CORRELATION OF COCHLEAR HYDROPS ANALYSIS MASKING PROCEDURE AND ELECTROCOCHLEOGRAPHY IN MENIERE'S DISEASE

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ALL INDIA INSTITUTE OF SPEECH AND HEARING,

MANASANGOTHRI, MYSORE – 570006

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CERTIFICATE

This is to certify that this dissertation entitled ***"Correlation of Cochlear Hydrops Analysis Masking Procedure and Electrocochleograpy in Meniere's Disease"*** is the bonafide work submitted in part fulfillment for the Degree of Master of Science (Audiology) of the student with Registration No. : 09AUD020. This has been carried out under the guidance of a faculty of this institute and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

Prof. S.R. Savithri

Director

Mysore

June, 2011

All India Institute of Speech and Hearing,

Manasagangothri, Mysore-570 006

CERTIFICATE

This is to certify that the dissertation entitled ***"Correlation of Cochlear Hydrops Analysis Masking Procedure and Electrocochleograpy in Meniere's Disease"*** has been prepared under my supervision and guidance. It is also certified that this has not been submitted earlier in any other University for the award of any Diploma or Degree.

Mr. Prawin Kumar

Guide

Lecturer in Audiology

Department of Audiology

All India Institute of Speech and Hearing

Manasagangothri, Mysore - 570 006.

Mysore

June, 2011

DECLARATION

This is to certify that this Master's dissertation entitled ***"Correlation of Cochlear Hydrops Analysis Masking Procedure and Electrocochleograpy in Meniere's Disease"*** is the result of my own study under the guidance of Mr. Prawin Kumar, Lecturer in Audiology, Department of Audiology, All India Institute of Speech and Hearing, Mysore, and has not been submitted in any other University for the award of any Diploma or Degree.

Mysore

June, 2011 Register No. **09AUD020**

THIS DISSERTATION IS DEDICATED TO

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Chapter: One

INTRODUCTION

Meniere disease is an idiopathic inner ear disorder, an abnormal increase in the volume of the cochlear fluid (endolymph) in the inner ear (Ries, Rickert, & Schlauch, 1999). Further, it is characterized by recurrent, spontaneous episodes of vertigo, fluctuating hearing loss, aural fullness and tinnitus or with a combination of these signs and symptoms fluctuating over months and years (Sajjadi & Paparella, 2008). The reissner's membrane as being displaced from the basilar membrane in some instance and at the apex of the cochlea, the membrane was seen to bulge through the helicotrema (Morrison, Moffat, & O'Conor, 1980)

The etiology of Meniere's disease has been linked to endolymphatic hydrops, with evidence from histological studies (Hallpike & Cairns, 1938; Horner, 1991). Endolymphatic hydrops refers to swelling of cochlea at the boundaries of the scala media from excessive accumulation of the endolymph (Hall, 2007).

There are various subjective and objective tests like Pure Tone Audiometry, Glycerol test, Auditory Brainstem Response (ABR), Electrocochleography (ECochG), Electronystagmography, Cochlear Hydrops Analysis Masking Procedure (CHAMP) etc. to measure the extent of Meniere's disease but the present study will be focusing on ECochG and CHAMP findings in individuals with normal hearing and Meniere's disease. However, the

histological findings, which help in the confirmation of a Meniere's disease diagnosis, can only be obtained through post-mortem biopsies (Roeser, Valente, Hosford & Dunn, 2000). Therefore, the administration of appropriate clinical diagnostic tools and treatment remains a challenging task.

Need of the Study

- There are controversial studies on CHAMP findings in individuals with Meniere's disease as well as in normal hearing individuals. In recent studies De Valck, Claes, Wuyts and Paul (2007) concluded that due to low sensitivity and specificity of CHAMP it cannot be used as a clinical tool to diagnose individual with Meniere's disease. Whereas other studies oppose these finding and found that CHAMP findings are consistent with the excellent sensitivity and specificity (Don, Kwong, & Tanaka, 2005; Kingma & Wit, 2010; Singh, 2010). So, there is a need for further study to correctly distinguish individuals with Meniere's disease from normal hearing individuals on the bases of the findings of CHAMP.

- The summating potential (SP) amplitude in ECochG has reported to be high in individuals with Meniere's disease (Coats, 1977; Mori, Asai**,** Doi, & Matsunaga, 1987; Al-momani, Ferraro, Ator & Gajewski, 2009), but other's reports contradict the significance of such findings and refer to the large individual variation in SP (Aso, Watanabe, & Mizukoshi, 1991; Nguyen, Harris & Nguyen, 2010). Thus, the value of recording of SP amplitude as a diagnostic tool to identify Meniere's disease has been set in question. Therefore, there is a need

for further investigation to study summating potential recording using extratympanic method in individuals with Meniere's disease.

The SP and AP amplitude ratio gives an important indication of the Meniere's disease (Gibson, Moffat, & Ramsden, 1977; Mori et al., 1987; Aso et al., 1991; Al-momani et al., 2009). Hence, there is a need to study SP/AP amplitude ratio in Meniere's disease and to compare with non Meniere's disease individuals.

Aim of the study

The purpose of this study was to find the diagnostic value of CHAMP and ECochG in Meniere's disease. Also, to find the inter-method reliability in the detection of Meniere's disease using these two different diagnostic tools. Specifically, the main aims of the present study were:

i. To study the summating potential (SP) and action potential (AP) amplitude and the ratio (SP/AP) between the two potentials in individuals with normal hearing and with Meniere's disease.

ii. To study the diagnostic value of CHAMP in individuals with normal hearing and individuals with Meniere's disease.

iii. To correlate the findings of ECochG and CHAMP in individual with normal hearing and individuals with Meniere's disease.

Hypothesis

Based on clinical observations and the findings reported in the literature, it was hypothesized that:

- ECochG would define results in the diagnosis of Meniere's disease. The rationale for this hypothesis is that ECochG objectively yields a positive or negative testing result to confirm diagnosis as to whether a person has Meniere's disease or not by measuring the SP/AP amplitude ratio.

- The wave V latency shift in two conditions, click alone and click + 0.5 KHz high pass masking noise (HPM) in CHAMP is different in individuals with Meniere's disease and individuals without Meniere's disease.

- ECochG and CHAMP findings together will yield a reliable finding in Meniere's disease.

Chapter: Two

Review of literature

Endolymphatic hydrops is a histological finding consisting of dilation of the endolymphatic spaces of the membranous labyrinth. Hydrops has been a consistent finding in the temporal bones of individuals with Meniere's disease (Arts, kileny & Telian, 1997). Hydrops are also found in the temporal bones of individuals with syphilis, trauma, otosclerosis, infection and other disorders. All these conditions are associated with symptoms of episodic vertigo, tinnitus, aural fullness and fluctuating sensorineural hearing loss. However, the general concept of associating Meniere's disease with endolymphatic hydrops is questioned. Hydrops was not found in all persons with Meniere's disease but it was found (6%) on autopsy studies of persons who had no Meniere's type symptoms (Rauch, Merchant & Thedinger, 1989). Meniere's disease occurs in roughly 0.2/100 persons but hydrops was found in 6/100 temporal bones, therefore, there are more individuals with hydrops than Meniere's disease. Thus logically, there must be something more than simply hydrops involved in the origin of Meniere's disease.

2.1 Etiology and Symptoms

Meniere's disease can be considered idiopathic with no satisfactory explanation as to its cause. Meniere's disease can arise from genetic factors, inflammatory, and immunologic dysfunction, infection, trauma and vasculopathy. Disturbance of barometric pressure, hydrostatic pressure and perfusion pressure

have all been incremented at one time or another as factor in Meniere's disease. Rauch (2010) stated that individuals with Meniere's disease exhibit huge variability in symptoms. These symptoms may occur in clusters or sporadically. They may have a great deal of fluctuation in hearing or rapid loss but relatively infrequent vertigo; frequent and severe vertigo attacks but only infrequent fluctuations of mild hearing loss; auditory and vestibular symptoms that occur together; and with relatively equal frequency and severity.

2.2 Diagnostic tools for Meniere's disease

The diagnosis of Meniere's disease has always been a source of confusion. There is no single test that is definitive for the diagnosis. A search of the vast literature shows that there are several tests that can distinguish individuals with Meniere's disease and individuals with non-Meniere's disease. There are several subjective as well as objective tests (Audiological and Non Audiological) to diagnose Meniere's disease.

2.2.1 Subjective Assessment of individuals with Meniere's disease

Several diagnostic tools can be used to assist in the assessment of individuals with Meniere's disease. In common practice, a subjective assessment following American Academy of Otolaryngology-Head and Neck Surgery Committee on Hearing and Equilibrium criteria (AAO-HNS CHE) is used for the diagnosis of MD. For diagnostic purpose, this subjective assessment method can

be used on its own or in combination with an instrumental approach, such as ECochG and CHAMP measures.

AAO-HNS CHE Criteria

In 1972, the first standard for Meniere's disease diagnosis was established by the AAO-HNS CHE using a letter designation system to categorize various forms of patient presentations. These guidelines were revised many times and made to reflect the advancement in the knowledge gained from the research on Meniere's disease. These guidelines have been used to this date. They classified the diagnosis of MD into four levels: "***possible***", "***probable***", "***definite***", and "***certain***" (Members of the Committee on Hearing and Equilibrium, 1995). For a person to be diagnosed as having "***possible***" Meniere's disease, they must have all other possible causes of vertigo excluded and have experienced either an episode of vertigo of the Meniere type, which is spontaneous rotational vertigo lasting for 20 minutes or greater (may be hours), often prostrating and accompanied by disequilibrium which may last for days. Nausea is common and horizontal rotatory nystagmus is always present. The patient must also have no audiometrically established hearing loss or a fluctuating or fixed sensorineural hearing loss with disequilibrium but without definitive episodes. For "***probable***" Meniere's disease, the person must show one episode of vertigo, audiometrically established sensorineural hearing loss on at least one occasion, and tinnitus or aural fullness in the affected ear, with all other possible causes of the vertigo excluded. For "***definite***" Meniere's disease, the person must have two or more

impulsive episodes of vertigo that last for at least 20 minutes in duration as well as audiometrically established sensorineural hearing loss on at least one occasion, and tinnitus or aural fullness during episodes of vertigo in the affected ear, with all other possible causes of the vertigo excluded. Finally, to have a diagnosis of "***certain***" Meniere's disease, the individuals must have presented with definite Meniere's disease and have post-mortem histopathological confirmation.

2.2.2 Audiological Assessment

Audiometric configuration in individuals with Meniere's disease

Hearing loss in those with Meniere's disease often occurs unilaterally but can also occur bilaterally (Thorp & James, 2005). Hearing loss in Meniere's disease is, by nature, highly variable and frequently fluctuating (Arts et al., 1997). Sensorineural hearing loss (SNHL) was found to fluctuate in the early stages of Meniere's disease, with the loss typically starting from low frequencies. After 8-10 years from onset, the hearing loss usually stabilizes at a moderate to severe sensorineural hearing loss (Vrabec, Simon, & Coker, 2007). Fluctuating sensorineural hearing loss is one of the cardinal symptoms of Meniere's disease (Levine, Margolis, & Daly, 1998). Eliachar, Keel, and Wolfson (1973) reported that the most common pattern of hearing loss to be a flat hearing loss in 44% of all Meniere's ears. In 1981, Meyerhoff, Paparella, and Gudbrandsson attempted to classify the pattern of hearing loss in clinically determined cases of Meniere's disease, but no single pattern emerged as diagnostic. They reported that 40% of

the subject with Meniere's disease had flat sensorineural hearing loss and 31% had a peaked pattern.

Ries et al. (1999) compared the audiogram configuration on three different patient groups: persons with unilateral Meniere's disease, persons with unilateral acoustic tumor and persons from the general clinical population. Result revealed that 27% (13/48) of individual with unilateral Meniere's disease showed peaked audiograms in one ear and flat audiometric configuration in the other. Peaked audiometric configurations were also observed in 9% (8/89) of the general clinical population and in 12.5% (7/56) of ears of persons with acoustic tumors. This finding indicated that individuals with Meniere's disease had a higher incidence of peaked audiometric configuration but it could not be concluded that the peaked audiometric configuration was pathognomonic of Meniere's disease.

Vestibular Evoked Myogenic Potentials (VEMP) in individuals with Meniere's disease

VEMP is a vestibulocollic reflex, the afferent limb of which arises from acoustically responsive sensory cells and neurons in the saccule. VEMP reflex depends on integrity of the saccule and inferior vestibular nerve. According to Rauch, Zhou, Kujawa, Guinan, and Herrmann (2004) Meniere's disease produces a threshold shift and alteration of tuning in the VEMP reflex, presumably arising from hydropic distention of the saccule. They hypothesized that the cochleosaccular hydrops of Meniere's syndrome leads to alterations in saccular

motion that change the dynamics of the VEMP. VEMP testing, using ipsilateral broadband click and short tone-burst stimuli at 250, 500, 1,000, 2,000, and 4,000 Hz, was done on 14 normal hearing individuals and 34 individuals with unilateral Meniere's disease. Result of the study revealed that Meniere's ears had significantly increased VEMP thresholds as compare to normal hearing individuals and normal unaffected ears. Thresholds were also shifted at all frequencies in Meniere's ears. Therefore, this study concluded that Meniere's ears display alterations in VEMP threshold.

It was stated by Honaker and Samyy (2007) that role of VEMP has yet to be defined in the diagnosis and treatment of common vestibular disorders, including Meniere's disease, vestibular neuronitis, labyrinthitis, and other diseases. However, they concluded that VEMP may provide additional information about the vestibular system and allow site of lesion testing (e.g. saccule and inferior vestibular nerve) in both pediatric and adult individuals.

VEMP testing abnormality was also found in a study by Ferdinand et al. (2006). They evaluated VEMP thresholds using 250, 500, and 1,000 Hz tone burst stimuli in 14 normal individuals and individuals with Meniere's disease, 12 with tumarkin drop attacks and 82 without drop attacks. Result of the study revealed presence of VEMP in both ears of all normal individuals and in unaffected ears of individuals with unilateral Meniere's disease, VEMPs were undetectable in 13%

of measurements attempted, 18% in affected ears of individuals with unilateral Meniere's disease and 41% in Meniere's ears with tumarkin drop attacks.

Hence, it can be concluded from the given literature that alteration in VEMP thresholds can be observed in individuals with Meniere's disease with respect to normal hearing individuals.

Electrocochleography in individuals with Meniere's disease

ECochG is a measurement of stimulus related electrical potentials, which include the cochlear microphonics (CM), summating potentials (SP) and compound action potentials (AP) of the auditory nerve. This is an ideal test for the diagnosis of Meniere's disease (Levine et al., 1998). It is thought to reflect changes in the anatomic position of the hair cells. This bias in the position of the hair cell is what is expected to occur in active Meniere's disease (Levine et al., 1998).Thus, ECochG have focused on amplitude measure of SP alone or on the amplitude ratio of SP and AP. The purpose of measuring ECochG include monitoring of cochlear and auditory nerve function during surgery, which could result in compromising of these function, and improving the ease with which wave I is identified during ABR testing (Hall, 2007). Another area of clinical interest and application of the ECochG response is in differential diagnosis of Meniere's disease (David, DeBonis & Donohue, 2008).

In 1989, Asai and Mori evaluated the change in summating potential and action potential during fluctuation of hearing in 8 individuals with Meniere's disease by using extratympanic ECochG. The relationship of SP and AP parameters to hearing thresholds was examined. Result of the study revealed that SP amplitude in Meniere ear is independent of degree of hearing loss at each frequency whereas, AP amplitude decrease and SP/AP amplitude ratio increases with increase in hearing loss at higher frequencies.

A clinical study supporting the SP/AP amplitude ratio increased in Meniere's disease was conducted by Aso et al. (1991). ECochG was done on 168 ears with definite Meniere's disease. The results were compared with recordings from 29 normal ears and 444 ears with other types of sensorineural hearing loss. It was shown that the SP/AP amplitude ratio is much more useful indication than SP amplitude alone for detecting endolymphatic hydrops. A mean values of SP/AP amplitude ratio being near 0.25. From 0.30 to 0.40 of SP/AP amplitude ratio was considered adequate as the upper limit. Following intravenous administration of glycerol, a significant decrease in SP/AP amplitude ratio was found in 21 Meniere's ears. A postoperative decrease of 10% or more in SP/AP amplitude ratio was observed in 5 individuals, 10 individuals followed up for 2 years or more after surgery did not show a statistically significant change of SP/AP amplitude ratio and pure tone threshold.

Conlon and Gibson (2000) conducted a study to analyze ECochG recordings obtained from ears demonstrating symptoms highly suggestive of Meniere's disease by using transtympanic recording needle, situated in the round window niche. Analysis was made of the 1 kHz tone burst SP and the SP/AP amplitude ratio response to a 90 dB click. Results demonstrated a significant difference in the 1 kHz SP response, and the SP/AP amplitude ratio, between normal hearing ears and Meniere's ears. Sensitivity of the test using tone burst approached 85%. This study also suggests the usefulness of electrocochleography in diagnosing endolymphatic hydrops, and demonstrated improved sensitivity of the 1 kHz SP response, compared with SP/AP amplitude ratio for clicks, in the diagnosis of Meniere's disease.

Ferraro and Durrant (2006) reported that ECochG is an important tool in the diagnosis/assessment/monitoring of Meniere's disease. In another study, conventional analysis of the click-evoked ECochG included measurement of the amplitudes of SP and AP to derive the SP/AP amplitude ratio. It was documented that an amplitude ratio where SP is elevated relative to AP may be a positive finding for endolymphatic hydrops in individuals suspected of having Meniere's disease (Ferraro & Tibbils, 1999).

Similar findings were also obtain in a study conducted by Al-momani et al. (2009) to assess the sensitivity and specificity of the ECochG for suspected Meniere's diseased individuals. They measured both the amplitudes and areas of

the SP and AP to clicks (to derive the SP/AP amplitude and area ratios), and the SP amplitudes to 1000 and 2000 Hz tone burst. Results indicated that the SP amplitude and area to click stimuli, the total SP-AP area, and the SP/AP area ratio were revealed to be the most sensitive and specific measures associated with a diagnosis of Meniere's disease. The more sensitive and specific ECochG parameters include SP amplitude and area, total SP-AP area, and SP/AP area ratio to click stimuli. Sensitivity and specificity values associated with these measures were 92% and 84%, respectively.

A study conducted by Baba et al., (2009) evaluated the utility of the SP/AP area curve ratio in transtympanic ECochG for the diagnosis of Meniere's disease. One hundred and ninety eight individuals (209 ears) with Meniere's disease were considered. Result of the study showed that with regard to SP/AP amplitude ratio, 57.1% in definite cases of Meniere's disease, 39.6% in probable cases of Meniere's disease and 50.0% in the cases who had transformed from probable Meniere's disease to definite Meniere's disease showed abnormally high values. Abnormally high values were observed in 43.9%, 27.7%, and 30.0% in SP/AP area ratio in three groups respectively, indicating that abnormal values were observed more frequently in the amplitude ratio than in the area ratio in all three groups. This study, hence, suggested that SP/AP area ratio may not necessarily have higher sensitivity in the diagnosis of endolymphatic hydrops of Meniere's disease than SP/AP amplitude ratio in transtympanic ECochG.

In 2010 a survey study was done by Nguyen, Harris, and Nguyen for evaluating the clinical use of ECochG for diagnosis/treatment of Meniere's disease among members of the American Otological Society (AOS) and American Neurotology Society (ANS). Findings of the survey indicated that in suspected cases of Meniere's disease, 45.5% of respondents did not use ECochG at all, 17.5 % used ECochG routinely, and 37.1% used it only in questionable cases. ECochG users differed widely in electrode approach and stimulus modality used, with extratympanic approach and click stimuli used most frequently. Most respondents (73.2%) thought that ECochG is a test of indeterminate value. Only 3.6% required an abnormal ECochG to diagnose endolymphatic hydrops. Still, 77.9% think that ECochG findings do fluctuate with activity of the disorder, but only 18.0% agree that when the ECochG reverts to normal, one can predict remission of symptoms. Almost half of respondents (46.7%) reported that they have stopped ordering ECochG due to variability in results and lack of correlation with their individuals' symptoms. They concluded that among AOS/ANS members, there is low clinical use of ECochG in diagnosis/management of Meniere's disease. For approximately half of respondents, ECochG has no role in their clinical practice.

It can be concluded from the given literature that diagnostic value of ECochG is a matter of controversies. Some authors found the utility of SP/AP amplitude ratio and the amplitude in Meniere's disease whereas others support the

fact that sensitivity and specificity of ECochG is very less in diagnosing Meniere's disease.

Auditory brainstem responses in individuals with Meniere's disease

In individuals with Meniere's disease ABR is found to be normal, but it has been suggested that cochlear travelling wave velocity increases in these individuals (Thornton & Farrell, 1991). Theoretically, the increase in velocity of travelling wave along the basilar membrane could be associated with endolymphatic hypertension of endolymphatic fluid, hence making the basilar membrane more stiffen (Parker & Thornton, 1978; Tonndorf, 1986). The studies (Parker & Thornton, 1978; Gould & Sobhy, 1992; Donaldson & Ruth, 1993) have revealed that using tone burst of different frequencies, travelling wave velocity cannot be estimated considering the wave V latency. Hence, use of derive band technique, that is, use of clicks with ipsilateral masking noise can be used to detect Meniere's disease.

Murry, Cohn, Harker and Gorga (1998) conducted a study to determine whether tone burst ABR latencies could be used to detect an increase in cochlear travelling wave velocity in individuals with Meniere's disease. Study was conducted on 10 individuals with normal hearing, 10 individuals with cochlear hearing loss (not because of Meniere's disease) and 12 with Meniere's disease. It was found that there were no significant differences in absolute wave V latency

and in wave V latency difference responses between the groups. Therefore this study concluded that wave V latency responses and estimation of travelling wave time cannot be used to distinguish Meniere's disease from other form of cochlear hearing loss or from normal ears.

Various studies showed that ABR waveforms cannot distinguish Meniere's disease from other form of cochlear hearing loss or from normal ears. Hence, researchers introduced a new technique called cochlear hydrops analysis masking procedure to distinguish Meniere's disease from other form of cochlear hearing loss in which click is presented with various high pass masking noise and the latency difference between the V peaks of click alone is compared with the click with high pass noise.

Cochlear Hydrops Analyses Masking Procedure (CHAMP) findings in individuals with Meniere's disease

Half a decade ago, the cochlear hydrops analysis masking procedure (CHAMP) was introduced as a method to distinguish objectively active Meniere's disease individuals (Don et al., 2005). The method consists of measurement of the change of the latency of wave V response in the auditory brainstem response, caused by the addition of high-pass making noise to the click stimulus. A reasonable assumption in cochlear hydrops is the increase in endolymphatic pressure could increase the stiffness of the basilar membrane. This increased

stiffness could increase the speed of travelling wave propagation (Tonnodorf, 1957; Flottorp, 1980). Using ABR latencies obtained with high pass masking noise and assuming a normal frequency place map in the cochlea, Thornton and Ferrell (1991) and Donaldson and Ruth (1996) calculated abnormally high travelling wave velocities in individuals with Meniere's disease. Thus, in individuals with Meniere's disease it is assumed that increased endolymphatic pressure alters basilar membrane's mechanical properties which in terns increase the apparent travelling wave velocity (Don et al., 2005).

De Valck et al. (2007) evaluated the applicability and diagnostic value of CHAMP in a series of Meniere's disease and non-Meniere's disease individuals. They concluded that CHAMP does not differentiate individuals with Meniere's from non- Meniere's disease. This yields a sensitivity of 31% and a specificity of 28%. There was no significant difference between the mean latency difference (mean) for Wave V of the Meniere's disease group (0.43 ms) and the non-Meniere's disease group (0.65 ms). Don et al. (2007) reviewed the data obtained in the study by De Valck et al. (2007) and found errors in the data that led to misleading and inappropriate conclusion. All the responses errors were reviewed and suggested that once these errors are corrected sensitivity and specificity will consistently improve to 100% and 80% respectively.

Similar finding of Don et al. (2005) were also obtained in the study by Singh (2010). The study was aimed to determine the findings of CHAMP in subjects with suspected & confirmed Meniere disease & comparing it with the findings of Non-Meniere's disease individuals. The results revealed the an overall specificity of CHAMP to be 76.6% & sensitivity to be 73.8% when the shift in latency of wave V responses for 0.5 KHz high pass masking noise from click alone were measured. This study also yields the shift in latency of wave V increases with successive decreases in high pass masking noise from 8 KHz to 0.5 KHz but the shift was minimum in individuals with Meniere's disease.

A study done by Ordonez-Ordonez, et al. (2009) shows that if Meniere's disease is suspected definite, an abnormal result on CHAMP confirms the diagnosis. The alteration in cochlea's behavior may affect the masking and suppressing effect of masking noise. Thus, that effect can be obtained through recording auditory brainstem responses (ABRs) to moderate level clicks and simultaneous ipsilateral high-pass masking. They also determined the diagnostic value of the CHAMP in individuals with definite Meniere's disease. Study was conducted on individuals with definite Meniere's disease, differential diagnosis (another audio vestibular diseases or neurologic disorders), and normal hearing individuals. Results showed Sensitivity of 31.3% and specificity of 100% were found in individuals with definite Meniere's disease, features that are more helpful in confirming the diagnosis than in rejecting it. If definite Meniere's

disease is suspected, an abnormal result confirms the diagnosis; however, a normal result does not rule out the Meniere's disease diagnosis.

Kingma and Wit (2010) investigated the usefulness of the CHAMP as an additional diagnostic test in individuals with definite unilateral Meniere's disease. Results indicated that latency delays could be measured in both ears. The mean latency delay of wave V responses for the affected ears (0.55 ms; standard error, 0.12 ms) differs significantly from that for the unaffected ears (3.36 ms; standard error, 0.43 ms). These authors considered less than 2 msec as cutoff criteria for latency shift to confirm a diagnosis of Meniere's disease in CHAMP.

2.2.3 Non Audiological tests

Glycerol test findings in individuals with Meniere's disease

A positive glycerol test is considered to be a specific diagnostic sign of Meniere's disease (Snyder, 1971, 1974). In addition to its diagnostic use, the glycerol test is also said to be valuable for evaluating the suitability of individuals for endolymphatic sac operations (Arenberg & Spector, 1977). This is particularly true of glycerol-positive cases, because the disease in such individuals is thought to be in an early phase. Thomsen and Vesterhauge (1979) express the view, however, that psychological factors have a very significant effect upon the outcome of the glycerol test, and they warn against selecting individuals for operative treatment on the basis of results in the glycerol test.

Karjalainen, Karja, and Nuutinen (1984) investigated the correlation of results of the glycerol test to hearing level and caloric reactions in Meniere's disease, and to assess how the test results depend on the stage of the disease. Results revealed that glycerol test was positive in 27 individuals and negative in 33 individuals. The PTA values were 56.7 dB (Range 45 to 77 dB) in glycerol-positive individuals, and 43.6 dB (Range 23 to 75 dB) in glycerol negative individuals. Also the outcome of the glycerol test in individuals with Meniere's disease depends on the pre-test threshold levels. If the hearing loss was mild or moderate, the number of negative test results and normal caloric reactions appeared to increase. In this study, the PTA values in the glycerol-negative individuals were 13.1 dB better than the PTA values in glycerol-positive individuals. The difference was statistically significant. Threshold values were distinctly better in glycerol negative individuals with normal caloric reactions.

Another study, in which comparison between electrocochleography and glycerol test in the diagnosis of Meniere's disease, was done by Mori, Asai, Suizu, Ohta, and Matsunaga (1985). These tests were performed in 51 Meniere's ears. The positive rate of both tests was compared. It was found that the positive rate of ECochG and glycerol test was 63 % and 51 %, respectively. The ears with positive result of both tests and of either test were 15/51 ears (29%) and 43/51 ears (84%). respectively. The positive rate of ECochG was higher in ears with a moderate to severe hearing loss at high frequencies, while the positive rate of glycerol test was higher in ears with a moderate to severe hearing loss at low

frequencies. This study has demonstrated that ECochG is different in selectivity of detection of the endolymphatic hydrops from glycerol test and that the combination of both tests increases the detection rate of the endolymphatic hydrops in Meniere's disease.

Chapter: Three

METHOD

The present study was carried out with the aim:

- To study the summating potential and action potential amplitude and the SP/AP amplitude ratio (ECochG) in individuals with normal hearing and with Meniere's disease.
- To study the wave V latency shift (CHAMP) in individuals with normal hearing and with Meniere's disease.
- Correlation in the findings of ECochG and CHAMP in individual with normal hearing and individuals with Meniere's disease.

To conduct the study, the following method was used to investigate the ECochG and CHAMP in normal hearing individuals and individuals with Meniere's disease.

3.1 Participants

There were two groups of participants, individuals with normal hearing (control group) and individuals with Meniere's disease (experimental group). A detailed case history was taken for each participant in each group. Individuals in both the groups with any otologic and neurologic conditions were excluded from the study.

Control Group

Total thirty three ears (33) of 10 females and 7 males were considered in this group. All individuals were within the age range of 20 – 40 years with the mean age of 22.2 years. They all had pure tone thresholds better than 15 dBHL at octave frequencies between 250 Hz to 8000 Hz in both the ears. The overall mean pure tone average (0.5 kHz, 1 kHz & 2 kHz) was 6.01 dBHL. They had no indication of middle ear pathology, revealed by 'A' type tympanogram with present reflexes.

Experimental Group

Total thirty ears of 9 females and 8 males with the mean age of 32.1 years were considered. The pure tone thresholds were within the range of Mild to Moderate (26 - 55 dBHL) at octave frequencies between 250 Hz to 8000 Hz. The overall mean pure tone average (0.5 kHz, 1 kHz & 2 kHz) of all individuals was 35.69. They had no indication of middle ear pathology, as per immittance finding. Auditory Brainstem Response and otoacoustic emissions were done on each individual, to rule out retrocochlear pathology and those individuals indicating retrocochlear pathology were excluded. They all had at least 3 of the 4 hallmark symptoms (tinnitus, vertigo, fluctuating hearing loss & fullness) used in the diagnosis of Meniere's disease (Committee on Hearing and Equilibrium, 1995). A detailed case history was taken for each individual and the individuals who fulfilled the above mentioned criteria along with the ENT provisional diagnosis of

Meniere's disease were included. The summary of symptoms for each individual with Meniere's disease (MD) is given in table 3.1.

Table 3.1:

Symptoms of individuals with Meniere's disease.

MD ears	Tinnitus	Vertigo	Aural fullness	fluctuating hearing loss
P1	✓	✓	✓	✓
P2	✓	✓		✓
P3	✓	✓		✓
P4	✓	✓	✓	✓
P5	✓	✓	✓	✓
P6	✓	✓		
P7	✓	✓		
P8	✓	✓		
P9	✓	✓	✓	✓
P10	✓	✓	✓	✓
P11	✓	✓		
P12	✓	✓	✓	✓
P13	✓	✓	✓	
P14	✓	✓		✓
P15	✓	✓		✓
P16	✓	✓	✓	
P17	✓	✓	✓	✓
P18	✓	✓	✓	
P19	✓	✓		✓
P20	✓	✓	✓	
P21	✓	✓	✓	
P22	✓	✓		
P23	✓	✓	✓	✓
P24	✓	✓		✓
P25	✓	✓	✓	✓
P26	✓	✓		
P27	✓	✓	✓	
P28	✓	✓		✓
P29	✓	✓		✓
P30	✓	✓		✓

3.2 Instrumentation

The following equipments were used for the study:

i. A calibrated two channel clinical audiometer OB-922 with TDH- 39 headphones and bone vibrator BC -71 was used for pure tone audiometry.

ii. A calibrated immittance meter, GSI- TYMPSTAR was used to assess the middle ear functioning of the individuals.

iii. Otodynamic ILO-V6 software and accompanying hardware was used to record otoacoustic emissions.

iv. ABR software installed in Bio-logic Navigator Pro AEP (version 7.0) system was used to record and analyze the waveforms of ABR. Bio-logic inserts earphones were used for ABR recording.

v. To record and analyze the findings of CHAMP, stacked ABR software installed in Bio-logic Navigator Pro AEP (version 7.0) system was used. Bio- logic Broadband inserts earphones were used for CHAMP recording as these inserts have the extended high frequency response needed to acquire valid data for CHAMP (Biologic AEP user's manual)

vi. ECochG (TM recording) software installed in Bio-logic Navigator Pro AEP (version 7.0) systems was used to record and analyze the findings of ECochG. Bio-logic inserts earphones and a TIPTRODE was used for recording ECochG.

3.3 Procedure

All individuals were tested in an acoustically sound treated room with adequate illuminations as per ANSI (1991). Pure tone thresholds were obtained at octave frequencies between 250 Hz to 8 kHz for air conduction and between 250 Hz to 4 kHz for bone conduction thresholds. Tympanometry was carried out with a probe tone frequency of 226 Hz and acoustic reflexes thresholds were measured for 500 Hz, 1 kHz, 2 kHz, and 4 kHz ipsilaterally and contralaterally. OAEs were obtained using click presented at 70 dBSPL. The probe tip was positioned in the external ear canal and was adjusted to give flat stimulus spectrum across the frequency range. Responses with the reproducibility more than and equal to 80 % was accepted.

Auditory Brainstem Responses (ABR)

ABR recording were obtained to rule out retrocochlear pathology. For ABR recording subject was made to relax on a reclining chair. The site of electrode placement was prepared with the use of preparation gel. Silver chloride (AgCl) cup electrodes were used with the conducting gel. It was ensure that impedance for each electrodes were less than or equal to 5kOhm. The test protocols for ABR recording are mentioned in the table 3.2.

Table 3.2:

The following protocol was used for ABR recording.

Electrode placement	Non inverting- vertex (channel 1)
	Inverting- mastoid of the test ear (channel 1)
	Ground- opposite ear (common)
Stimulus	Clicks
Stimulus polarity	Rarefaction
Stimulus intensity	90 dBnHL
Repetition rate	11.1/sec and 90.1/sec
No. of sweeps	1500
Filter settings	100 - 3000Hz
Time window	10 msec
Gain	100000

Cochlear Hydrops Analyses Masking Procedure (CHAMP)

For recording CHAMP, individuals were made to relax on reclining chair. CHAMP was recorded from 1 channel. The site of electrode placement was prepared with skin preparation gel. Silver chloride (AgCl) electrodes with conducting gel were used for recording CHAMP. It was ensured that impedance for each electrode was less than 5 kOhms. Broadband insert earphones were used to record the CHAMP waveforms. The test protocols for CHAMP recording are mentioned in the table 3.3.

Table 3.3:

The following protocol was used for CHAMP recording.

Electrode placement	Non inverting - vertex (channel 1)
	Inverting - mastoid of the test ear (channel 1)
	Ground - opposite ear (common)
Stimulus	Click alone, click + 8kHz HPM, click + 4kHz HPM, click + 2kHz HPM, click + 1kHz HPM, click + 0.5kHz HPM
Transducer	Broad band insert 580 – BINSER
Intensity	60 dBnHL
Filter	0.1-3 kHz
Repetition rate	45.5/sec
Polarity	Rarefaction
Amplification	100000
Analysis window	16 msec
No. of channel	Single
No. of repetition	2

Electrochochleography (ECochG)

For recording ECochG, individuals were made to relax on reclining chair. ECochG was recorded from 1 channel. The site of electrode placement was prepared with skin preparation gel. Silver chloride electrode with conducting gel and a Tiptrode was used for recording ECochG. It was ensured that impedance for each electrode was less than 5 kOhms. The test protocols for ECochG recording are mentioned in the table 3.4.

Table 3.4:

ECochG was recorded using the following test protocol

Electrode placement	Non inverting electrode (+ve) – Ear canal
	Inverting electrode (-ve) – opposite mastoid
	Ground electrode – forehead
Stimulus	Clicks
Transducers	Insert
Intensity	90 dBnHL
Filters	10 Hz – 1500Hz
Repetition rate	7.1/sec
Amplification	50000
Analysis window	10.66 ms
Polarity	Alternating
No. of channel	Single
No. of stimulus	1024
No. of repetition	2

CHAPTER: FOUR

RESULT AND DISCUSSION

In this section, the results obtained from the present study are discussed. The data obtained was subjected to statistical analysis using the SPSS (version 10.0) software. The analysis was done to obtain information on the following measurements:

- The latency shift of wave V responses for click alone and wave V for click + 0.5 kHz high pass masking noise (HPM) in both the groups, control & experimental.
- The change in latency of wave V responses for click alone and wave V for different frequencies HPM condition in both the groups, control & experimental.
- The SP and AP amplitude & latency difference between the two groups.
- The SP/AP amplitude ratio in both the groups.
- The correlation in the finding of ECochG & CHAMP in both control & experimental group

The above measurements were analyzed using descriptive statistics, parametric tests which include Independent sample t-test and Pearson correlation two tailed test and non-parametric test such as Wilcoxon signed rank test.

Cochlear Hydrops Analysis Masking Procedure (CHAMP) and Electrocochleography (ECochG) were administered on two groups, group of the individuals with Meniere's disease (experimental) and group of the individuals without Meniere's disease (control). For CHAMP recording, the latency of wave V in six conditions (click alone, click + 8 kHz HPM, click + 4 kHz HPM, click + 2 kHz HPM, click + 1 kHz HPM & click + 0.5 kHz HPM) was measured in each group. The latency and amplitude of summating potential (SP) and action potential (AP) and the SP/AP amplitude ratio were measured while recording ECochG. Mean and standard deviation was calculated for each group separately. Independent sample t-test was carried out to check if there is a statistical difference in ECochG recording between individuals with normal hearing and with Meniere's disease. Descriptive statistics was done to measure the significant difference between the values obtained from each group. Pearson correlation two tailed test was carried out to measure the correlation between the two tests administered on two groups. The Wilcoxon sign rank test was administered to check whether there is a significant difference in CHAMP recording between individuals with normal hearing and with Meniere's disease.

Cochlear Hydrops Analysis Masking Procedure (CHAMP) in Individuals with Normal Hearing

CHAMP was administered on total number of thirty three ears (sixteen right and seventeen left ears). Absolute latency of wave V responses was

measured in six different high pass masking noise conditions i.e., click alone, click + 8 kHz HPM, click + 4 kHz HPM, click + 2 kHz HPM, click + 1 kHz HPM and 0.5 kHz HPM. All ears had wave V responses in click alone, click + 8 kHz, click + 4 kHz and click + 2 kHz HPM condition. However, twenty nine ears out of thirty three ears (87.87 %) had wave V responses in click + 1 kHz HPM condition and only twenty four ears out of thirty three ears (72.72 %) had wave V response in click + 0.5 kHz HPM condition. The absence of wave V responses in individuals with normal hearing could be because of undermasking condition. As literature suggests that even in individuals with normal hearing required higher level of noise than the average which will be slightly undermasked (Don et al., 2005). The mean and the standard deviation of absolute latency of wave V response are given in table 4.1.

Table 4.1:

Mean and standard deviation (SD) of absolute latency of wave V responses obtained in click alone, click + 8 kHz, click + 4 kHz, click + 2 kHz, click + 1 kHz & click + 0.5 kHz high pass masking noise condition in individuals with normal hearing.

	No. of ears	Mean (msec)	Standard Deviation	Minimum	Maximum
Click alone	33	5.66	0.24	5.14	6.32
Click+8kHz	33	6.01	0.30	5.39	6.82
Click+4 kHz	33	6.44	0.36	5.42	6.95
Click+2 kHz	33	6.74	0.54	5.42	8.07
Click+1 kHz	29	7.36	1.11	6.01	9.20
Click+0.5 kHz	24	7.44	1.34	6.01	10.51

Table 4.1 clearly shows that as the cutoff frequency of the masking noise decreases, since the whole basilar membrane is masked from basal to apical end, the latency of wave V increases. Further, this change in the peak could be expected because of the factors related to the travelling wave delay, the peak latency of the response increases as the area of the unmasked cochlea is successively restricted to lower frequencies (Don et al., 2005). The mean latency for click alone condition was 5.66 msec whereas the mean latency increased up to 7.44 msec for the click + 0.5 kHz HPM condition. Study by Singh (2010) showed mean latency of wave V responses for click alone as 5.70 msec and for click + 0.5 kHz HPM condition as 8.70 msec. The present study also showed similar findings for click alone and click + 0.5 kHz HPM condition. Furthermore, it is evident from table 4.1 that the standard deviation (SD) is increasing as high pass masking noise is reducing which shows variability is more at low frequency high pass masking noise conditions.

In individuals with normal hearing, the latency shift of wave V response from click alone condition to different high pass masking noise condition was determined by subtracting the latency of wave V response of click alone condition. The minimum mean latency shift was observed in click + 8 kHz HPM condition (0.35 msec), and the maximum mean latency shift (1.78 msec) for click + 0.5 kHz HPM condition. Previous studies (Don, et al., 2005; Singh 2010) also illustrate the similar findings. In addition to this, it is evident from table 4.2 that

both mean and standard deviation of wave V latency increases as high pass masking noise decreases.

Table 4.2

Mean and standard deviation (SD) of wave V latency shift for click alone and different high pass masking noise condition in individuals with normal hearing.

	No. of ears	Mean (msec)	Std. Deviation
Click+8 kHz - Click alone	33	0.34	0.21
Click+4 kHz - Click alone	33	0.78	0.32
Click+2 kHz - Click alone	33	1.08	0.51
Click+1 kHz - Click alone	29	1.72	1.06
Click+0.5 kHz - Click alone	24	1.78	1.28

Cochlear Hydrops Analysis Masking Procedure (CHAMP) in Individuals with Meniere's disease

Total thirty ears (sixteen left ear and fourteen right ears) were tested. Absolute latency of wave V responses was measured in six different high pass masking noise conditions i.e., click alone, click + 8 kHz HPM, click + 4 kHz HPM, click + 2 kHz HPM, click + 1 kHz HPM and 0.5 kHz HPM. All ears had wave V responses in click alone, click + 8 kHz HPM, click + 4 kHz HPM and click + 2 kHz HPM, click + 1 kHz HPM condition but wave V responses for click + 0.5 kHz HPM condition was found only in twenty six ears out of thirty ears in this group. That indicates 86.66% Meniere's ears (72.72 % in contrast with

normal ears) had wave V responses in click + 0.5 kHz HPM condition. The absence of wave V at 500 Hz HPM along with click may be because of noise contamination or presence of PAM artifact. Furthermore, sometimes in Meniere's disease individuals, the amplitude is so low at lower frequencies high pass masking noise condition that it is difficult to interpret wave V response. Also, as literature suggests there may be multiple points or peaks in an undermasked condition, probably due to noise contamination (Don et al. 2007). Even in present study too could not able to trace wave V for all individuals with Meniere's disease at lower frequencies high pass masking noise. The mean and the standard deviation of absolute wave V latency response for different masking noise conditions are summarized in table 4.3.

Table 4.3:

Mean and standard deviation (SD) of absolute latency of wave V response obtained in click alone, click + 8 kHz, click + 4 kHz, click + 2 kHz, click + 1 kHz & click + 0.5 kHz high pass masking noise condition in individuals with Meniere's disease.

	No. of ears	Mean (msec)	Std. Deviation	Minimum	Maximum
Click alone	30	5.83	0.41	5.07	6.76
Click+8K	30	5.99	0.43	5.21	7.07
Click+4K	30	6.24	0.46	5.30	7.26
Click+2K	30	6.44	0.59	5.30	8.01
Click+1K	30	6.49	0.78	5.72	9.95
Click+0.5	26	6.50	0.94	5.72	10.64

The minimum absolute latency for click alone condition was found to be in the range of 5.07 msec to 6.76 msec, similarly the range of absolute latency for click + 0.5 kHz HPM condition was 5.72 msec to 10.64 msec. Furthermore, it is evident from table 4.3 and figure 4.1 that as high pass masking noise reduces from 8 kHz to 0.5 kHz, the mean and standard deviation of absolute latency of wave V response increases. Ideally in individuals with Meniere's disease this shift should be much lesser than normal hearing individuals because of undermasking phenomena. But in present study, the latency shift of wave V response is more probably because differences in methodology. The above finding is in consonance with previous studies (De Valck et al., 2007; Kingma & Wit, 2010; Singh, 2010). In comparison to individuals with normal hearing, the standard deviation of absolute latency of wave V response of Meniere's ears was found to be more.

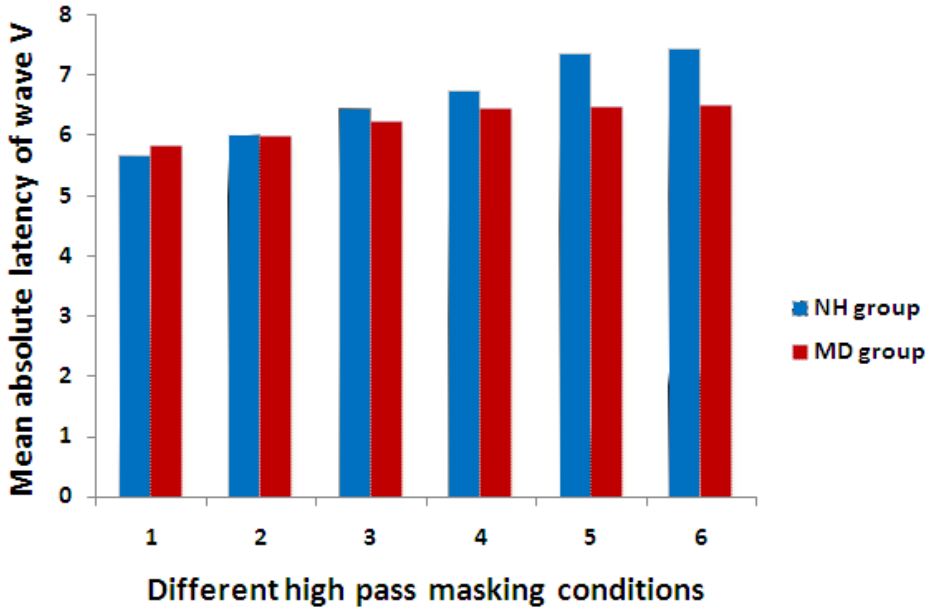

Figure 4.1. Comparison of absolute latency of wave V responses between individuals with normal hearing and Meniere's disease (Note in x-axis: 1 - Click alone; 2 - Clicks+8 kHz; 3 - Clicks+4 kHz; 4 - Clicks+2 kHz; 5 - Clicks+1 kHz; 6 - Clicks+500 Hz).

The latency shift of wave V response was observed in individuals with Meniere's disease for different high pass masking noise conditions. However, it was noticed that the latency shift was lesser for individuals with Meniere's disease than individuals with normal hearing group. The minimum mean latency shift seen for click + 8 kHz HPM condition was 0.15 msec (0.35 msec in control group) and the maximum mean latency shift was 0.74 msec (1.78 msec in control group) for click + 0.5 kHz HPM condition. The present finding is in consonance with previous studies in literature (Don et al., 2005; De Valck et al., 2007; Ordonez-Ordonez et al., 2009; Kingma & Wit, 2010; Singh, 2010) which concludes that the latency shift of wave V is lesser in individuals with Meniere's disease as compared to individuals with normal hearing. The mean and standard deviation of the latency shift of wave V in different noise conditions in individuals with Meniere's disease are summarized in table 4.4.

Table 4.4:

Mean and standard deviation (SD) of wave V response obtained with the difference of click alone and different high pass masking noise condition in individuals with Meniere's disease.

	No. of ears	Mean (msec)	Std. Deviation
Click+8 kHz - Click alone	30	0.15	0.32
Click+4 kHz - Click alone	30	0.41	0.40
Click+2 kHz - Click alone	30	0.62	0.53
Click+1 kHz - Click alone	30	0.66	0.77
Click+0.5 kHz - Click alone	26	0.73	0.94

The comparison in latency shift of wave V response for different high pass masking noise conditions with wave V response for click alone condition between individuals with normal hearing and Meniere's disease.

The comparison of latency shift of wave V responses for different high pass masking noise conditions (click + 8kHz, click + 4kHz, click + 2kHz, click + 1 kHz & click + 0.5 kHz) with wave V responses for click alone condition was done across the two groups using Wilcoxon signed ranks test. It can be clearly concluded from table 4.5 that two groups i.e., control and experimental, are significantly different with respect to wave V latency in different noise conditions. This difference is expected as the physiology of inner ear differs in individual with normal hearing and with Meniere's disease. The basic principle is that the endolymphatic hydrops in Meniere's disease causes changes in the physical properties of the basilar membrane. These changes lead to significant undermasking of the high frequency regions by the noise, resulting in a large undermasked component in the 500 Hz high pass response. This undermasked component is valuable in the detection of endolymphatic hydrops. The findings of the comparisons are given in the table 4.5.

Table 4.5:

Comparison of latency shift of wave V responses obtained from the difference of click alone and different high pass masking noise condition (click + 8 kHz HPM, click + 4kHz HPM, click + 2kHz HPM, click + 1 kHz HPM & click + 0.5 kHz HPM) between individuals with normal hearing and Meniere's disease.

	Significance value ($p < 0.01$)
(click + 8kHz HPM) – click alone	0.005*
(click + 4kHz HPM) – click alone	0.000*
(click + 2kHz HPM) – click alone	0.004*
(click + 1 kHz HPM) – click alone	0.002*
(click + 0.5 kHz HPM) – click alone	0.002*

* - significant difference at $p<0.01$

Several researchers recommended the difference in latency shift from no masking noise condition (click alone) to maximum masking noise condition (click + 0.5 kHz) as the diagnosis criteria for Meniere's disease (Don et al., 1998; Don et al., 2005; De Valck et al., 2007; Ordonez-Ordonez et al., 2009; Singh, 2010). Similar comparison is done in the present study to measure if the significant difference present between the two groups. Results of the present study revealed that there is a significant difference (table 4.5) in the latency shift of wave V for click alone and click +0.5 kHz HPM conditions between the two groups. The comparison summary is also given in fig. 4.2. This significant difference in the latency between two groups could be explained in terms of stiffness of the basilar membrane. The Endolymphatic hydrops might be confined at the apical part of

the basilar membrane (Tonndorf, 1957) whereas in normal ears such stiffness is not seen therefore the cochlea can easily be masked by 0.5 kHz high pass noise, hence there is more shift in latency of wave V in normal ears as compare to Meniere's ear.

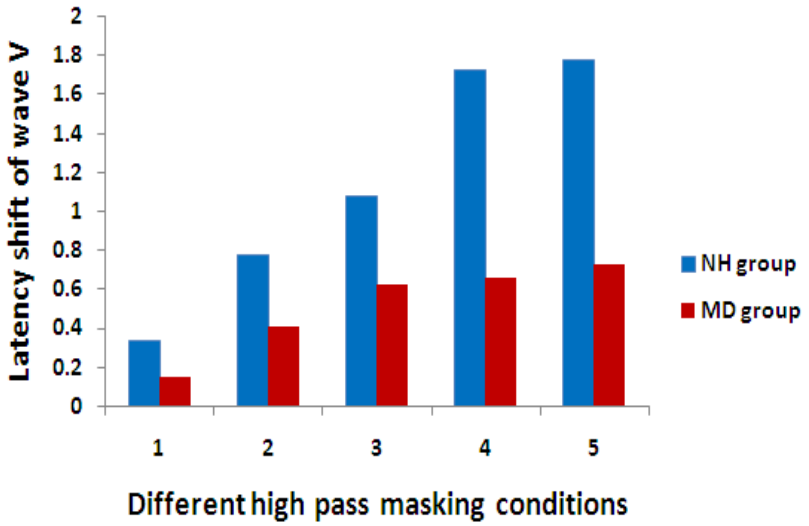

Figure 4.2. Comparison of latency shift of wave V responses between individuals with normal hearing and Meniere's disease {Note in x-axis: 1 (click+8 kHz - click alone); 2 (click+4 kHz - click alone); 3 (click+2 kHz - click alone); 4 (click+1 kHz - click alone); 5 (click+500 Hz - click alone)}

Don et al. (2005) reported that Meniere's disease is confirmed if the wave V latency shifts in click + 0.5 kHz HPM from click alone condition is less than 0.3 msec but if it is more than 0.3 msec, Meniere's disease will considered to be absent. In the present study only seven Meniere's diseased ears out of thirty ears showed wave V latency shift less than 0.3 msec. which accounts only 23.3 % ears with Meniere's disease as per Don et al (2005) criteria. On the other hand, Kingma and Wit (2010) reported that latency shift with less than 0.3 ms diagnostic criterion, the sensitivity of the CHAMP reduces. Therefore they

suggested using 2 msec as cutoff criterion the sensitivity of the CHAMP can be increases. Similarly, in the present study also if the cutoff criterion is set more than 0.3 msec the sensitivity will increase. Hence present study is also supported by Kingma and Wit (2010) findings. The difference in latency of wave V responses in click + 0.5 kHz HPM and click alone condition for individual ear of experimental group is summarized in table 4.6.

Table 4.6:

The frequency table of wave V latency in click +0.5 kHz – click alone condition of individuals with Meniere's disease.

Latency shift (msec)	Frequency (no. of ears)	Percentage of ears
0.06	1	3.3
0.13	1	3.3
0.18	1	3.3
0.19	3	10.0
0.25	1	3.3
0.31	1	3.3
0.33	1	3.3
0.38	2	6.7
0.43	1	3.3
0.56	4	13.3
0.83	1	3.3
0.84	1	3.3
0.88	3	10.0
1.00	2	6.7
1.06	1	3.3
1.57	1	3.3
5.00	1	3.3

Table 4.6 clearly indicates that except one ear, all Meniere's ears has wave V latency shift less than 2msec, which fulfilled the criteria of Kingma and Wit

(2010). For the control group, none of the ear had an abnormally short latency with a separation at 0.3 msec and but sixteen ears with a separation at 2 msec Therefore, 66.66% of control group also showed latency shift of less than 2 msec. which is not supported by Kingma and Wit (2010). The difference in latency of wave V responses in click + 0.5 kHz HPM and click alone condition for individual ear was measured for normal hearing group and it is summarized in table 4.7.

Table 4.7:

The frequency table of wave V latency in click +0.5 kHz – click alone condition of individuals with normal hearing.

Latency shift (msec)	Frequency (no. of ears)	Percentage of ears
0.51	1	2.9
0.56	1	2.9
0.62	1	2.9
0.68	1	2.9
0.69	1	2.9
0.75	1	2.9
0.81	1	2.9
0.89	1	2.9
0.97	1	2.9
1.19	1	2.9
1.27	1	2.9
1.31	2	5.9
1.32	1	2.9
1.33	1	2.9
1.38	1	2.9
2.81	1	2.9
2.82	1	2.9
2.93	1	2.9
3.25	1	2.9
3.45	1	2.9
3.69	1	2.9
3.75	1	2.9
4.81	1	2.9

Table 4.7 indicates that all individuals with normal hearing produced the latency shift more than 0.3 msec, supported by Don et al. (2005). In the present study if the cutoff latency value to diagnose Meniere's disease is considered to be 1 msec then in control group fifteen ears out of twenty four (62.5 %) can be separated from Meniere's disease ears. Similarly in individuals with Meniere's disease twenty three ears out of twenty six ears (88.45 %) will have abnormal short latency shift, which will confirm the diagnosis of Meniere's disease and hence, increases the sensitivity.

Electrocochleography (ECochG) in Individuals with Normal Hearing

ECochG waveforms were recorded in individuals with normal hearing. Twenty five ears out of thirty three ears can be traced for SP waveform, indicating 75.75% of the individual ear had SP waveforms. Literature also suggests that only in 60% individuals with normal hearing SP is traceable (Kithara, Takeda, Yazawa & Matsubara, 1981; Sinha, 2006). The mean and standard deviation for SP and AP is given in the table 4.8.

Table 4.8:

Mean and standard deviation of SP and AP in individuals with normal hearing.

		No. of ears	Mean	Std. Deviation
SP	Latency (msec)	25	0.86	0.13
	Amplitude (µV)	25	0.11	0.19
AP	Latency (msec)	33	1.57	0.15
	Amplitude (µV)	33	0.43	0.18

Several researchers reported that the range of the latency of SP varied from 0.64 msec to 1.11 msec with a mean latency of 0.87 msec (Chatrian et al., 1985; Sinha, 2006). The latency value of SP in the present study is also in consonance with earlier literatures. Similarly the amplitude of SP in the present study varied from 0.04 µV to 0.55 µV. Literature also indicates almost similar findings ranging between 0.04 µV to 1.30µV (Chatrian et al., 1985; Ferraro & Durrant 2004; Sinha, 2006). In the present study extratympanic electrode placement has been used whereas majority of the researches have been recorded EcochG with transtympanic electrode placements. It can be illustrated that because of differences in electrode placement, literature suggests higher amplitude and shorter latencies compared to present study (Gibson et al., 1977; Kanzaki, Ouchi, Yokobori & Ino, 1982; Conlon & Gibson, 2000).

Electrocochleography (ECochG) in Individuals with Meniere's disease

In individuals with Meniere's disease SP and AP waveforms were recorded. Twenty two ears out of thirty ears (73.33 %) had AP waveforms however only fourteen ears out of thirty ears (46.66 %) had SP waveforms. The mean latency and amplitude of SP is 0.93 msec and 0.29 µV in experimental group whereas in control group it was 0.64 msec and 0.11 µV respectively. It indicates the SP values increases both in terms of latency and amplitude in pathological condition. These findings could be explained by the fact that the SP is thought to result from the sum of the alternating current (AC) of the cochlear

microphonic, resulting in a direct current (DC) shift from the base line. This shift is exacerbated by asymmetrical basilar membrane movement, as found in hydrops (Colon & Gibson, 2000). Hence the amplitude of SP in the experimental group is abnormally larger than the control group. The mean latency and the standard deviation are given in the table 4.9.

Table 4.9:

Mean and standard deviation of SP and AP in individuals with Meniere's disease.

		No. of ears	Mean	Std. Deviation
SP	Latency (msec)	16	0.93	0.34
	Amplitude (µV)	16	0.29	0.27
AP	Latency (msec)	22	1.59	0.28
	Amplitude (µV)	22	0.52	0.42

The SP and AP amplitude & latency difference between individuals with normal hearing and Meniere's disease

The difference of SP and AP amplitude and latency between the two groups was statistically analyzed using independent sample t-test. Results showed that the SP amplitude is significantly different in both groups whereas no significant difference is found in SP latency. However significant difference was reported for both amplitude and latency for AP in both groups (Table 4.10 & Figure 4.3). Present finding is in consonance with previous studies (Gibson et al.,

1977; Aso et al., 1991; Colon & Gibson, 2000) but few of them found the significant difference in the SP latency too. This could be explained by the difference in the methodology, because studies have been done by using transtympanic recording rather than extratympanic, used in the present study.

Table 4.10:

The significant difference in SP and AP amplitude between Individuals with Normal hearing and Meniere's disease.

ECochG	Amplitude	Latency
SP	0.005*	0.38
AP	0.02*	0.00*

* - significant level at p <0.05

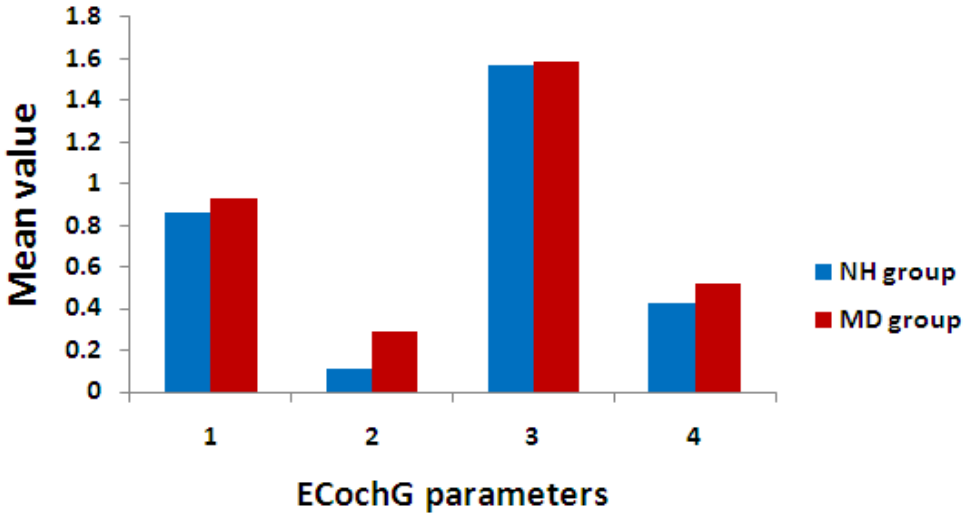

Figure 4.3. Comparison of mean SP and AP latency and amplitude for individuals with normal hearing and Meniere's disease. {Note in x-axis: 1 (Latency of SP); 2 (Amplitude of SP); 3 (Latency of AP); 4 (Amplitude of AP)}

The SP/AP amplitude ratio comparison between Individuals with Normal hearing and Meniere's disease

The SP/ AP amplitude ratio was measured separately for each group. The mean SP/AP amplitude ratio for normal hearing ear was 0.12 whereas mean SP/AP amplitude ratio for individuals with Meniere's disease was 0.28. In the present study the SP/AP amplitude ratio value in control groups is little lower than the value mentioned in literature using extra tympanic recording (Kithara et a., 1981; Ferrao, Best & Arenberg, 1983). Researches using either extratympanic recording or transtympanic (Gibson et al., 1977; Kithara et. Al., 1981; Ferrao et al., 1983; Aso et al., 1991; Colon & Gibson, 2000;) accept this fact that SP/AP ratio considerably differentiates Meniere's disease from normal group and same findings are also illustrated from the present study.

The difference in SP/AP amplitude ratio of each group was measured by using Wilcoxon signed rank test. It was found that there is a significant difference ($Z= 2.98$, $p= 0.003$, significance level at $p<0.05$) in SP/AP amplitude ratio between control and experimental group. Hence with these findings it can be concluded that SP/AP amplitude ratio can differentiate individuals with Meniere's disease from normal hearing.

The correlation in the finding of ECochG & CHAMP in Individuals with Normal hearing and Meniere's disease.

In the present study, by taking all the measurements into consideration from both the tests, CHAMP and ECochG of both group, the correlation was measured using Pearson correlation two-tailed test and it was found that there is a low negative correlation ($r = -0.09$, $n= 16$, $p>0.05$) between the two tests for Meniere's disease. Similarly correlation between CHAMP and ECochG was measured using Pearson correlation test for individuals with normal hearing and it was found that there is a low positive correlation ($r = 0.09$, $n= 20$, $p>0.05$) between the two test.

Hence, it can be concluded from the present study that both the test can be used to diagnose the Meniere's disease as both the test showed significant differences in the findings, but there is low correlation between the two tests. This could be because of differences in recording technique and interpretation of these two tests irrespective of same pathological condition. One limitation with the both tests could be higher degree of hearing loss.

Chapter: Five

SUMMARY AND CONCLUSION

Meniere's disease is an inner ear pathology characterized by episodic vertigo, hearing loss, tinnitus and/or aural fullness. The typical pathological finding in Meniere's disease is an idiopathic endolymphatic hydrops (Morita, Kariya & Farajzadeh, 2009). There are various diagnostic tools to distinguish Meniere's disease. These tests can include Pure Tone Audiometry, glycerol test, Auditory Brainstem Response (ABR), Electrocochleography (ECochG), electronystagmography, Cochlear Hydrops Analysis Masking Procedure (CHAMP) etc. The present study is focused on Electrocochleography & Cochlear Hydrops Analysis Masking Procedures findings in individuals with Normal hearing and Meniere's disease.

The purpose of the present study was to find the diagnostic value of CHAMP and ECochG in Meniere's disease and also the inter-method reliability in the detection of Meniere's disease using these two methods. These two diagnostic tests (CHAMP & ECochG) were administered on individuals with normal hearing and with Meniere's disease. The analyses were done for below mentioned parameters for both the groups:

- Summating potential (SP) and action potential (AP) amplitude and latency.
- SP/AP amplitude ratio.

- Latency shift of wave V for click alone and wave V for different high pass masking noise (click + 8 kHz, click + 4 kHz, click + 2 kHz, click + 1 kHz and 0.5 kHz HPM) specifically click alone and wave V for click + 0.5 kHz HPM.
- The correlation of the findings of ECochG and CHAMP in individual with normal hearing and individuals with Meniere's disease.

This study highlighted some important points related to the assessment of Meniere's disease using different tools. It can be concluded that ECochG and CHAMP are effective diagnostic tool and these should be used as assessment tool for the diagnosis of Meniere's disease. ECochG and CHAMP are generally in agreement regarding a patient's diagnosis of Meniere's disease. Findings of both the tests, CHAMP and ECochG, from both the groups of the present study are summarized and concluded below.

Cochlear Hydrops Analysis Masking Procedures (CHAMP)

- The latency of wave V response increased with the lowering of the high pass masking noise cutoff from 8 kHz to 0.5 kHz HPM in both the groups but the shift in latency was seen more in individuals with normal ears as compare to Meniere's diseased ears due to undermasked phenomena in later group.

- Results of the present study revealed that there is a significant difference in the latency shift of wave V responses for click alone and click +0.5 kHz HPM conditions across the two groups. This significant difference in the latency between two groups could be because of the presence of endolympahtic hydrops in the cochlea. Whereas it increases the stiffness of the basilar membrane in Meniere's ears, however in normal ears such stiffness is not seen therefore the cochlea can easily be masked by 0.5 kHz HPM.
- In the present study only seven Meniere's diseased ears out of thirty ears showed wave V latency shift less than 0.3 msec. That accounts only 23.3 % ears with Meniere's disease as per Don et al. (2005) criteria. On the other hand, using Kingma and Wit (2010) cutoff criterion of 2msec, 96.6% Meniere's diseased ear can be distinguished from normal ears.
- In the present study if the cutoff latency value to diagnose Meniere's disease is considered to be 1 msec then 62.5 % normal hearing ears can be separated from Meniere's disease ears and 88.45 % Meniere's disease ears will have abnormal short latency shift, which will confirm the diagnosis of Meniere's disease. Therefore, further studies can be conducted on large group of individuals to validate the cutoff criteria.

Electrocochleography (ECochG)

- In control group, 75.75% of the individual ear had SP whereas 73.33 % Meniere's ear had AP waveforms and only 46.66 % had SP waveforms in Meniere's ears.

- The mean latency and amplitude of SP were 0.93 msec and 0.29 µV in Meniere's ear whereas in normal ears it was 0.64 msec and 0.11 µV respectively. Therefore, from the present study one can conclude that the SP values increases both in terms of latency and amplitude in pathological condition.
- Only SP amplitude was significantly different across the two groups whereas no significant difference is found in SP latency. However significant difference was reported for both amplitude and latency of AP across the two groups.
- A significant difference in SP/AP amplitude ratio was reported in individuals with normal hearing and with Meniere's disease. Hence with these findings it can be concluded that SP/AP amplitude ratio can differentiate Meniere's disease from normal group.

On examining the data of the present study several conclusion can be drawn. Analyzing CHAMP separately one can conclude that it can be used as a diagnostic tool for Meniere's disease. Abnormality in wave V latency can distinguish Meniere's disease but the cutoff latency criteria should be revised so that the sensitivity of the test will improve. ECochG can also be used as a tool to diagnose Meniere's disease as this test has shown. In present study, the significant difference in amplitude and latency of SP and AP waveforms between Meniere's disease and normal ears. Literature has also suggested the significant importance of these tools in the diagnoses of Meniere's disease.

Clinical Implications

Findings from the current study have some clinical implications for the assessment of Meniere's disease. The study confirms that there is a low negative correlation between the diagnostic assessments of CHAMP and ECochG to diagnoses the individuals with Meniere's disease. As a result, it suggests that ECochG and CHAMP cannot be used alone in the diagnosis of Meniere's disease.

CHAMP used in combination with another assessment tools for the diagnosis of Meniere's disease, such as the ECochG is found to be beneficial. If agreement is shown between the two findings, then it is likely that the patient has Meniere's disease, if there is a disagreement, then the patient needs to be assessed closely, and other assessment tools should be employed. Both tests could be feasible in detecting early stage Meniere disease. In later stage if hearing loss is more the above mention test may not be helpful in diagnosis of endolymphatic hydrops.

Future Directions

- Meniere's disease is always a matter of controversies because of its fluctuating signs and symptoms, therefore no single diagnostic tool can predict the Meniere's disease specifically. There is also a lack of literature on correlation of CHAMP and ECochG, further studies can be conducted on large population to find the

better agreement between two diagnostic tools to diagnose Meniere's disease and to give best clinical services.

- In the present study, the cutoff latency was suggested to 1 msec, as it was in contrast with few studies, therefore further studies can be conducted by taking 1msec as a criteria to diagnose Meniere's disease.
- There is a dearth of literature on ECochG using extratympanic placement in Meniere's disease, so further studies can be conducted using extratympanic placement to diagnose Meniere's disease.
- Bilaterality, ear effect and also the gender effect can be considered in further researches.

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