TO STUDY AND COMPARE THE RESULTS OF THREE DIFFERENT TECHINQUES USED TO EVALUATE THE ACCURITY OF HEARING AND DIFFERENTIAL DIAGNOSIS ON A SAMPLE OF CASES

AN INDEPENDENT PROJECT SUBMITED IN PART FULFILMENT FOR THE III SEMESTER M.Sc. SPEECH AND HEARNIG EXAMINATION, UNIVERSITY OF MYSORE, 1979.

CERTIFICATE

This is to certify that this independent project has been prepared under my guidance and supervision.

Guide

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CERTIFICATE

This is to certify that the independent project "To study the merits and demerits of three different techniques used to evaluate the accurity of hearing and differential diagnosis on a sample of cases" is the bona fide work in part fulfillment for the III Semester. M.Sc. (Speech and Hearing) Examination, carrying 50 marks, of the student with Register Number:

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DECLARATION

This independent project is the result of my own study undertaken under the guidance of Sri. S.S.Murthy , Lecturer in Electronics, All India Institute of Speech and Hearing, Mysore, and has been submitted earlier at any University for any other degree and diploma.

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CONTENTS

Chapter		Page
I	INTRODUCTION	1 – 6
II	REVIEW OF LITERATURE	7 – 19
III	METHODOLOGY	20 – 29
IV	RESULTS AND DISCUSSION	30-32
V	SUMMARY AND CONCLUSION	33
	BIBOLOGRAPHY	

CHAPTER – I

INTRODUCTION

Audiology refers to the study of the hearing and hearing disorders. The field of audiology is a broad one which can be approached from many aspect and to which varied specialists contribute their knowledge and skills. Audiology is the offspring of speech pathology and otology, speech Pathology deals with the diagnosis and treatment of individuals, who suffer from disorders in oral language. Otology, is concerned with the diagnosis and treatment of individuals who suffer from disorders of ear. These two fields were wedded in world war II in so called aural rehabilitation centre for benefit of hearing impaired service per sonnel. As a matter of fact the word 'audiology ' did not come into use until 1945, when Raymond Carhart, a Speech pathologist recruited for the army aural rehabilitation work. Audiology as a popular term is coined by Carhart and Canfield.

There are many other fields related to Audiology both medical and nonmedical. Among medical and non-medical sides of family are paediatrics, psychiatry , and neurology Among non-medical relative audiology have psychology, physics and education. Audiology is related to education particularly in matters concerning the training of deaf and hard of hearing individuals.

Hearing impairment is a matter of degree of loss and also of pattern of loss when a patient complains to otologist that his hearing is defective they need to know information about patient's medical history and results of physical examination, will enable the audiologist to make diagnosis of the type of hearing impairment procedures. To perform these functions of diagnosis and prognosis, the audiologist needs to know. 1. How much hearing loss is there in low, middle and high frequency ranges of ear? 2. How does the patient's air conduction hearing Compare with his bone conduction hearing? 3. How seriously is this patient handicapped by his hearing less?

To provide the answers to these questions, otologists have devised various tests of patients hearing ranging from crude watch trick and coin tick tests so extensive quantitative measurements made possible by the developments of pure-tone and speech audiometers between these extremes fall tuning fork tests and spoken whispered voiced tests. Given with today's modern audiometric instrumentation available manyotologist prefer to use voice and tuning fork tests. The reason is that measurement of the hearing function with modern test equipment requires technical skill on the part of tester and more time than most otologists can spend with their patients, whereas the voice and the tuning fork tests are administered by audiologist himself and in a brief space of time.

Results from routine audiometric test generally are acknowledged as simply revealing the degree of hearing loss present. The focus of interest for development of differential tests in audiometry has cantered on prediction of the site of lesion within the auditory system. An essay of special test requiring examiner skill, patient co-operation, and occasionally some what complicated instrumentation has extended routine audiometry into a relatively time consuming method of evaluation.

Pure tone audiometric tests are not objective, thus affecting the results due to many variables such as bias of the clinician, co-operation of patient and children of smaller age, mentally retarded children, cases

With learning and emotional disorders cannot be tested with pure tone audiometry. Due to these and many other reasons objective audiometry came into existence. One of the objective audiometry methods commonly used in clinics is Impedance audiometry. Madsen impedance Bridge 20 72 is used in many clinics. It simply reveals the site of lesion in different types of middle ear pathologies. It helps a lot in differential diagnosis of conductive, cochlear and retro cochlear types of hearing loss.

Tuning fork test provide information concerning a patient's hearing at discrete frequencies, but these tests are useful primarily for providing a qualitative description of a patient's loss. The next logical development in hearing tests was an pure tone audiometer. Although some experimentation was conducted in the late nineteen century with "electrical" devices, the prototype of the modern, vacuum –tube audiometer was not developed until the 1920's.

The audiometer is an in instrument for electronically generating tones of essential "purity" such as those produced by the tuning fork. The intensity of these tones is accurately controlled by an attenuator, which is usually calibrated in 5dB steps, although some audiometers are calibrated in steps of 1 of 2 dB. Zero dB hearing level at each frequency is the lowest intensity at which the average normal ear can detect the presence of the test tone 50% of the time. Hearing loss is thus expressed as the number dB in excess of this, zero point that the intensity of tone must be increased in order for impaired ear just barely to detect its presence. The test tones produced by the audiometer are delivered to the patient's ear through an earphone for air conduction tests, and though a bone conduction vibrator for test of inner ear functioning.

Comparison of a patient’s hearing sensitivity by air and by bone yields information of diagnostic significance, as does the Rinne tuning fork test. With the added advantage of measuring the amount of loss in dB by each method by testing. The audiometer provides a more accurate type of schwa back test, since it measures BC loss in dB. Therefore the audiometer perfumes both the Rinne and schwa back tests in an improved manner.

The Weber test can also be administrated with the audiometer, by means of the bone conduction vibrator instead of a tuning fork, although these would be little point in performing an audiometric Weber test for routine diagnostic purposes, as the hearing loss in each ear can be accurately measured with the audiometer both the air and by bone.

A modern audiometer contains all the frequencies : 125-250-500-1000 to 1500-2000-3000-4000-6000 and 8000 cps. The human ear is more sensitive to the frequencies in range from 1000 through 4000 cps than it is lower and higher frequencies. The sound pressure level required to make any frequency barely audible to the average normal ear is called zero hearing level. The hearing level dial reads 0dB for the average, normal threshold level at each frequency. Because of the uneven response of the ear, more intensity must be provided for the frequencies bellow 1000cps and above 4000cps in order to make these frequencies audible. The sound pressure level required to make any frequency barely audible to the average normal ear is called zero hearing level. The Hearing level required to reach the threshold of an impaired ear is hearing loss for that ear.

In modern audiometer there is provision for testing speech reception threshold and discrimination scores and other special test like ABLB, SISI, TD for differential diagnosis. Speech reception Threshold (SRT)

Is included in the audiological battery. The threshold for speech also serves as a check on the reliability of pure tones responses in the range of frequencies that relates to the energy in speech. Sounds. SR tests of a practical clinical nature use simple words, usually of two syllables (spondee). The faintest intensity at which the patient identifies 50% of words and repeats them correctly is called speech reception threshold. The history of speech reception testing goes back to the times of using spoken and whispered voice tests. The first widely used recorded auditory test for measuring hearing loss for speech was developed by Bell Telephone Laboratories in 1925. SRT for normal was established. A statistical average SRT was computed based on the result of normal listener. The result was 22dB SPL with reference to 0.002 microbar and that level is used as a basis or 0dB is most commercially available speech audiometers. Relationship between SRT and PT average according to I.S.O (1964) is between -8 to +6dB. Speech discrimination score is also obtained to assess the hearing function of auditory system (Fetcher, 1929m 1953, Bell Laboratories).

Recently many other objective techniques of obtaining hearing level thresholds, as well as for differential diagnostics have been developed. These techniques are Bekesy Audiometry, Impedance audiometry, Evoked response audiometry (ERA), Electrochohleography (ECG) and PGSR.

The discovery of perceptual fluctuations of electrical potentials in the animal cortex was made in 1875 by caten who described them as feeble currents of the brain. The first recordings from the human brain were made by Hans Barger in 1924. The consummation of this techniques was

Achieved by Clark (1958) with the development of evoked response computers. Another contribution to automatic audiometry was of Bekesy audiometry by Bekesy in 1947. The Bekesy audiometer is a continuously variable frequency automatic recording unit. The Grason-Stadler Bekesy audiometer is currently used. The psycho galvanic skin resistance audiometry (PGSR) was identified by Mc Clearry (1950).

The recognition of these characteristics tuning fork results. Audiometric contours and Impedance results has proven to be of immune value in the refinement of otologic diagnosis.

CHAPTER – II

REVIEW OF LITERATURE

The accurate measurement of hearing and hearing loss is vital to assessment of communication handicap and to otologic diagnosis. To understand and how modern hearing test can contributed to the total evaluation of hearing impaired patient, it is necessary to consider the nature of sound, the measurement of sound intensity and the limits of human hearing.

Sound in air result from the alternate compression and re-refraction of air particles. The rate at which this compression and re-refraction takes place in the frequency of the sound. Signal compression and re-refraction is called a cycle. Frequency is the number of such cycles occurring on each second of time and unit of frequency is Hertz (Hz). The intensity of sound is most conveniently described by the alternating pressure it exerts. The unit of sound pressure is the dyne per square/cm^2 . The hearing level is expressed in decibel scale with a reference of 0.0002 dyne/ cm^2 . The decibel marking on the hearing loss dial of an audiometer represent a hearing level.

Roughly, human ear can hear frequencies on the range on the range from 20 to 20,000Hz. However, the ability to hear very high frequencies declines with age. The upper intensity boundary is about 140dB above 0.0002/ cm^2 .

Examination of Hearing:

There are tow chief classes of hearing loss and the first step is to determine which type is present of whether the hearing loss is of mixed type.

1. Conductive deafness: This results from any interruption to the passage of sound up to and including the stapediovestibular joint.

2. Sensori-noural Deafness : It results from a lesion of the sensory apparatus i.e., organ of corti or the neural apparatus, i.e., the eighth nerve , its ganglion and its connections special audiometric tests are necessary to differentiate between sensory and neural lesions.
3. Mixed deafness: In many instances both types of deafness are present example: otitis media or otosclerosis.

The first step is to decide whether the patient is suffering from conductive or sensori-neural deafness, as a rule this is possible by tuning fork tests. These tuning forks are of various types, the most useful type of fork for this examination is one of above 512 double variations per second.

There are many tuning fork tests. Namely, Rinne Test, Weber Test, Bing Test , and schwa back's test. The Rinne test decides whether conductive deafness is present or not. Weber test is used to compare the degree of deafness in the two ears both of which are affected. Schwa bach's test can detect sensori-neural deftness, not only where this is the sole cause of hearing defect, but also the underlying degree of sensori-neural loss in conductive loss cases. These tests will be described in detail later in the paper.

Another most common form in which the results of hearing tests are displayed is called audiogram. The purpose of the audiogram is to provide a graphic plot of the patient's loss in threshold sensitivity expressed in decibel scale Audiogram covers the frequency rang from 125Hz to 8000Hz and intensity conditions for audiometry, an audiometer , a suitable testing environment and a competent audiometric.

Audiometers produce pure tones at octave or half octave intervals from 125 to 8000Hz and permit variations of intensity upto 140dB.

Bekesy (1932) was the first to demonstrate clearly that made of vibration for AC & BC signals, is identical. He conducted an experiments and concluded that the vibration of the basilar membrane are produced by movements of the fluid near the stapes, and thus the two modes of transmission must excite the sensory cells in the same manner. This experiment was a key contribution to BC theory. It also provided information for the clinical use 66 BC thresholds to estimate the integrity to sensory neural system.

Most of the currently accepted concepts regarding BC have involved the investigations and theoretical explanation of Herzoy and Krainz (1926). Bekesy (1932), Barnay (1938), Kirikae (1959), Huzing (1960), and Groen (1962). Two modes of stimulation, compression and inertia are the most commonly accepted concepts.

Bone conduction measurement is the most frequently used clinical procedure next to bone conduction measurements, in spite of its importance the clinical assessment has been played by numerous inherent problems other difficulties are related to.

1. Participation of the middle ear in the total , BC response.
2. The lack of a reliable, valid method of specifying the vibrational output of a BC hearing system.
3. Difficulties and limitation of making the non-test ear.
4. Other equipment and procedural variables such as the type of vibrator the placement of vibrator and the force of vibrator application.

In the proposed international standards for bone conduction thresholds the suggested application force will be approximately 550 gm for a BC vibrator with a plane circular force area of 1.75 cm^2

In clinical practice, pure tone threshold are determined for two main purposes.

1. To assist in the diagnosis of ear pathology and
2. To acquire information which may be used in obtaining appropriate habilitation in rehabilitation programs for hearing impaired persons.

Variables which influence the AC thresholds:

1. Techniques of measurement
2. Instruction given to subject
3. Positioning of earphones
4. Audiometer limitation of frequencies and intensity, minimum and maximum levels.
5. Subject variability:
   a) Ear pathology

   b) Motivation during the test

   c) Ability to co-operate

Limitations:

1. Subjective responses are obtained
2. We don't come across pure tones in our communication of every day life.
3. A qualified and experienced audiologist is required.
4. Air conduction thresholds can't be obtained for small children, mentally retarded, brain damaged cases and for people with learning and emotional problems.
5. Interpretation is also subjective. It may be affected by the bias of the tester.
6. Pure tone testing has to be done in a sound treated environment, whereas the hearing level should be measured in natural environment.

7. Criteria of normal AC threshold
8. A battery of test is required to give a confirmed diagnosis.

Advantages:

1. Pure tone threshold give an accurate qualitative as well as quantitative data about a hearing level of a individual.
2. All the frequencies of speech as well as other sounds in daily life can be tested separately.
3. Masking is used to rule out the participation of the normal ear.
4. The type of lesion can be interpreted.
5. Pure tone threshold along with SRT and DS gives a complete picture of a individuals hearing for speech as well as pure tones.
6. When a pure tone threshold is obtained other supra-threshold tests can be applied.
7. Pure tone testing is one of the important test among impedance, tuning fork test and Bekesy audiometry and E.N.T findings.

Tuning Fork Tests:

In otology, the classic method by measuring or more properly describing hearing loss is by nothing the patient's responses to vibrating tuning forks. Forks of various frequencies are selected for administering the standard tests. These frequencies are octaves of 'c' on the scientific scale, form 128 cps through 8192 cps. The most common tuning fork tests are the Rinne, Weber, and the Schwabach , named after their nineteenth century German originators.

The Rinne test's purpose is to differentiate between conduction and perceptive hearing loss and then assist the otologist in a diagnosis of the types of hearing impairment that a particular patient exhibits. This test is less time consuming.

There are limitations to the use of Rinne, of which the audiologist must be aware in the first place, before a negative Rinne can be obtained, the patient must have exhibited more than a slight conductive loss. Since normally the ear is much more sensitive to air-borne sounds, a slight conductive impairment will not overcome the normal differential between air and bone conduction and the test result will be a positive Rinne even though the patients impairment is actually of the conductive type. Another limitation involves the testing of a patient who has a sensori-neural impairment in one ear. The other ear having normal or close to normal bone conduction. Then the Rinne test result will be negative (i.e., BC better than AC) on the severally impaired ear which actually has a sensori-neural loss. The result might head the audiologist to diagnose a conductive loss which ofcourse, would be grossly wring. What produces this misleading test results in the participation of the ear with normal bone conduction and handle of the fork is pressed against the mastoid of the poorer ear. When the fork is placed on the mastoid the bones of the skull are set into vibration, and the fluid in both the inner ears is agitated.

If the nerve endings in only one inner ear are insensitive to the vibrations on the fluid, the sound will be heard by the other normal inner ear. The patient with a unilateral loss who states that he hears the fork longer by bone conduction than by air-conduction. Therefore might actually be responding to the bone conducted vibrations in his better ear. To safeguard against making a false diagnosis, the audiologist must prevent the participation of the better ear by introducing a masking noise to better ear in masking noise of sufficient intensity to make it impossible for better ear to hear the bone conducted sound produced by the handle of fork pressing against the mastoid of the opposite ear. With a unilateral hearing loss however, the audiologist can check the results of Rinne against the results of the next test (Weber).

Limitations:

1. The results are drawn on subjective responses and the interpretation is subjective.
2. The results are qualitative and quantitative thus not giving the degree of loss.
3. Cannot be used with small children and people with learning and emotional problems.
4. Intensity is not controlled.
5. Calibration of tuning forks is necessary to control the damping effect.

Weber Test:

Caution must be exercised in evaluating the patient's responses to the Weber test. Unless the patient is informed that he might hear the tone in the poorer ear, he is likely to respond consistently that be hears the tone in his better ear, because it is not logical to the patient that he could ever hear better in his poorer ear. His judgement thus belies the evidence of his senses. Qualitative not quantitative results. It cannot be administered with young children and people with learning disorders and emotional problems. Patient may not give reliable responses, if he is confused. Calibration part of the tuning forks is difficult. Intensity is not controlled in test and retest.

Schwabach Test:

The Rinne and Weber tests are qualitative test of hearing that is, they give information as to what type of loss the patient has,

1. Results in terms of time, not in dB, the unit of sound loudness or intensity
2. Subjective interpretation
3. The time gap when the tester places the funning fork on his mastoid bone is a variable affecting the results.

INTROUDUCTION TO IMPEDANCE:

Impedance is technique for making measurements of the function and integrity of the middle ear system. Because the system is mechanical. The measurement can be made objectively.

The technique is based upon measuring the changes in sound pressure level in the ear canal caused by manipulation of the tympanic membrane and the ossicular chain. The manipulation is accomplished either pneumatically or by middle ear muscle contraction. The tests performed by pneumatic manipulation are called tympanometry , and thoseby muscle contraction are called reflex tests.

Tympanometry is conducted by creating, in sequence, positive and negative air pressures in a sealed ear canal and recording the changes in mobility of the tympanic membrane, ossicular chain system thus caused. The point of maximum compliance (minimum impedance) will occur when there is no artificially induced stiffness, i,e, when the air pressure in the external ear canal equal the air pressure in the middle ear space. If the air pressure in the ear canal is changed slowly from +200 to -200 mm the compliance, in a normal middle ear, will change from low to high and back to low. Any middle ear which does not produce a “tympanogram” falling within the shaded area of the sketch has some abnormality.

If an audio stimulus at about 70dB above threshold is presented to an ear and the stapedial muscle contracts the impedance change can be observed. In the absence of stapedial reflex, there is some abnormality of the middle ear.

The impedance bridge has two meters. The first is an electro-manometer, which is an accurate gauge for measuring the ear canal air pressure. The second is the balance meter which is operating as a sensitive sound level meter, for measuring SPL in ear canal.

The chart give some insight into the expected findings with the different pathologies.

Basic Principle:

The Madsen Z0 72 Impedance Bridge is one of a sense of instruments used to detect and measure middle ear functions. It can also measure the action of middle ear muscles. Z0 72 works on the principle that when a hard walled clarity has a calibrated audio tone applied to it a SPL will be established. If volume of such a clarity is large the intensity of the tone must be relatively large to attain a give SPL within the cavity. Some applies when the volume of cavity is small, the intensity required will small.

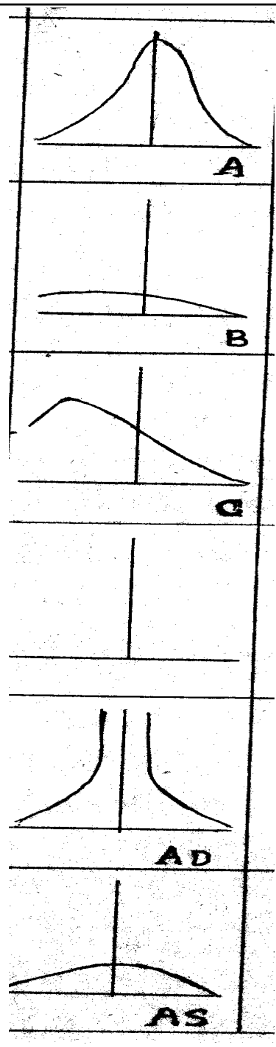
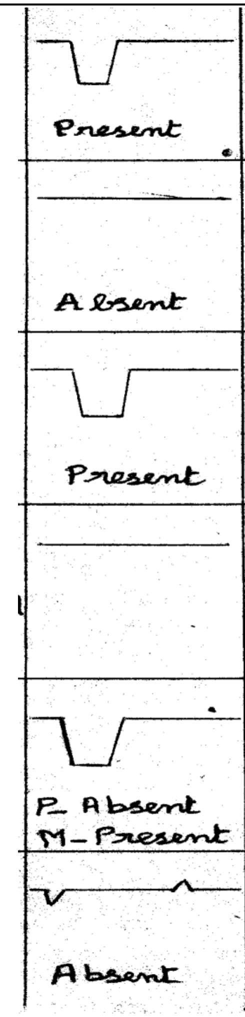
Manual Recording of Tympanograms:

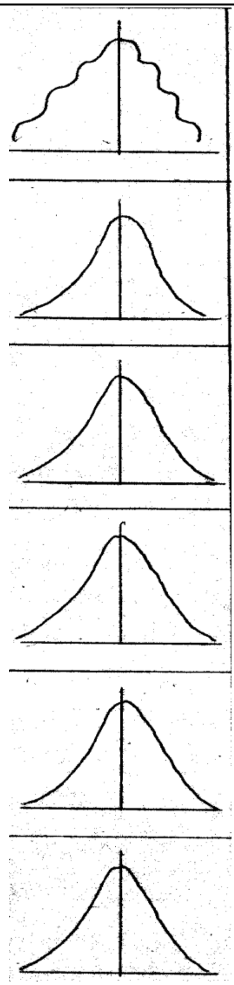
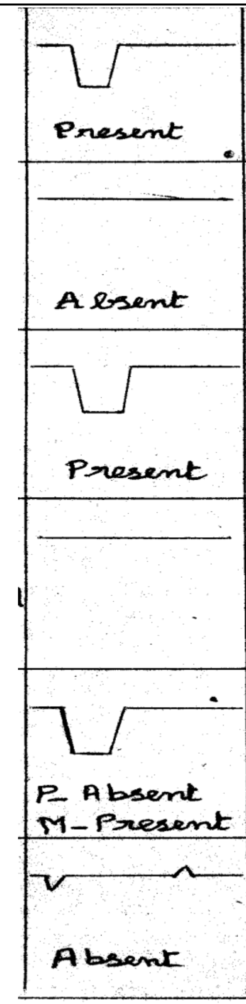
Tympanometry is used to test mechanical condition of the middle ear. The test include checking of mobility of the tympanic membrane and associated ossicies. Fluid and air pressure in the middle ear as well as conditions of the eusta chain tube.

Under normal conditions the air pressure in the middle ear equals the pressure in ear canal, because the ear canal as well as the middle ear, via the eusta chain tube, has normal atmospheric pressure.

When plotting tympanogram manually, take the reading of the compliance at different pressures applied to ear canal. Start with +200 mm pressure and adjust compliance so that balance meter shows 10. Plot this on your form change pressure to 150mm and plot reading on balance meter 9. Proceed like this, and for a normal ear you will see a tympanogram similar to example shown in the figure.1.

To find the actual pressure in a middle ear, the pressure in a middle ear, the pressure is the refer .

PATHOLOGY	TYMPANOGRAM	MIDDLE EAR PRESSURE	COMPLIANCE VARIATIONS	COMPLIANCE	ACOUSTIC REFLEX	REFLEX DECAY	TENSOR REFLEX	HEARING
Normal		Normal	Normal	Normal		Normal	Normal	Normal
Fluid filled or serious otitis		High negative 200mmmore	Absent	Low				Mild to moderate conduction hearing loss
Occluded Eustachian tube		Negative -100mm 200mm	Normal	Normal		Normal	Normal	Mild moderate conduction hearing loss
Performed tympanic membrane		Cannot be measured	Absent	Cannot be measured				Mild moderate conduction hearing loss
Ossicular discontinuity peripheral [p] & Medial (m) to stapes muscle attachment		Normal	Greater than normal	High		M- normal	Greater than normal	Conduction hearing loss
Otosclerosis or stapes fixation		Normal	Less than normal	Low			Less than normal	Conduction hearing loss

PATHOLOGY	TYMPANOGRAM	MIDDLE EAR PRESSURE	COMPLIANCE VARIATIONS	COMPLIANCE	ACOUSTIC REFLEX	REFLEX DECAY	TENSOR REFLEX	HEARING
Patulous eustachain		Normal	Normal	Normal				Normal
Lesion of facial new peripheral nerve medial to stapes muscle		Normal	Normal	Normal			Normal	Normal hearing level
Cochlear lesion		Normal	Normal	Normal		Normal	Normal	Sensory neural hearing level
Retro cochlear lesion		Normal	Normal	Normal		A lognormal decay		Sensory neural hearing level
Lesion of facial new peripheral to stapes muscle		Normal	Normal	Normal		normal	Normal	Normal hearing level
Prediction of unfonous HL		Normal	Normal	Normal		Normal	Normal	Sensory neural hearing level

Change from +200 towards a negative pressure. The balance meter is watched and the air pressure that creates the lowest reading on the red scale equals the pressure in the middle ear.

Compliance in the plane of the Tympanic Membrane:

The acoustic impedance or compliance can be measured in the plane of tympanic membrane in the following way:

An air pressure of 200 mm is applied to the ear canal, and thus clamps the tympanic membrane, then which becomes more or less as rigid as the walls of the ear canal. When the compliance is measured in this condition, the cc reading on the compliance scale gives a very good approximation of the volume of the ear canal itself, because the effect of TM is eliminated. When the pressure in the ear canal and middle ear are equalized, the TM comes back to its most compliant position and therefore it will now affect the total compliance. When re-adjusting the compliance the new reading on the cc scale combines the equivalent volume. If we therefore detect our first measurement (volume of the ear canal) from our last measurement (volume of ear canal + volume of TM) we are left with the equivalent volume of the T,M or termed property as compliance of TM and ossicles. On the compliance scale we can read equivalent reading in acoustic ohms also.

Acoustic reflex Test:

When a sound of a relatively high intensity (70-90dB above threshold) is applied to an ear, the stapdius muscle in both ears will be contracted. When the muscle contracts it will make a slight pull on the ossicles, which will be transmitted to the tympanic membrane and result is in small change of compliance. Because the compliance change is very small, it is important that the pressure in the external canal exactly equals the middle ear pressure, whether it is 0,-20-40 etc. in order to ensure that the tympanic membrane in its most compliant position. When the stimulus is

Presented to one ear, the acoustic signal goes via the middle ear, cochlear and the nerve system to the brain. If the loudness sensation is enough, the brain will through the 7^{th} nerve, cause the stapedius muscles in both ear to contract.

When the stapedius muscle contracts, it makes the system less compliant, therefore the balance meter will give a deflection to the right as long as the stimulus is on. In a normal hearing person a stimulus intensity of 70-90dB S1 will cause a stapedius muscle contraction. Normally the contraction will be clearly seen on the balance meter when sensitivity switch is set at 3. It the deflection is very small, the sensitivity can be increased very small, the sensitivity can be increased 5 times by setting sensitivity at 4.

Merits of Impedance Audiometry:

Measurement of relative dynamic changes in acoustic impedance have been used to determine the existence of an acoustic reflex.

1.
2. The threshold of the acoustic reflex
3. Adaptation of the acoustic reflex
4. Opening of the Eustachian tube.
5. Contraction of the stapedius muscle.
6. Contraction of the tensor tympani, muscle.
7. The general effects of air pressure upon the middle ear transmission system.
8. Measurements of static acoustic impedance at the tympanic membrane are of primary value in differential diagnosis of conductive lesions. These measurement reflect the transmission characteristics of the middle ear system.

The studies of impedance involve an analysis of the ‘opposition’ offered by an system to the flow of energy. In audiology we are concerned.

With the performance of electrical, mechanical and acoustic systems. The concept of impedance may be applied to each of these systems.

Heaviside (1986) first used the term impedance in an analysis of an alternating current network. Webster (1919) was probably the first to suggest that the concept of impedance could be used to simplify the analysis of mechanical and acoustic circuits.

The term impedance may be defined as the complex ratio of a force like quantity of a related velocity like quantity.

Although the concept of acoustic impedance was introduced in 1914 (Webster, 1919) its application to clinical audiology did not become evident until Metz (1946) published his classic monograph.

1. The relation between threshold of audibility and threshold of acoustic reflex for pure tones has been used as an objective measure of hearing sensitivity for neonates and for young children (Terkildsen, 1960; Wedenberg, 1963; Robertson, Peterson and Lamb, 1968; Jerger, 1970)
2. To determine the existence and magnitude of non-organic hearing loss (Jepson, 1953, 1963; Thomson,1955; Terkildsen, 1964; Lamb, Peterson and Hunsen, 1968).
3. To determine the difference between the clinical otosclerosis and ossicular discontinuity (Kristousen and Jepsen, 1952; Metz, 1952, Thompson, 1955).
4. An objective measure of abnormal auditory patient's with pressure lesions or demyelinating lesions of VIII nerve (Anderson, Barr and Wedenberg, 1969; Albesti and Krishousen, 1970).
5. To rule out the existence of conductive lesions for patients with severe sensory-neural hearing losses.
6. For topographic localization of lesion of VIII nerve (metz,1946).

7. In differential diagnosis for patients with brain stem lesions (Jepsen, 1963; Rasmussen, 1970).

8. Acts as an indirect measure of changes in intracranial pressure.

9. As a test for motor function of nerve or as a test for contraction of tensor tympanic muscle.

10. It is a possible index of susceptibility to some extent to the noise exposure.

11. Used to identity the normal hearing carriers of genes, carriers of genes for recessive deafness (Andersen, Wedenberg, 1968).

12. Used to provide an objective estimation of temporal summation of the auditory system for pure tones (Zwislocki, 1971).

13. Each of three basic measurement of techniques has been used to evaluate eustachain tube function.

Aim Of This Study

1. To review the present techniques used to evaluate the accurity of hearing loss.

2. To evaluate the merits and demerits of hearing evaluation procedures carried out in a sample of 50 cases, reported at All India Institute of Speech and Hearing.

3. To discuss and compare the validity of results, carried out under three different hearing evaluation procedures.

CHAPTER – III

METHODOLOGY

This study comprises the following parts:

a) Obtaining pure tone air conduction and bone conduction thresholds for all the 50 cases i.e., 100 ears totally.
b) To obtain responses for Rinne Weber tuning fork tests using tuning forks of frequencies 256, 512, 1024Hz.
c) To obtain results of impedance audiometric procedures- the tympanometry, compliance and acoustic reflex.
d) Comparison of the results of above three rests of hearing.

Selection of cases:

Patients coming to All India institute of Speech and Hearing for check up and treatment, formed a group of 50 cases. Their age range was 11 to 60 years and the mean age was 35.5 years. The cases coming to All India Institute of Speech and Hearing from 18-12-78 to 30-12-78 were included in the study regardless of the type of problem, type of hearing loss etc. the age range below 10 was not included to avoid the unreliable responses for tuning fork test and puretone audiometry. Psychological evaluation was do for all the subjects and cases only with average intelligence level were included in the study.

Test Procedures:

All the tree test evaluation namely Tuning Fork testing, pure tone testing (AC and BC Thresholds), and Impedance testing was performed for all the 50 subjects, that is 100 ears.

The test environment for the tuning fork testing and pure tone testing was the sound treated room No.A at All India Institute of Speech and Hearing.

The testing environment for impedance audiometry was the Electronics Laboratory at AIISH.

For each case first tuning fork testing was done then following by pure tone testing and then Impedance audiometry. The tuning fork test was done for all the subjects by the same clinician, where as for the other two findings different clinicians tested different subjects. The subjects were given a rest for sometime after each test to avoid fatigue and thus unreliable responses. All the three test were conducted for all the subjects on the same day.

First step was to give instructions to the subject about the respective testing, the instructions were repeated if the subject did not respond correctly or if some confusion was noticed on the part of the subject.

Rinne Test:

Instruction: "Now please listen to the tone produced by this tuning fork. When I place this near your ear, tell me whenever you can hear or not. Please concentrate and hear".

Procedure: To perform the test, first the Otologist set a tuning fork into vibration (by striking the fork to a rubber pad) and held it close to the patient's ear. When the patient reported that he could no longer hear the sound or tone produced by the fork, then the otoloist quickly placed the handle of the vibrating fork against the patient's mastoid soon and asked if the patient could again hear the tone. If the subject replied affirmatively, the result of the test was said to be a 'Rinne negative' which was indicative of a conductive type lesion of the hearing loss. If the patient heard the fork longer by air conduction than by bone conduction, the result is labeled as Rinne positive and indicative of sensori-neural loss.

A Rinne test on a normal ear would yield a positive result, since normally our hearing was more sensitive by air conduction then by bone conduction. The tuning forks used for testing were of three frequencies 256Hz. 512 Hz, 1024Hz.

The are limitation to the use of Rinne test of which the audiologist aware of and the precautions were taken before handle them. The responses of the Rinne test were taken down for all the subjects that is 50 subjects. The results were noted in terms of –ve and +ve Rinne indicating conductive loss and sensori-neural loss or normal loss respectively.

Weber Test:

Instruction: "When I place the tuning fork on your forehead, tell me when can you hear the sound produced by fork. Whether in left or right ear or in the center".

Procedure: This test also has its purpose as the differentiation between conductive and sensori-neural loss. The weber is used only in cases of unilateral loss. It is a test of lateralization, that is , a test to see to which of the ears the tone is referred or lateralized when the handle of the fork was placed on the forehead middling. If the patient reported that he hears the tone in his poorer ear, the impairment is sensori-neural type. If there is no difference between two ears the tone was heard equal in both the ears. The responses of weber test were noted as to left, centre of right. The results were interpreted depending on the better ear or poorer ear. The precautions were taken against the limitations.

Procedure for the Pure tone Testing:

After administration of two tuning fork test, next the ac thresholds and bc threshold were obtained for all the 50 subjects.

Instruction : "Prop your elbow on the arm of your chair, make a first and raise it keeping your elbow in contract with the chair. When you hear the tone, Raise your index finger, even when the tone is very soft. Hold it up as long as you hear it. When you no longer hear it, bring your finger right down, up when you hear it, down when you don't.

There instructions were accompanied by simultaneous gestures illustrating and reinforcing the verbal explanation.

Procedure: Air conduction Audiogram: The purpose of air conduction audiometry is to measure the sensitivity of the entire hearing mechanism, the outer and middle ear and sensory neural mechanism of the cochlea and auditory nerve. The air conduction audiogram was (AC) obtained by presenting short pulses of tone to the test ear via the earphone. At each test frequency the audiometerist varied the intensity systematically in order to find the patient's threshold hearing level for the test tone. Threshold usually understood to mean that level at which the patient responds to the tone presented just 50% of the time. The tone was presented at a level above the threshold, decreases the intensity of successive tone bursts until the patent ceases to respond, then increased the intensity until a response reappeared. The threshold was obtained and plotted on the audiogram for all frequencies, 250Hz, 500Hz, 1000Hz, 2000Hz, 4000Hz, 6000Hz, and 8000Hz usually.

Red o's denote the right ear AC. Blue X's denote left ear Ac. The various symbols were joint by short lines. A normal audiogram was plotted on next page. It sometimes happened that there is a substantial difference exceeds the inter aural attenuation factor for Ac sounds its is necessary

To put a suitable masking noise into the better ear when testing the poorer ear. Masking noise was necessary to rule out participation of better ear, while testing poorer ear or to avoid shadow response of better ear. We used studebaker's or Martin's formula of Ac making.

Bone conduction Audiogram: The purpose of the bone conduction audiometric was to measure the sensitivity of the sensory-neural mechanism only. The bone conduction (bc) audiogram was obtained by presenting the test tones directly to the patient's skill by means of Bc vibrator, supplied with the audiometer. The procedure for Bc followed was the same as that used in the air conduction audiometry and it was entered directly on the audiogram. Placement of vibrator was done either on mastoid bone or forehead. Masking was done whenever required Even when all agree that masking should be used there was considerable lack of agreement of masking to be used. 'Hood' has suggested a relatively fool proof method but it is time consuming. And further the conductive loss cases can exist in which it is impossible to use enough masking to exclude the non test ear without, at the same time using to much masking, there by affecting results obtained on the test ear.

Interpretation: The wide use of the audiometer has resulted in accumulation of large numbers of audiograms on cases with every variety of hearing impairment. The difference between the air and bone conduction curves is called the air bone gap. The exact measurement of this gap is an important element in the prognosis fro the middle ear surgery in such patients. We can illustrate different audiometric patterns like Bilateral high frequency loss due to the excessive noise exposure, acoustic trauma Menier's disease, otosclerosis and acoustic neurome etc.

TYMPANOMETRY:

Step by step Procedure:

1. Place the probe in ear to be investigated.
2. Place the receiver on opposite ear.
3. Air pressure – turn knob clockwise until manometer gives a reading of +200mm. check that meter gives a steady deflection indicating that probe is giving a good seal in ear canal.
4. Manometer monitor air pressures in the external canal.
5. Set the sensitivity knob to 1.
6. Adjust the compliance, so that the balance meter gives deflection to 10 on red(lower) scale.
7. For adjusting air pressure, turn knob slowly anti-clockwise. The pressure in the ear canal will go from positive towards negative. Keep your eyes on the balance meter and watch the needle moving to the left. Keep on lowering the pressure by turning air pressure knob(3) anti-clockwise until the balance meter needle starts to move to the right. Then turn air pressure knob back and forth until you find the lowest deflection on balance meter. When this has been achieved, read the pressure of the manometer, which is equal to the pressure in the middle ear. Also, notice the deflection on the balance meter as the middle ear. Also, notice the deflection on the balance meter as the amount of deflection given an indication of the mobility of the TM. Normal mobility gives approximately half scale deflection when sensitivity is in position (1).

COMPLIANCE PROCEDURE:

1. Place the probe in the ear to be investigated.
2. Place the receiver on the opposite ear.
3. Set the air pressure to +200mm and check for good seal.

4. Manometer monitors air pressure in ear canal.
5. Set sensitivity knob to l.
6. Adjust compliance so the balance meter is in balance. Make a note of the setting of cc scale.
7. Change air pressure so that the pressure in ear canal equals pressure in the middle ear in order to get the highest compliance of the TM.
8. Re adjust compliance so that the balance meter again reads 0. Make a note of the new setting on cc scale.

Acoustic Reflex Test:

1. Place the probe in ear opposite to the one to be tested.
2. Place the receiver on the ear to be tested.
3. Set pressure in external canal to equal the pressure in middle ear in order to get highest compliance of TM.
4. Manometer monitors air pressure in ear canal.
5. Put sensitivity knob to 1.
6. Adjust compliance so that the balance meter is in balance (0 on upper scale).
7. Set sensitivity knob to 3.
8. Readjust compliance to maintain 0 on balance meter.
9. Set input to desired stimulus tone, white band or narrow band noise.
10. Set hearing level to desired dB level.
11. Set frequency as desired.
12. Meter gives deflection to broad line on the scale within certain division when stimulus is on.

Reflex Decay Test:

1. Place the probe and receiver as in acoustic reflex procedures.
2. Put sensitivity knob to 1.

3. Adjust compliance so that balance meter is in balance.

4. Set sensitivity to 3.

5. Readjust compliance to maintain 0 on balance meter.

6. Set tone input.

7. Set a desired dB level and desired frequency level.

8. Present the stimulus, by pressing interrupter switch.

9. Meter gives deflection to broad line on scale when stimulus is on

10. An X-Y reorder is needed for this test. Set switch in position "10 sec". In this mode the y axis is connected to the balance meter and records compliance changes. When the interrupted is pushed the pen recorder will move to the left within 5sec.

In patients with acoustic nerve lesions the reflex decay is markedly increased. A measure of this decay is the time it takes for the reflex to become reduced to half the initial size. In patients with acoustic tumours half time of reflex never exceeds 5 seconds.

Equipment and Test Environment: For tuning fork testing and pure tone audiometery the sound treated rooms of All India Institute of Speech and Hearing were used throughout the study. For the impedance testing the electronics laboratory of All India Institute of speech and Hearing was used.

Tuning fork test: Two tuning fork tests, Rinne and Weber tests were conducted for all the cases with use of same tuning forks throughout the study. The frequencies of tuning forks were 256, 512, 1024Hz. The tuning fork tests were conducted by the same clinician throughout the study.

Pure tone Testing : Madsen 0B-70 Audiometer was used for testing the AC +BC thresholds of all the subjects. Red and blue markers were used for graphing the thresholds on the audiogram sheets. Here the subjects were tested by different clinicians as it was not possible for the conductor of this study to test all the cases.

Impedance Testing: Madsen impedance Bridge Z0 72 was used throughout the study for tympanometry, compliance and acoustic reflex procedures. Probe tips of different sizes were used for air tight scaling. Tympanograms were used for plotting the response of the test with red and blue markers represent ting right and left ear respectively. Hear again different clinicians tested the cases.

Calibration:

Tuning fork: Tuning fork used in the experiment were calibrated using NAL vibration pick up and frequency counter (Radart type). Each tuning forks was excited and placed in front of the vibration pick up. The electrical output of the vibration pick up was fed to the frequency counter. The frequency counter reading was taken as the frequency of the tuning fork.

Pure tone Audiometry: Checking calibration is necessary to be sure that an audiometer produces a pure tone at the specified level and frequency, that the signal is present only in the transducer to which it is directed and that the signal is free from distortion or unwanted noise interference when the audiologist has demonstrated his equipment to be in calibration he will be able to report his results with confidence.

The parameters for pure tone audiometer are frequency, intensity and time (phase + signal duration). Equipment useful for checking calibration are : intensity calibration:- Oscilloscope , vacuum tube voltmeter, microphones, spectrometer \, graphic level recorder, sound level meter. Frequency calibration : Oscilloscope, electronic counter, frequency analyzer, distortion meter. Time Calibration: oscilloscope electronic counter, level recorder. Earphone calibration: Basically 2 procedures for calibration of ear phones

1. Subjective method 2. Objective method. The most commonly used is that of the artificial ear or coupler. The artificial ear consists of a condenser microphone and a 6 cc coupler (carlin and Burchard, 1953).

Bone vibrator Calibration: The original techniques for checking bone vibrator calibration was to use real ears (AMA, 1951). Another procedure for calibration of bone conduction vibrators involves the use of an artificial mastoid. Artificial mastoid s were proposed as early as 1939 by Hawley (1939) and in the 1950's by Carlirle and person. But it was not until Weiss (1960) developed such a device they because commercially available for routine calibration checks in hearing clinics.

Impedance Audiometry : Impedance audiometer was calibrated extremely using a variable cavity 0.5cc to 5cc (Madsen Electronics). Switch on the instrument and insert the probe into the .5cc variable cavity. Turn the sensitivity knob to 1. Adjust the balance meter shows zero. Shift the compliance scale to 2cc by simultaneously shifting the probe into 2cc cavity. Again adjust the balance needle, so that the balance meter reads zero. Repeat this procedure for 5cc.

Probe tone calibration: Mount a 2cc coupler on SPL meter and place the probe of impedance audiometer on 2cc coupler using a ear tip. Turn the compliance scale to 2cc and the balance meter to zero. The SPL meter should read 85dB, otherwise adjust it by turning the tone adjuster at the back.

CHAPTER – IV

RESULTS AND DISCUSSION

In the present study the three hearing evaluation procedures namely, tuning fork tests, puretone audiometry and impedance testing results are compared. Total 50 cases were tested that is 100 ears. The observed results for these three tests are given below.

Out of 100 ears, in 79 ears all 3 test could be conducted. Out of these 79 ears, in 64 ears all the three test results tally with each other indicating conductive or sensori-neural hearing loss or normal hearing. In remaining 15 ears the three test results do not tally. These results are discussed later.

In 21 ears, the three tests could not be performed. Out of 21 in 15 ears, impedance testing could not be done, due to following reasons: 1. Air tight sealing could not be obtained 2. Discharge 3. Artesia In these 15 ears pure tone and tuning fork results tally with each other. In next 6 cases, funning fork test could not be included due to unreliable responses, or no response from cases (profound sensori-neural loss). In these cases pure tone and impedance results tally with the each other.

Out of 15 ears where the three test results do not tally are given as below:

In 9 ears, tuning fork results and pure tone responses tally with each other and indicates conductive and sensori-neural loss, where as impedance show different results.

In another 3 ears pure tone and impedance test results tally, whereas tuning fork results differ. In a last 3 ears, results of impedance and tuning fork tally with each other, where as the pure tone results varies.

Obtained results are summarized as follows:

Tests tallying	Number of ears
Tuning fork, pure tone and impedance results	64
Tuning fork and pure tone	24
Pure tone and impedance	9
Impedance and tuning fork	3
Total	100

Out of 100 ears, 64 ears all the three test result tally with each other. And concluding the type of loss either conductive or sensori-neural hearing loss or normal hearing. When the test equipments used in all the three tests was in calibration the test results tally with each other. The results also indicates that the procedure adopted by different specialists was constant and normal.

In another set of 15 ears, the impedance test could not be performed either due to discharge, perforation and Artesia. In these ears the pure tone and tuning fork results tally with each other, indicating conductive hearing loss in most of the ears and sensori-neural loss in few of them.

In another 6 ears, the tuning fork test could not be done due to either unreliable responses or no response such as in case of profound sensori-neural loss.

Out of the last set of 15 ears in 9 ears tuning fork and pure tone results tally, and the impedance results vary.

In the next 3 ears, the tuning fork and impedance test results tally with each other where as the tuning fork results vary.

In the last 3 ears, the tuning fork and impedance tally with each other, where as the pure tone results vary.

From above results we can discuss that out of 100 ears, in 64 ears all the three test results tally with each other in the remaining 30 ears at least two of the three test results tally with each other. For each ear out of these 30 ears in 21 ears we could not perform impedance and tuning fork tests, due to reasons mentioned already. For the remaining 15 ears, discrepancies between the results were observed for the three test results. These ears will be discussed below.

In 4 cases for both the ears, that is totally, 8 ears the tuning fork and pure tone results show conductive loss, where as the impedance shows sensori-neural loss.

In another 2 cases, for 3 ears, the pure tone and impedance show sensori-neural loss where as tuning fork shows conductive loss. So we can see that in these ears, the tuning fork may be showing varied results, because of participation of the other ear, as in tuning fork test masking is not done.

In one case, both ears, the tuning fork and impedance show sensori-neural loss, where as pure tone tests show conductive loss.

In another 2 cases, i.e., 2 ears totally the tuning fork and puretone test results show sensori-neural loss, where as impedance shows conductive loss. In these cases it is diagnosed as otosclerosis by the ENT specialist. This discrepancy may be due to otosclerosis.

CHAPTER – V

SUMMARY AND CONCLUSIONS

In the present study 100 ears are studied by 3 audiological tests. The test results are discussed.

In maximum number of ears that is 64 ears, all the three test results tally with each other. Thus indicate the reliable and valid results together.

Tuning fork and pure tone test results tally for 24 ears. This combination of these two is also quite reliable, but less than the combination of the results of the three tests together.

In ears, pure tone and impedance results tally.

In diagnosis we usually take these three test results into consideration. In places where , the impedance results are not available, we can diagnose a case fairly well with pure tone results and tuning fork tests.

Impedance and pure tone test results will also give good diagnostic results. When we are interested in differential diagnosis, impedance audiometry is very essential.

Impedance and tuning fork test alone will not give quantitative and qualitative diagnostic results. In the present study we have not found even a single ease showing three different test results in above evaluation.

In general pure tone audiometry is a must in audiological evaluation

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