instructed to maintained same posture throughout the test run. A visual feedback box in the IHS instrument with the green and red LED lights was provided to the participants in order to maintain the tonocity of the SCM muscle within 50 microvolt and 100 microvolt. Green light indicates sufficient muscle tension and red light shows insufficient muscle tension. The software has been designed in such a way that whenever the muscle tension in sufficient it averages the responses and whenever the muscle tension is less or more it does not

averages the responses. The techniques have been used previously in various studies (Chang et al., 2007).

Unrectified method of cVEMP: - The participants were asked to turn their head towards the opposite side of the recording ear. The tension on the SCM muscle was monitored by using a specially fabricated apparatus as shown in figure 3.1. SCM muscle tension was considered appropriate when subject turn and touch their chin to the reference point made on the apparatus. All the participants were given similar task to create a particular amount of muscle tension in SCM. The apparatus was also made in such a way that it would guard against any head and shoulder movement during recording.

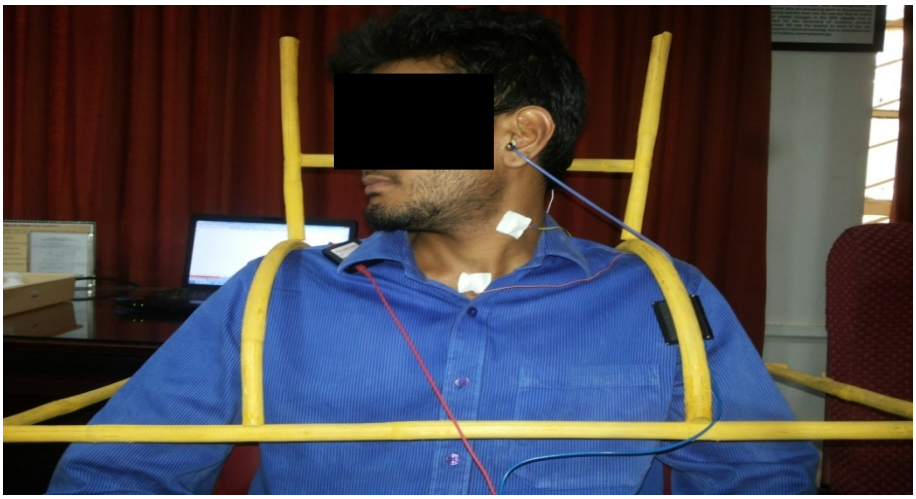

Figure 3.1. Recording of unrectified VEMP from one of the participants using the specially fabricated apparatus. (Photograph was obtained with informed consent of the participant).

The recording protocol for the cVEMP is given in table-3.1

Table 3.1

The recording protocol for the cVEMP

Stimulus parameter	**Acquisition parameter**
Type of stimuli : Tone burst	Analysis time: 70 msec.
Stimulus frequency : 500 Hz (Blackman window)	Filter setting: High pass- 30 Hz Low pass- 1500Hz
Stimulus duration : 2-0-2 cycle	Notch filter: off
Intensity: 95 dBnHL	Amplification: 5,000
Repetition rate: 5.1/sec	Number of channels: 1
Polarity: rarefaction	Number of recordings: 2
Total number of sweeps: 200	Electrode montage: Non inverting electrode- 2/3rd of the distance of the insertion of SCM muscle, on the same side of the test ear Inverting electrode- sternoclavicular junction Ground: lower fore head.

Analysis of the Data:

The first positive peak in the waveform was marked as P1 and first negative peak was marked as N1. The representative waveform is shown in figure-3.2

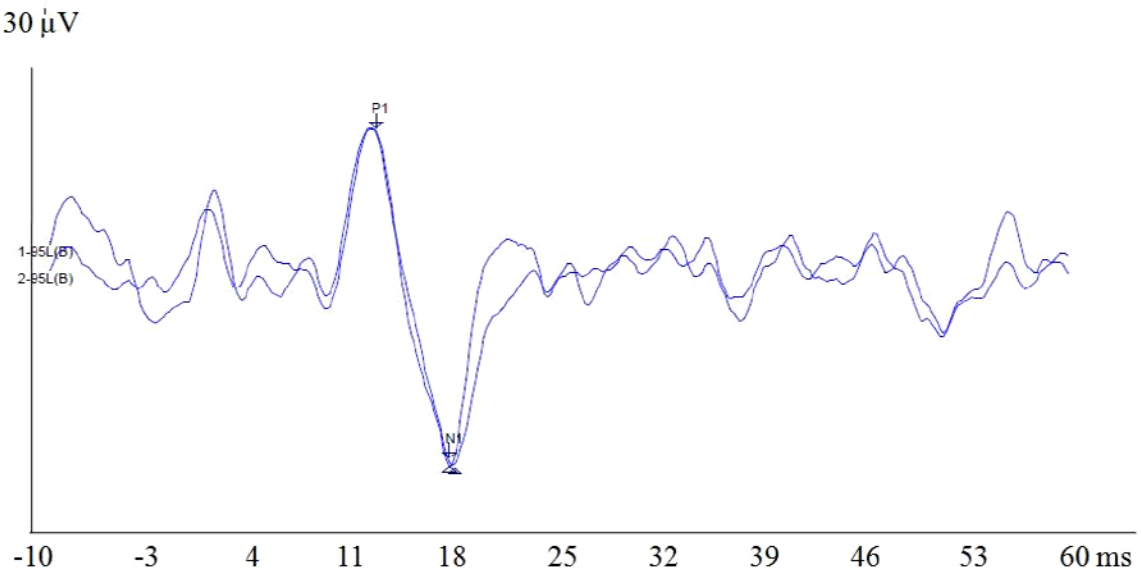

Figure 3.2. Representative waveform shows the P1 & N1 peak.

The recorded cVEMP responses were analysed and peaks (P1, N1) were identified for the participants in the experimental and control group. The following latency and amplitude measures of these identified cVEMP responses were measured. Following analysis was done.

1. Latency of P1 and N1 of rectified and unrectified method of cVEMP for normal and experimental group.
2. Amplitude of P1-N1 complex for rectified and unrectified method of cVEMP for normal and experimental group.

Further the results of the caloric test was obtained for all the individuals with Meniere's disease from Vestibular clinic at All India Institute of Speech and Hearing and the results of the caloric test was correlated with cVEMP findings using rectified and unrectified method.

Chapter-IV

RESULT

The aim of the present study was to investigate the difference between rectified and unrectified method of cVEMP in 15 normal hearing individual and 15 individuals diagnosed with Meniere's disease. Latency of P1 peak, N1 peak and amplitude of P1-N1 complex was measured for both the groups for rectified and unrectified. SPSS version 16.0 was utilized to do the statistical analysis.

Following statistical analyses were done.

- Descriptive statistics was done to obtain mean and standard deviation values for latency measures of rectified and unrectified method of cVEMP for experimental and control groups.
- Descriptive statistics was done to obtain mean and standard deviation values for amplitude measures of P1-N1 complex for rectified and unrectified method cVEMP for experimental and control groups.
- Wilcox on Signed Rank Test was done to compare the latency of P1 and N1 for rectified and unrectified method of cVEMP in Control group.
- Wilcox on Signed Rank Test was done to compare the latency of P1 and N1 for rectified and unrectified method of cVEMP in Meniere's ears.
- Wilcox on Signed Rank Test was done to compare the latency of P1 and N1 for rectified and unrectified method in contralateral ears of individuals with Meniere's disease.

- Non parametric Mann Whitney U test was done to compare the latency of P1 and N1 of cVEMP between the individual with Meniere's disease and normal hearing for rectified method of cVEMP**.**
- Non parametric Mann Whitney U test was done to compare the latency of P1 and N1 of cVEMP between the individual with Meniere's disease and normal hearing for unrectified method of cVEMP**.**
- Non parametric Mann Whitney U test was done to compare the P1-N1 amplitude complex of cVEMP between the individual with Meniere's disease and normal hearing for rectified method of cVEMP.
- Non parametric Mann Whitney U test was done to compare the P1-N1 amplitude complex of cVEMP between the individual with Meniere's disease (contralateral ears) and normal hearing for rectified method of cVEMP.
- Chi square test was done to see an association between caloric test results and cVEMP test results obtained in individuals with Meniere's disease.

Latency and amplitude of cVEMP for control group

cVEMP could be recorded from 27 ears and it was absent in 3 ears using rectified method in normal hearing individuals whereas cVEMP could be recorded from 29 ears and it was absent in 1 ear using unrectified method of cVEMP.

Figure- 4.1 shows presence and absence rectified and unrectified waveform recorded from one of the individual from control groups.

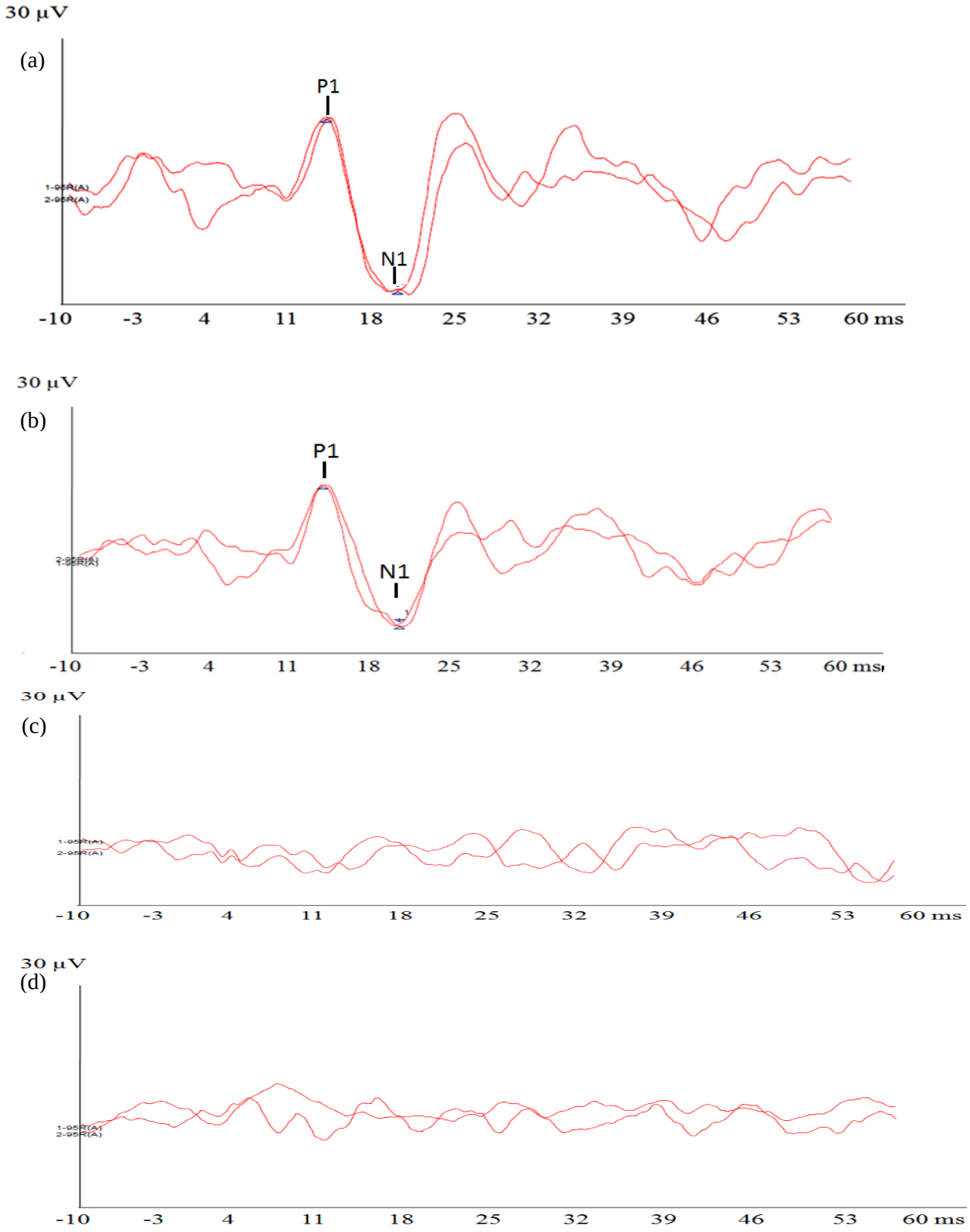

Figure 4.1 (a) rectified waveform present (b) unrectified waveform present (c) rectified waveform absent (d) unrectified waveform absent (control group)

The peaks P1 and N1 were marked and latency of P1, N1 and amplitude of P1-N1 complex were tabulated. The mean and standard deviation (SD) were calculated for P1 latency, N1 latency and amplitude of P1-N1 complex in control group using descriptive statistics. The mean and standard deviation (SD) of P1 latency, N1 latency and amplitude of P1-N1 complex are shown in table 4.1.

Table 4.1

Mean and standard deviation of latency and amplitude in control group

	Rectified				**Unrectified Method**			
		Latency (ms)		Amplitude (µV)		Latency (ms)		Amplitude (µV)
	N	P1	N1	P1-N1	N	P1	N1	P1-N1
Mean	27	13.90	19.51	34.39	29	14.20	19.66	43.48
Standard deviation	27	1.16	1.64	19.27	29	1.59	2.59	24.73

N= Number of ears.

It can be seen from table-4.1 that the latency of P1 is more for unrectified compare to rectified method of cVEMP. The latency of N1 is almost same for both the methods. It can also be seen that the amplitude of P1-N1 complex is more for unrectified method compare to rectified method of cVEMP.

To understand the significant difference between the various latency and amplitude measure of rectified and unrectified method of cVEMP with in control group Wilcox on Signed Rank test was done. Wilcox on Signed Rank test did not reveal any significant difference in latency of P1 ($Z=0.82$, $p>0.05$) and N1 ($Z=0.96$, $p>0.05$)

between rectified and unrectified method of cVEMP. However Wilcox on Signed Rank test revealed significant difference in amplitude of P1-N1 complex ($Z=2.57$, $p<0.05$) between rectified and unrectified method of cVEMP. To conclude there was no difference in latency of P1 and N1 between unrectified and rectified method of cVEMP in control group, however there was difference in amplitude of P1-N1 complex between and unrectified and rectified method of cVEMP in control group.

Latency and amplitude of cVEMP in Experimental group (in the ears diagnosed with Meniere's disease)

In experimental group 15 participants with Meniere's disease were taken. Out of 15 participants 14 had unilateral Meniere's disease whereas 1 had bilateral Meniere's disease. Total 16 ears with Meniere's disease and 14 ears contralateral ears to Meniere's disease were taken for the present study. cVEMP could be recorded from 8 Meniere's ears and it was absent in 8 Meniere's ears in both rectified and unrectified method. The responses of cVEMP were present in 14 contralateral ears in both rectified and unrectified method. Figure 4.2 shows presence and absence responses recorded of rectified and unrectified method of cVEMP recorded from Meniere's ears from one of the individual in experimental group.

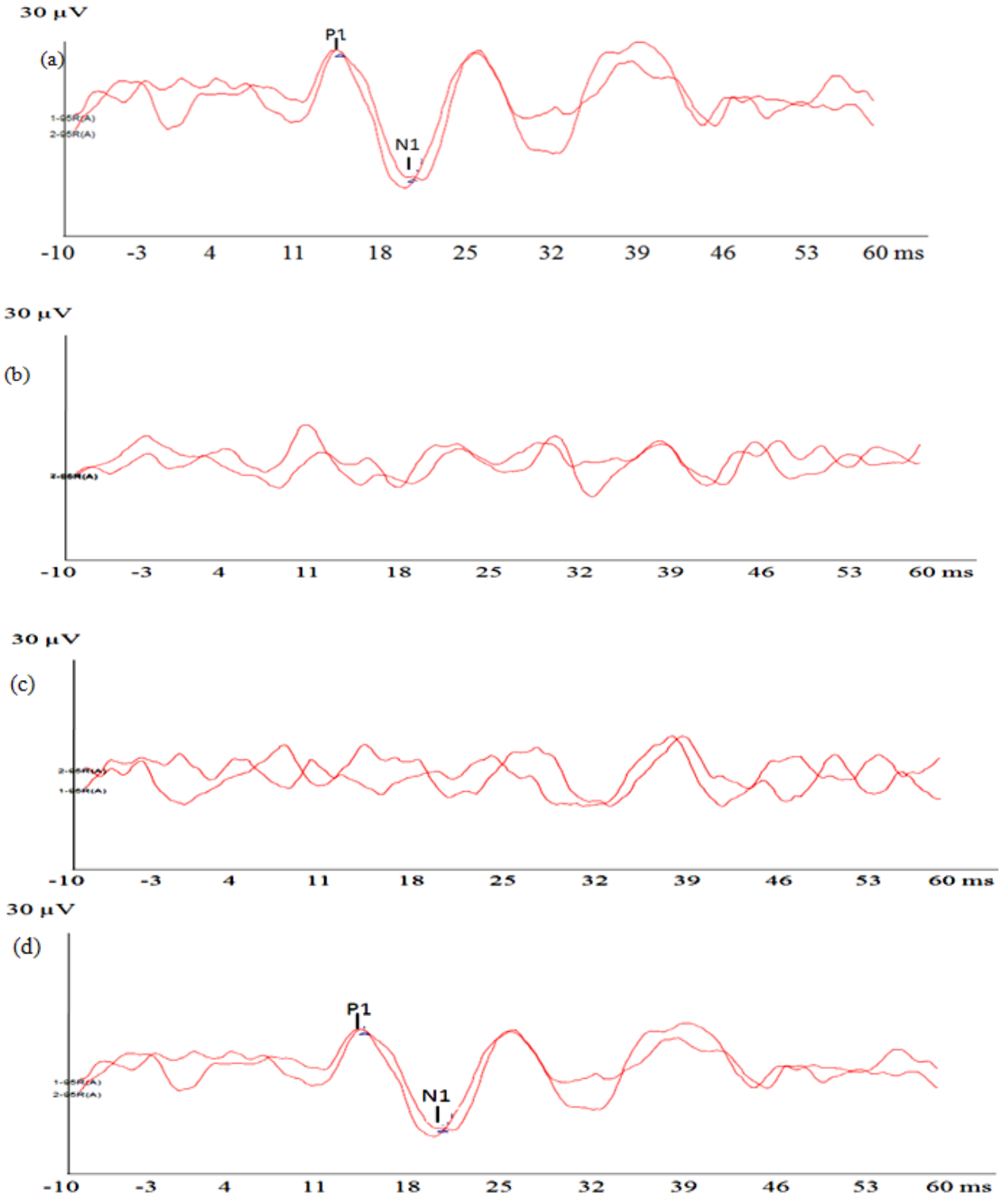

Figure 4.2 (a) rectified waveform present (b) rectified waveform absent (c) unrectified waveform abesent (d) unrectified waveform present (Meniere's ear)

The peaks P1 and N1 were marked and latency of P1, N1 and amplitude of P1-N1 complex were tabulated. The mean and standard deviation (SD) were calculated for P1 latency, N1 latency and amplitude of P1-N1 complex were calculated for the Meniere's ears. The mean and standard deviation (SD) of P1 latency, N1 latency and amplitude of P1-N1 complex of Meniere's ears are shown in table 4.2.

Table 4.2

Mean and standard deviation of latency and amplitude in Meniere's ears

	Rectified Method				**Unrectified Method**			
		Latency (ms)		Amplitude (μV)		Latency (ms)		Amplitude (μV)
	N	P1	N1	P1-N1	N	P1	N1	P1-N1
Mean	8	15.12	19.69	18.65	8	15.75	21.20	25.12
Standard deviation	8	1.62	1.826	2.01	8	1.58	1.58	11.15

N= Number of ears

It can be seen from table-4.2 that the latency of N1 is more for unrectified compare to rectified method of cVEMP. The latency of P1 is almost same for both the method. The amplitude of P1-N1 complex is more for unrectified method compare to rectified method of cVEMP.

To understand the significant difference between the various latency and amplitude measure of rectified and unrectified method of cVEMP with in Meniere's ears, Wilcox on Signed Rank test was done. Wilcox on Signed Rank test did not reveal any significant difference in latency of P1 ($Z=1.37$, $p>0.05$), N1 ($Z=1.62$, $p>0.05$) and amplitude of P1-

N1 complex (Z=1.52, p>0.05) between rectified and unrectified method of cVEMP in individuals with Meniere's disease. To conclude there was no difference in latency of P1, N1 and in amplitude of P1-N1 complex between and unrectified rectified method of cVEMP in Meniere's ears.

Latency and amplitude of cVEMP in Experimental group (contralateral ears in the individuals diagnosed with Meniere's disease)

cVEMP responses could be recorded in all the contralateral ears (14 ears) in individuals with Meniere's disease. Descriptive statistics was done to calculate the mean and standard deviation for the P1 latency, N1 latency and the amplitude of P1-N1 complex of the contralateral ears of the individuals diagnosed with Meniere's disease were calculated. The mean and the standard deviation for the same are given in Table 4.3

Table 4.3

Mean and standard deviation of latency and amplitude in contralateral ears

	Rectified Method				**Unrectified Method**			
		Latency (ms)		Amplitude (µV)		Latency (ms)		Amplitude (µV)
	N	P1	N1	P1-N1	N	P1	N1	P1-N1
Mean	14	15.92	21.26	21.24	14	15.98	21.12	29.68
Standard deviation	14	1.51	1.80	6.8	14	1.47	1.32	10.47

N= Number of ears.

It can be seen from table 4.3 that the amplitude of P1-N1 complex is more for unrectified method compare to rectified method of cVEMP. The latency of P1 and N1 is almost same for both the method.

To understand the significant difference between the various latency and amplitude measure of rectified and unrectified method of cVEMP with in contralateral ears of Meniere's disease individuals, Wilcoxson Signed Rank test was done. Wilcoxson Signed Rank test did not reveal any significant difference in latency of P1 ($Z=0.44$, $p>0.05$) and N1 ($Z=0.35$, $p>0.05$) between rectified and unrectified method of cVEMP. Wilcoxson Signed Rank test however revealed significant difference in amplitude of P1-N1 complex ($Z=2.34$, $p<0.05$) between rectified and unrectified method of cVEMP. To conclude there was no difference in latency of P1 and N1 between and unrectified rectified method of cVEMP in contralateral ears of individuals diagnosed with Meniere's disease, however, there was difference in amplitude of P1-N1 complex between and unrectified rectified method of cVEMP in contralateral ears of individuals diagnosed with Meniere's disease.

Comparison of latency and amplitude of rectified and unrectified method of cVEMP across normal ears in control group and Meniere's ears in experimental group.

Mean and standard deviation for P1 latency, N1 latency and amplitude of P1-N1 complex of rectified and unrectified method of cVEMP were calculated for both control group and experimental group. The latency of P1 and N1 for control group and Meniere's ears of experimental group is shown in figure-4.3, the amplitude of P1-N1 complex for control group and Meniere's ears of experimental group is shown in figure-4.4.

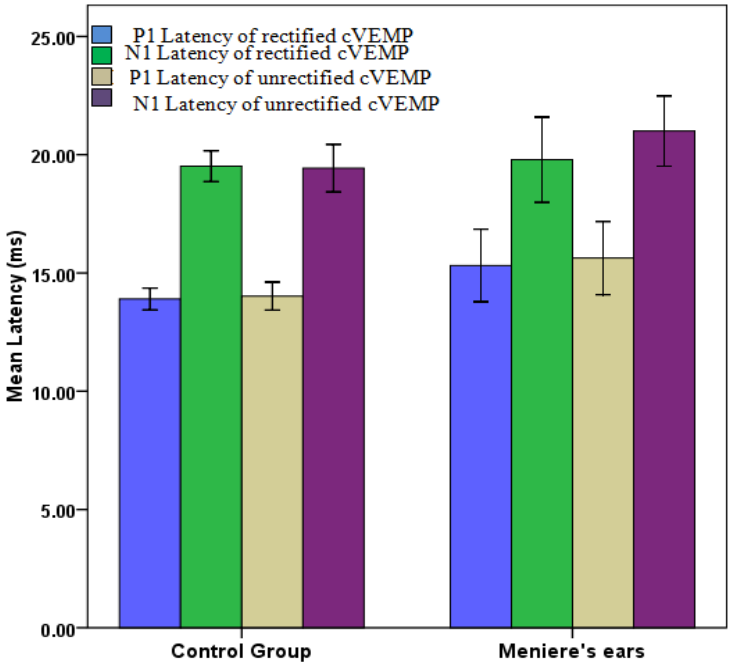

Figure 4.3 Latency of P1 and N1 latency for control group and Meniere's ears

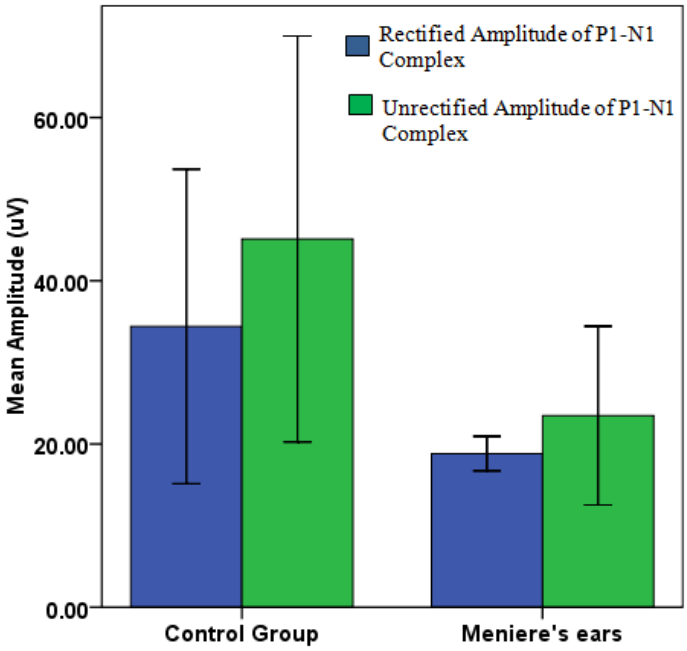

Figure 4.4 Amplitude of P1-N1 Complex for control group and Meniere's ears.

Non parametric Mann Whitney U test was done to compare the latency of P1 and N1 and amplitude of P1-N1 complex between control group and Meniere's ears in

experimental group in rectified and unrectified method of cVEMP. Mann Whitney U Test revealed significant difference in latency of P1 ($Z=2.11$, $p<0.05$), however Mann Whitney U test revealed no significant difference in the latency of N1 ($Z=0.02$, $p>0.05$) but it revealed significant difference for amplitude of P1-N1 complex ($Z=3.26$, $p<0.05$) in rectified method between control group and Meniere's ears. Mann Whitney U Test revealed significant difference in latency of P1 ($Z=2.40$, $p<0.05$), no significant difference in latency of N1 ($Z=1.75$, $p>0.05$) and amplitude of P1-N1 complex ($Z=0.05$, $p>0.05$) in unrectified method between control group and Meniere's ear. To conclude there was no difference of latency of P1 and N1 in rectified and method of cVEMP between control group and Meniere's ears of individuals with Meniere's disease, however there was a difference in amplitude of P1-N1 complex in rectified method of cVEMP between control group and Meniere's ears of individuals with Meniere's disease. Further there was no difference in latency of P1, latency of N1 and amplitude of P1-N1 complex in unrectified method of cVEMP between control group and Meniere's ears of individual with Meniere's disease.

Comparison of latency and amplitude of rectified and unrectified method of cVEMP across normal ears in control group and contralateral ears in experimental group.

Mean and standard deviation for P1 latency and N1 latency of rectified and unrectified method of cVEMP were calculated for both control group and experimental group. The latency of P1 and N1 for control group and contralateral ears of experimental group is shown in figure-4.5 and the amplitude of P1-N1 complex for control group and contralateral ears of experimental group is shown in figure-4.6.

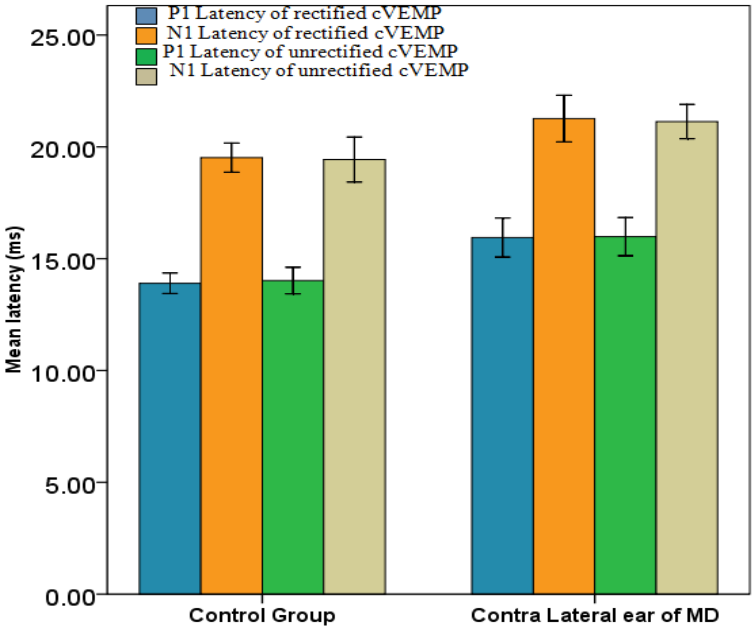

Figure 4.5 Latency of P1 and N1 latency for control group and contralateral ears of Meniere's disease

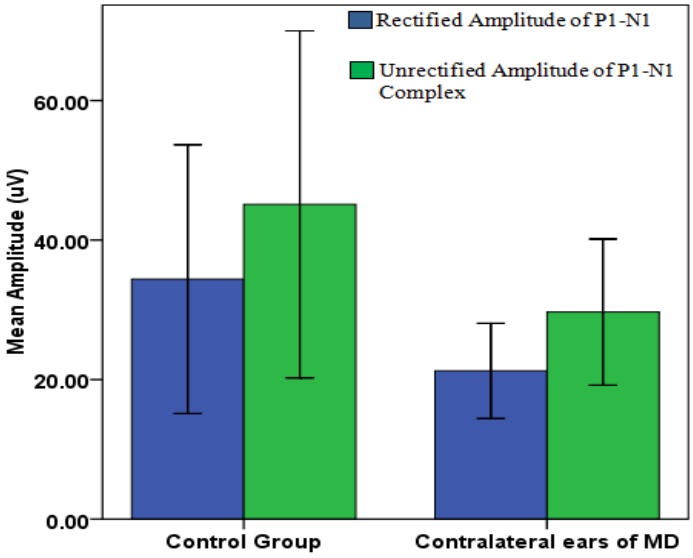

Figure 4.6 Amplitude of P1-N1 Complex for control group and contralateral ears of Meniere's disease

Non parametric Mann Whitney U test was done to compare the latency of P1, N1 and the amplitude of P1-N1 complex between control group and contralateral ears and

Meniere's ears of experimental group separately in rectified and unrectified method of cVEMP. Mann Whitney U test revealed significant difference in latency of P1 ($Z=3.50$, $p<0.05$) and latency of N1 ($Z=3.00$, $p<0.05$) in rectified method between control group and contralateral ears of individuals with Meniere's disease. Mann Whitney U test also reveled significant difference in amplitude of P1-N1 complex ($Z=2.72$, $p<0.05$) in rectified method between control group and contralateral ears of individuals with Meniere's disease. Mann Whitney U Test revealed significant difference in latency of P1 ($Z=3.00$, $p<0.05$), latency of N1 ($Z=2.19$, $p<0.05$) but it did not show any significant difference in amplitude of P1-N1 complex ($Z=1.45$, $p>0.05$) in unrectified method between control group and contralateral ears of individuals with Meniere's disease. To conclude there was a difference of latency of P1 and N1 and amplitude of P1-N1 complex in rectified method of cVEMP between control group and contralateral ears of individuals with Meniere's disease. There was also a difference in latency of P1 and N1 for the unrectified method of cVEMP between the normals and the contralateral ears of Meniere's disease but there was no difference in amplitude between the normals and the contralateral ears of Meniere's disease using unrectified method of recording cVEMP.

Association between caloric results and cVEMP test results obtained in Meniere's ears.

Caloric test results could be obtained for 12 participants with Meniere's disease only. To see the association between caloric results and cVEMP test results chi square test was done. Chi square test revealed no association between caloric results and rectified method of cVEMP test result ($p>0.05$) and unrectified method of cVEMP ($p>0.05$) in Meniere's ears. Chi-square test results are given in table-4.4

Table 4.4

Chi-square test results for association between the caloric test and cVEMP

		Rectified cVEMP			Unrectified cVEMP		
		Present	Absent	Total	Present	Absent	Total
Caloric Result	Present	1	4	5	4	3	7
	Absent	4	4	8	1	5	6
	Total	5	8	13	5	8	13
		p value* 0.27			p value* 0.13		

*Chi-square test

To summarize responses were present in 27 ears in control group, 8 Meniere's ears and 14 ears in contralateral ears of individuals with Meniere's disease in rectified method of cVEMP however responses were present in 29 ears in control group, 8 Meniere's ears and 14 ears in contralateral ears of individuals with Menier's disease in unrectified method of cVEMP. Result reveled that there was no difference in the latency of P1 and N1 between rectified and unrectified method of cVEMP in control group and

contralateral ears of individuals with Meniere's disease however there was difference in the amplitude of P1-N1 complex between rectified and unrectified method of cVEMP in control group and contralateral ears of individuals with Meniere's disease. The latency of P1, N1 and the amplitude of P1-N1 complex between rectified and unrectified method of cVEMP was not different in Meniere's ears. The latency of P1 and the amplitude of P1-N1 complex was different however the latency of N1 was not different between control group and Meniere's ears in rectified method of cVEMP. There was no difference in the latency of N1 and the amplitude of P1-N1 complex however there was difference in the latency of P1 between control group and Meniere's ears in unrectified method of cVEMP. The latency of P1 and N1 was different in control group and contralateral ears of the individuals with Meniere's disease in both rectified and unrectified method of cVEMP. The amplitude of P1-N1 complex was not different between control group and contralateral ears of the individuals with Meniere's ears using unrectified method however it was different between the control group and contralateral ears of individuals with Meniere's disease in rectified method of cVEMP. There was no association between caloric test results and rectified, unrectified method of cVEMP.

Chapter-V

DISCUSSION

The aim of the present study was to investigate the difference between rectified and unrectified method of cVEMPs in normal hearing individual and individuals with Meniere's disease and also to correlate the caloric result with the cVEMP result in individual with Meniere's disease. Test batteries which include detailed case history, pure tone audiometry, Immittance, reflexometry, auditory brainstem response and rectified and unrectified method if cVEMP was used. Result subjected to the statistical analysis and the result obtained is discussed in this chapter.

1. Cervical vestibular evoked myogenic potentials in control group

In the present study cVEMP was recorded from 15 individuals (30 ears) in control group using rectified and unrectified method of cVEMP. Responses were present in 27 ears (90% response rate) and 29 ears (96% response rate) in rectified and unrectified method of cVEMP respectively.

Different studies have reported different prevalence rate of cVEMP using rectified and unrectified method of cVEMP. Wu, Shiao, Yang & Lee, (2007) reported 100% response rate in unrectified method, Cody et al., (1964) reported 86% response rate in unrectified method of cVEMP. Vijayashankar, (2008) reported 88% response rate in rectified method, Madappa, (2009) reported 85% response rate in rectified method, Ghosh, (2012) and Thomas, (2013) reported 100% response rate in rectified method. The instrument used in the present study was similar to the previous studies (Vijayashankar, 2008; Madappa, 2009).

The mean latency of P1, N1 and the mean amplitude of P1-N1complex was 13.90 ms, 19.51 ms and 34.39 µV respectively in rectified method. The mean latency of P1, N1 and the mean amplitude of P1-N1 complex was 14.20 ms, 19.66ms and 43.48 µV respectively in unrectified method of cVEMP.

Different studies have reported the mean latency of P1 and N1 to be around 12 ms-16 ms and 19 ms-23ms respectively using rectified and unrectified method of cVEMP in normal hearing individuals (de Wu, Shiao, Yang & Lee, 2007, McCaslin, Jacobson, Hatton, Foeler & Andrew, 2013; Kaushlendra, 2006; Vijayshankar, 2008; Madappa, 2009; Ghosh, 2012, Thomas, 2013). Studies have reported the mean amplitude of P1-N1 complex 20 µV-200 µV using rectified and unrectified method of cVEMP in normal hearing individuals (Murofushi, Akin, Murnane & Proffitt, 2001; Kaushlendra, 2006, Wu, Shiano, Yang & Lee, 2007 ; Vijayshankar, 2008; Madappa, 2009; Ghosh, 2012, Thomas, 2013). The present study is in consonance with the previous studies (Vijayshankar, 2008; Madappa, 2009; Gosh, 2012).

There was no difference found in the latency of P1 and N1 between rectified and unrectified method of cVEMP however, there was significant difference found for amplitude between rectified and unrectified method of cVEMP in the present study. The mean amplitude in unrectified method was more compare to rectified method of cVEMP.

Different studies have done to compare rectified and unrectified method of cVEMP in normal hearing individuals (Lee, kim, Son, Lim, Bang, and Kaga, 2008; Anoop, 2011). Previous studies have also reported a higher amplitude of cVEMP using unrectified method compared to the rectified method of cVEMP. The present study is in

consonance with the previous studies (Lee, kim, Son, Lim, Bang, and Kaga, 2008; Anoop, 2011). The possible explanation for this difference in amplitude is the amount of muscle tension maintained in the SCM in both the method. It is known and well established fact that the amplitude of VEMP is directly related to the amount of muscle tension in the SCM (Akin, Murnane, Panus, Carutrher, Wilkinson and Proffitt 2004; Versino et.al, 2001; Ochi et al, 2001). In the rectified method the muscle tension will be fixed to a range of values whereas in unrectified method the muscle tension is not monitored and hence the head of the subjects are turned maximally to the opposite side of the stimulating ear which might result in more amplitude of cVEMP using unrectified method of cVEMP.

2. Cervical vestibular evoked myogenic potentials in Experimental group

In the present study cVEMP was recorded from 15 individuals (16 Meniere's ears and 14 contralateral ears) using rectified and unrectified method of cVEMP in experimental group. Responses were present in 8 Meniere's ears (50% rate) and 14 contralateral ears (100% rate) in rectified and unrectified method of cVEMP.

The result of the present study implies that the detection percentage of abnormality in individuals with Meniere's disease is similar using the two methods of recording cVEMP. There are equivocal response rate of cVEMP in Meniere's disease. Different studies have reported different prevalence rate of cVEMP in rectified and unrectified method of cVEMP. Thomas (2013) reported 38% response rate in Meniere's ears and 100% response rate in contralateral ears using rectified method of cVEMP, Young et al. (2003) reported 88% response rate in Meniere's ears using unrectified method. The difference in response rate could be different participants for different

studies. The response of cVEMP depends upon the stages of Meniere's disease. Young et al., (2003) has reported that cVEMP responses might be present in early stage but might disappear in the later stage. The response of cVEMP may be related to the progressive degeneration of the saccular structure in the Meniere's ears (Rosenhall et al. 1977). The shift in the frequency tuning also could be the reason for the absent response in Meniere's ears.

There was no difference found in the latency of P1, N1 and the amplitude of P1-N1 complex between rectified and unrectified method of cVEMP in Meniere's ears. Also, no difference could be found for latency of P1 and N1 however, the difference was noted for the mean amplitude of P1-N1 complex between rectified and unrectified method of cVEMP in contralateral ears of individuals with Meniere's disease. The mean amplitude was more for unrectified method compare to rectified method.

This result did not follow the similar trend as control group. The probable reason could be that the Meniere's disease is a progressive degenerative disease which could result in vaccuolation of sensory cells and cystic formation (Stahl, 1991). The vacuolation results in the unspecific damage to the vestibular system whereas cystic formation affects sensory cells of the macula and crista ampularis (Rosenhall et al. 1977). The large cystic spaces will developed between the sensory cells and the nerve chalice due to cystic degeneration (Rosenhall, 1977). This denegation might leads to the system insensitive to changes in the overall level of EMG activity in the recording of cVEMP so there muscle tension maintained in the SCM is same in both the method of cVEMP which resultant in the same amplitude in both method of cVEMP in the Meniere's ears. The difference in

amplitude between rectified and unrectified method of cVEMP could be due to extra muscle tension caused during the recording of unrectified cVEMP.

Comparison of latency and amplitude of rectified and unrectified method of cVEMP in control group and Experimental group (Meniere's ears)

The latency of P1 and the amplitude of P1-N1 complex were different for Meniere's disease. However, the latency of N1 was same in control group and Meniere's ears using rectified method. Also, the P1 latency and the amplitude of P1-N1 complex was different however, the N1 latency not different between control group and Meniere's disease using unrectified method.

Different studies have reported that the latency of P1 and N1 in Meniere's ears is similar to normal ears (Young et al.,2003; Rauch et al., 2004; Ochi et al., 2001 and Murofushi et al., 2001). Studies stated that latency of cVEMP is not affected by the Meniere's disease (Young et al., 2003; Rauch et al., 2004; Ochi et al., 2001 and Murofushi et al., 2001). However the present study is not in agreement with the previous studies as a significant delayed P1 latency has been recorded for individuals with Meniere's disease. However, there was no delay for N1 latency using both the methods. The delay in latency for P1 peak is not possible to explain at this point of time. Probably another study with more number of subjects night throw some light on this.

The amplitude of P1-N1 complex was lesser using rectified method Meniere's ears compare to Control group. However, no significant difference could be noted for P1-N1 amplitude between normal hearing individuals and individuals with Meniere's disease using unrectified method of cVEMP.

The present study revealed an abnormality in amplitude of P1-N1 complex using rectified method; however the same could not be obtained for unrectified method of cVEMP. This implies that the rectified method of cVEMP is better for the diagnosis of individuals with Meniere's disease compared to the unrectified method of cVEMP. The reduction in amplitude of cVEMP could be due to the loss of saccular macula associated with collapse of saccular wall onto the otolith membrane (Young et al. 2003).

Comparison of latency and amplitude of rectified and unrectified method of cVEMP across normal ears in control group and contralateral (normal) ears of experimental group

The latency of P1, N1 and the amplitude of P1-N1 complex was different in control group and contralateral ears in rectified method of cVEMP. There was difference in the latency of P1 and N1; however there was no difference in the amplitude of P1-N1 complex in unrectified method between control group and contralateral ears of individuals with Meniere's disease in unrectified method of cVEMP.

A significant delayed P1 and N1 latency has been recorded for individuals with Meniere's disease using both the techniques. The delay in latency for P1 and N1 peak is not possible to explain at this point of time. Probably another study with more number of subjects night throw some light on this.

The amplitude of cVEMP using rectified method was reduced in individuals with Meniere's disease compared to the normal hearing individuals using rectified method compared to the unrectified method. Different studies have reported that in around 31%

to 37% of the cases have involvements of contralateral ears in individuals with Meniere's disease (Thomas et al. 1971; Green et al. 1991). The amplitude differences could be due to the lesser amplitude recorded with rectified compared to the unrectified method of cVEMP.

Association between caloric results and cVEMP test results obtained in Meniere's ears.

Present study attempted to investigate the association between caloric result and cVEMP test result obtained in Meniere's disease. Result revealed no association between caloric result and both the method of cVEMP.

The present study follow the same trend reported by Murofushi, Nakahara, Yoshimura and Tsuda (2011); Waele, Huy, Diard, Freyss and Vidal, 1999 and Young, Huang and Cheng, 2003. The similar result was found by Murofushi, Nakahara, Yoshimura and Tsuda (2011), Chiarovano et al., (2011) for other peripheral vestibular disorders. This dissociation of the caloric result and the cVEMP could be due to different system involved in both the tests. Caloric result mainly assesses the semi circular canal while the cVEMP assesses saccule and in Meniere's disease saccule is affected more compare to semicircular canal.

Chapter-VI

SUMMARY AND CONCLUSION

Present study was conducted with an aim to characterize the rectified and unrectified cVEMP results in normal hearing individual and individuals with Meniere's disease. To achieve the aim two groups of participants were taken for the study. First group consisted of 15 individuals with Meniere's disease (16 Meniere's ears and 14 contralateral ears). Second group consisted of age matched 15 normal hearing individuals (30ears). The participants were diagnosed as Meniere's disease, based on American Academy of Otolaryngology–Head and Neck Surgery, 1995. All the participants went for routine audiological tests, detailed case history, pure tone audiometry, Immittance, reflexometry, uncomfortable loudness level and ABR. cVEMP was recorded using both rectified and unrectified method for normal hearing individuals and individuals with Meniere's disease. To record cVEMP non-inverting electrode was placed on the 2/3rd distance of the SCM, inverting electrode was placed on sternoclavicular junction and ground electrode on the fore head. cVEMP was recorded from both the ears in control group and experimental group using 500 Hz Tone burst stimulus presented at 95 dB nHL. The responses were filtered from 30 Hz to 1500 Hz.

Analysis of cVEMP

- The first positive peak in the waveform was marked as P1 and first negative peak was marked as N1.
- Descriptive statistics was done to obtain mean and standard deviation values for latency measures of rectified and unrectified method of cVEMP for experimental and control groups.

- Descriptive statistics was done to obtain mean and standard deviation values for amplitude measures of P1-N1 complex for rectified and unrectified method cVEMP for experimental and control groups.
- Wilcoxson Signed Rank Test was done to compare the latency of P1 and N1 for rectified and unrectified method of cVEMP in Control group.
- Wilcoxson Signed Rank Test was done to compare the latency of P1 and N1 for rectified and unrectified method of cVEMP in Meniere's ears.
- Wilcoxson Signed Rank Test was done to compare the latency of P1 and N1 for rectified and unrectified method in contralateral ears of individuals with Meniere's disease.
- Non parametric Mann Whitney U test was done to compare the latency of P1 and N1 of cVEMP between the individual with Meniere's disease and normal hearing for rectified method of cVEMP**.**
- Non parametric Mann Whitney U test was done to compare the latency of P1 and N1 of cVEMP between the individual with Meniere's disease and normal hearing for unrectified method of cVEMP**.**
- Non parametric Mann Whitney U test was done to compare the P1-N1 amplitude complex of cVEMP between the individual with Meniere's disease and normal hearing for rectified method of cVEMP.
- Non parametric Mann Whitney U test was done to compare the P1-N1 amplitude complex of cVEMP between the individual with Meniere's disease and normal hearing for rectified method of cVEMP.

- ❖ Chi square test was done to see an association between caloric test results and cVEMP test results obtained in individuals with Meniere's disease.

Results of the present study are as follows:

a. cVEMP responses were present in 27 ears in control group, 8 Meniere's ears and 14 ears in contralateral ears of individuals with Meniere's disease in rectified method of cVEMP. cVEMP responses were present in 29 ears in control group, 8 Meniere's ears and 14 ears in contralateral ears of individuals with Menier's disease in unrectified method of cVEMP.

b. Wilcoxson Signed Ranks test did not reveal any significant difference in latency of P1 and N1 between rectified and unrectified method of cVEMP in normal hearing individuals. However Wilcoxson Signed Ranks test revealed significant difference in amplitude of P1-N1 complex between rectified and unrectified method of cVEMP in normal hearing individuals.

c. Wilcoxson Signed Ranks test did not reveal any significant difference in latency of P1, N1 and amplitude of P1-N1 complex between rectified and unrectified method of cVEMP in Meniere's ears.

d. Wilcoxson Signed Ranks test did not reveal any significant difference in latency of P1and N1 between rectified and unrectified method of cVEMP. Wilcoxson Signed Ranks test however revealed significant difference in amplitude of P1-N1 complex between rectified and unrectified method of cVEMP in contralateral ears of individuals with Meniere's disease.

e. Mann Whitney U Test revealed significant difference in latency of P1, Mann Whitney U test revealed no significant difference in the latency of N1 and but revealed significant difference in amplitude of P1-N1 complex in rectified method of cVEMP between control group and Meniere's ears.
f. Mann Whitney U Test also revealed significant difference in latency of P1, no significant difference for latency of N1 and also no significant difference in amplitude of P1-N1 complex in unrectified method between control group and Meniere's ear.
g. Mann Whitney U test revealed significant difference in latency of P1 and latency of N1 in rectified method between control group and contralateral ears of Individuals with Meniere's disease. Mann Whitney U test also revealed significant difference in amplitude of P1-N1 complex in rectified method between control group and contralateral ears.
h. Mann Whitney U Test revealed significant difference in latency of P1, latency of N1 but it did not show any significant difference in amplitude of P1-N1 complex in unrectified method between control group and contralateral ears of individuals with Meniere's disease.
i. There was no association between caloric result and rectified, unrectified method of cVEMP in individuals with Meniere's disease.

Conclusions

Present study revealed that there was no difference in responses rate of cVEMP responses in individuals with Meniere's disease and normal hearing individuals for rectified or unrectified method of cVEMP recording. However, the amplitude of cVEMP

was lesser in Meniere's ear compared to the normal hearing individuals using rectified method compared to the unrectified method of cVEMP. This could be due to higher amplitude of cVEMP using unrectified method. This implies that rectified method of cVEMP is more sensitive to the Meniere's disease compared to the unrectified method. Also, when responses of the normal hearing individuals was compared with the contralateral ears, no significant difference could be noted between two groups using unrectified method of cVEMP, however, amplitude differences could be noted for rectified method of cVEMP. Again this could be due to higher amplitude obtained for the unrectified method of cVEMP. Comparison between normal ears and contralateral ears may indicate a possible pathology in the contralateral ears, as it has been reported that around 30% of the individuals with Meniere's disease might have pathology in contralateral ears (Sarvanan, 2011). To conclude, the rectified method of cVEMP could give better results for the diagnosis for the Meniere's disease compared to the unrectified method of cVEMP.

Implications of the study:

- This study provides information regarding the diagnostic significance of cVEMPs, using rectified or unrectified method of cVEMP in individuals with Meniere's disease.
- The study will help in identifying the saccular lesion in subjects with Meniere's disease.

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