IMPEDANCE AUDIOMETRIC RESULTS FOR THE DIFFERENT PROBE TONES

Register No. 8410

SRIDHARAN .K.

A Dissertation submitted as part fulfilment for

Final year M.Sc.. (Speech and Hearing)

to the University of Mysore

All India Institute of **Speech &** Hearing

MYSORE-570006.

MAY—1986

TO MY BELOVED AMMA APPA

CERTIFICATE

This is to certify that the Dissertation entitled "IMPEDANCE AUDIOMETRIC RESULTS FOR THE DIFFERENT PROBE TONES" iS the bona fide work submitted ia part fulfillment fOr M.Sc., in speech and Hearing of the student with Register No. 8410

Dr.M.Nithya Seelan
Director
All India Institute of
Speech and Hearing,
Mysore - 570006.

CERTIFICATE

This is to certify that this Dissertation entitled "IMPEDANCE AUDIOMETRIC RESULTS FOR THE DIFFERENT PROBE-TONES'has been prepared under my guidance and supervision.

DT.M.N.Vyasamurthy
GUIDE

ACKNOWLEDGEMENT

I express my gratitude be Dr.M.N. Vyasamurthy for his invaluable guidance.

My thanks are due to Dr.M.N.Nithya Seelan, Director, All India Institute of Speech & Hearing, Mysore.

I wish to thank Dr.(Miss) S.Nikam, Professor and Head, Department of Audiology, All India Institute of Speech and Hearing, Mysore who helped me by providing instruments far the purpose of my study.

I thank Ms.Rajalakshmi R Gopal for her expert typing.

My deepest gratitude goes to my colleagues who were ay subjects for the study.

DECLARATION

This Dissertation entitled "IMPEDANCE AUDIOMETRIC RESULTS FOR THE DIFFERENT PROBE TONES is the result of my own study under taken under the guidance of Dr.M.N.Vyasamurthy Department of Audiology, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier at any University for any other diploma or degree.

Mysore Register No. 8410

Date: May 1986

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CONTENTS

INTRODUCTION

Impedance Audiometry yields information quickly and it does not require judgements by the patient. The results are relatively easy to interpret, and it can be valid and reliable measure, provided the clinician respects the procedural and instrumentational variables that can influence the results. Examples of some of these variables are listed below:

a. Frequency of the probe-tone
b. Rate of air-pressure change
c. Direction of air-pressure change
d. Range of air-pressure
e. Sensitivity of the recorder
f. Chart speed of the recorder
g. Unit of measure
h. Adherence to manufacturer's calibration procedure

(Jerger and Northern 1979).

The 'W' pattern tympanograms (which include type D and an undulating type E tympanograms) are directly related to the frequency of the probe-tone. The higher probe tone frequency is likely to yield a 'W' pattern in a variety of hearing disorders. The frequency of the probe-tone has a direct effect on the type of tympanograms obtained on a variety of ears.

(Alberti and Jerger 1974).

Liden and Colleagues (1974) report a high correspondence between the 'W' pattern and simple scarred ear drum and in cases with aa atrophic or flaccid ear drum. It is possible that a small atrophic sear, even non-visible, on the tympanic membrane may cause a 'W of type D tympanogram. The apparent significance of a type E or undulating tympanogram presents a conflict when selecting a probe tone frequency. This pattern signifies the presence of an ossicular chain discontinuity.

The prospective user of impedance audiometry mast judge what probe frequency to use for tympanometry. It appears that the higher probe frequency, the more sensitive tympanometry is for the detection of abnormalities of the conductive portion of the hearing mechanism. At the same time, when a higher probe frequency is used (ie. 660Hz or 800Hz), the clinician must be prepared to yield a greater percentage of false positive cases, that is, ears that appear to have an abnormality but actually do not have any particular consequence. But this error can be reduced if other audiologic and otologic data are taken into consideration whan interpreting the tympanometric results.

(Jerger and Northern 1979)

Tympanometry with low frequency probe tones provides useful clinical information for patients with disorders of tympanum, the tympanic membrane, and the euatachian tube. However, low-frequency probe tone is relatively insensitive to many lesions that affect the ossicular chain. For example Clinical Otosclerosis, complete oasicular discontinuity, ossicular disruption with fibrous union. Congenital ossicular malformation or absence, fracture of the stapedial head, neck or crura, congenital fixation of one or more ossicles; avulsion of an intact stapes from the oval window, forcing of the stapes into the vestibule, fractured Crura with stapes fixation, osteogenesis imperfecta tarda, and ossicular fibrous dysplasia often do not yield distinctive patterns when a typical clinical probe tone (inthe range from 220 to 275 Hz) is used for tympanometric measurements.

(Lilly 1984).

<u>Need for the present study:</u>

It is known that low-frequency probe tones are insensitive to identify and differentially diagnose few pathological conditions. High–frequency probe-tones provide additional information and help us to identify those pathological conditions which do not always yield pathognomonic patterns with conventional tympanometry (which use low-frequency probe-tones). Hence diagnostic findings for the different probe-tones need to be compared. Present study is carried out to compare the results obtained using the high frequency probe tones and low frequency probe-tones, (in normals as well as few pathological subjects)

Aim of the study is to establish normative data for the different probe-tones (i.e. 226Hz, 660Hz and 1KHz probe-tone frequencies). Study is carried out oa normals as well as few pathological subjects also. Hence, comparison between normals and clinical population is made possible.

Null Hypothesis:

There is no significant difference between static compliance values obtained using 226Hz and 660Hz probe-tone frequencies.

There is no significant difference between Middle Ear Pressure Values obtained using 226Hz and 660Hz, and 226Hz and 1KHz probe tone frequencies.

There is no significant difference between Gradient values obtained using 660Hz and 1KHz probe tone frequencies.

There is no significant difference between compliance (PVT) values obtained using 226Hz tod 660Hz, 660Hz and 1KHz. and 226Hz and 1KHz probe-tame frequencies.

There is no significant difference between Contra Reflex Threshold Values obtained using 226Hz and 660Hz, 660Hz and 1KHz, and 226Hz and 1KHz probe-tone frequencies.

REVIEW OF LITERATURE

Brief review about Impedance Audiometric results for the different probe-tones:

Tympanometry, the measurement of aural acoustic immittaace as a function of ear canal air pressure, was introduced by Terkildsen and Thomsen (1959) as a method of evaluating the middle ear pressure. Because most clinical acoustic immittance instruments have provided with only one low-frequency probe-tone (220 or 226Hz) relatively little clinical experience has been acquired with higher probe frequencies.

With one notable exception the investigations into the clinical utility of high frequency tympanometry (500Hz) have led to the conclusion that important clinical information can be obtained from tympanograms recorded with higher probe frequencies. (Alberti and Jerger 1974)

In 1974, Liden et al reported that 800Hz probe frequency was found to be most useful for detecting ossicular abnormalities.

Colletti (1975,76) recorded tympanograms from normal subjects and a variety of pathological ears. He suggested that the frequency regions of various tympanometric shapes provided information of diagnostic significance.

Van de Heyning et al (1982) pointed out that high frequency tympanograms obtained from patients with low impedance abnormalities were distinctly abnormal. The shapes of low-frequency tympanograms, on the other hand, were not always distinguishable from those obtained from normal ears.

Cases of high impedance pathologies have been reported by Shurin et al (1976) and Margolis (1978), who similarly demonstrate that high frequency tympanometry produces important clinical information.

Van Camp et al (1903, 85) pointed oat that the optimal probe frequency for detecting abnormal middle ear conditions based on tympanometrlc shape is in the vicinity of 660Hz.

Van Camp, Cretan, Van de Heyning, Decraemer and Van Peperstraete (1983) conducted a study. The relative occurrence of bell-shaped and various types of W-shaped susceptance, conductance and admittance phase tympanograms at a probe-frequency of 660Hz was determined on normal ears. The diagnostic value of the susceptance, conductance versus admittance-phase representations of tympanograms was studied on pathological middle ear systems. Using probe-tone frequencies from 510Hz upto 910Hz, tympanograms for all four immittance components were recorded on 10 pathological ears and the diagnostic value compared. It was concluded that the admittance-phase approach at a probe tone frequency between 500 and 700Hz is found to be good.

^

Terkildsen and Nielson (1960) have recommended 220Hz. In their first commercially available model of acoustic impedance meter (Madsen Electronics A/s Model ZO-61) the electronic bridge is balanced to zero by adjusting amplitude and phase. By using a 220Hz tone they are of opinion that unwanted resonances can be avoided. Furthermore, the SPL of the intra-aural muscle reflex threshold is higher in the low-frequency range than in the mid-range. Thus the intensity of the carrier tone can be increased without danger of eliciting the reflex, and the pick-up microphone becomes less sensitive to surrounding noise.

Moller (1961) advocates using 800Hz. At this frequency the change in impedance during muscle contraction is high because this frequency is closer to resonance frequency of the ossicular chain.

Also, a probe-tip with very narrow openings can easily become blocked with cerumen. So the tubes with larger diameters are preferable, however, that this critically lowered the impedance of the probe, Transducers with low impedance strive to maintain constant SPL, at least ia the low—frequency range, independent of changes in the impedance of the ear. At 800Hz a probe-tip with relatively large openings, however, has sufficiently high impedance to make measurements of the change of the ear-impedance possible.

(Liden, Bjorkman and Peterson 1974)

In 1970, Liden, Peterson and Bjorkman carried out a study using probe frequencies of 220, 625 and 800Hz.

20 normal ears and 2 ears with abnormal tympanic membrane were tested with three tyapanometry systems using probe frequencies of 220, 625 and 800Hz. In case of normal ears, the major differences among the throe frequencies, were in the shape of the positive half of the tympanograms and in the depth and position of the notch. The only statistically significant difference among the characteristics for the three frequencies is between 230 and 800Hz for the magnitude of the difference in SPL between the two end points of the tympanograms.

Tympanograms were obtained with three probe frequencies (200, 625 and 800Hz) for the right ear of a 20 year-old woman With normal hearing. Otoscopic examination revealed a small scar in the posterior inferior quadrant, and a hyper-mobile drum upon evaluation with siegle Otoscope. The curves obtained for probe frequencies of 625 and 800Hz show a rapid oscillation just to the negative side of zero-pressure. This oscillation did not occur for the 220 Hz probe tone. Because of the fluctuating pattern near the notch for the two higher probe tones, the pattern of progressive depth with increasing probe frequency was not apparent. If however, the upward peaks were inverted to form the notch of the tympanogram, the same frequency relationship was observed.

Tympanograms were obtained with three probe frequencies (220, 625 and 800Hz) for the left ear of a 25 year old woman with a hypermobile tympanic membrane. The 800Hz probe tone produced a large sudden peak near atmospheric pressure. A smaller but evident peak was also present for the 625Hz probe tone. When using the 220Hz probe tone the notch irregularly ties completely disappeared and the notch depth was leas.

In 1961, Moller pointed out that the positive pressure in the ear canal resulted in higher impedance for frequencies around 800Hz than for frequencies approaching 200Hz. Also, he observed that the notch becomes progressively deeper when moving to higher probe frequencies and that it shifts slightly to the left when moving from a high frequency probe tone (800Hz) to a low frequency probe tone (220Hz).

The abnormalities in the tympanograms for probe frequencies of 625 and 800Hz may be associated with the wave length of these frequencies, as related to dimensions of the tympanic cavity. Reflection patterns between the medial wall of the middle ear cavity and the medial surface of the tympanic membrane may be creating the fluctuations seen in the tympanograms near the pressure balance point. Because of the longer wave length for 220Hz such reflection patterns apparently do not occur. Many ears showing hypermobile tympanic membrane or hypermobility in combination with small insignificant scarring will show a 'W' pattern on the tympanograms using 800Hz probe frequency.

(Leden, Peterson and Bjorkman 1970)

The so-called W notching of tympanograms can be explained if some realistic assumptions are accepted about the dependence on the pressure in External Auditory Meatus of the acoustical resistance and the acoustical reactance at the ear drum. It is easy to understand why W-pattems occur only at higher frequencies. Indeed it ia known that the reactance XD of the human ear at P=0 increases with frequency and can become positive.

(Zwislocki 1962)

A small supplementary increase in X is due to the factor β=tgkl in the transformation term (mathematically) from ear drum to measuring plane. This factor also increases with frequency. The appearance of a W-pattem in the admittance proves that for a certain P interval, the ear becomes mass controlled. Also, for higher frequency probe tones, no pathology is necessary to explain W-notching.

(Vanhuyse, Creten and van Camp 1975)

In going from low frequency probe tones to higher probes tone frequencies, W-notching of tympanograms were reported. The effect was related to some ear-dram pathologies or flaccid ear drums. It was observed that for a given subject these W-pattems become less pronounced and may disappear in going to lower probe tones.

(Liden et al., 1970)

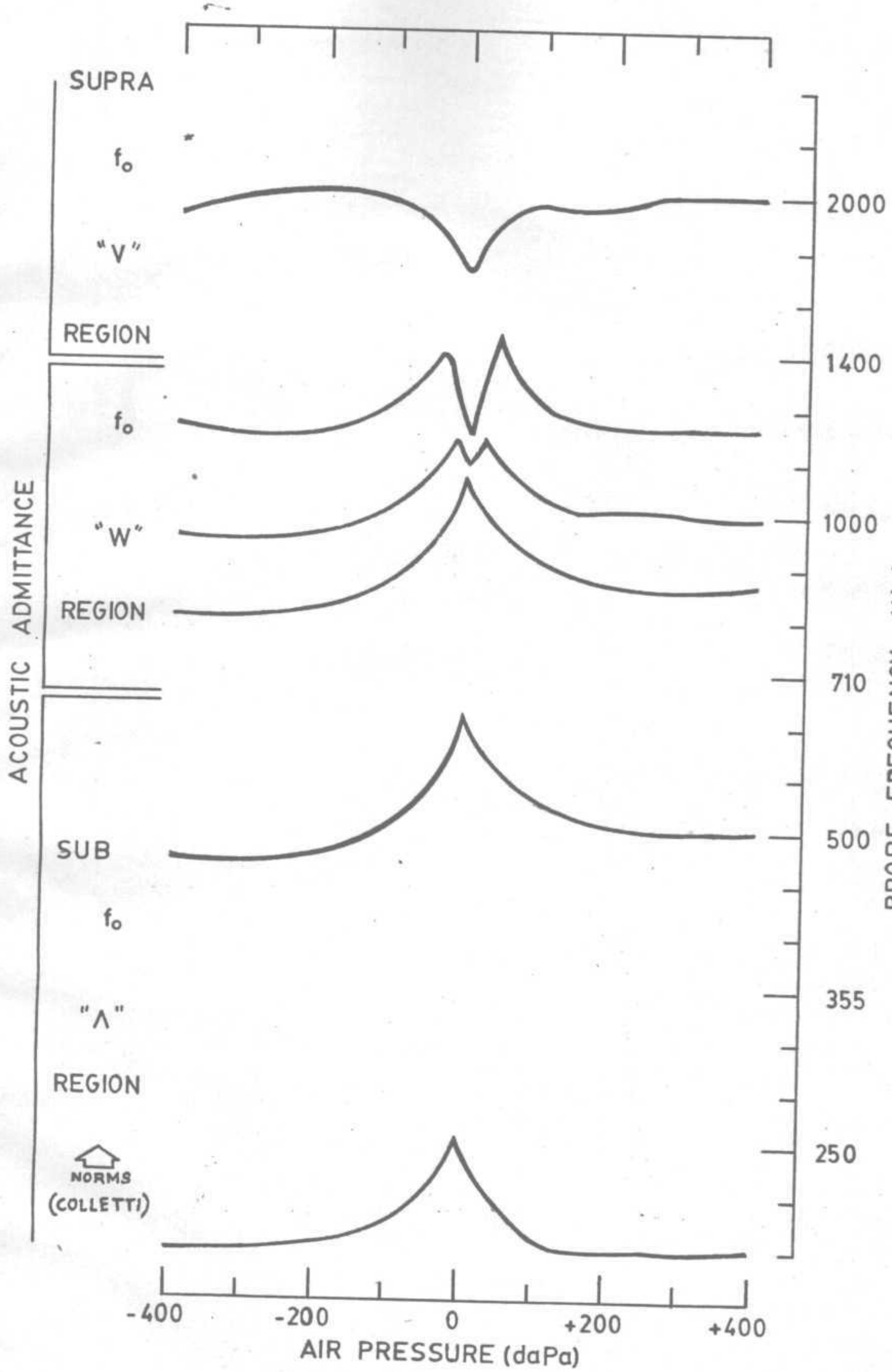
Not much difference exists between measurements with the different probe tones in normal ears in terms of pressure infornation, the magnitude of acoustic impedance or shape of the tympanogram, but there are differences which appear in abnormal ears which do influence the measurements and tympanogram shape, but not the pressure determination. Certain pathologies are known to result in increased impedance. The presence of Otoscloroais, malleolar fixation or adhesions for example, may be inferred from increased impedance. However, because the middle ear behaves as a stiffness dominated system for low frequencies anyway, this change, while evident, would tend to be less noticeable with a low frequency probe tone. On the other hand, the effect of these stiffening pathologies is more e with higher frequencies. This is a consequence of the fact that these pathologies shift the resonant point of the ear upward and the proportional increase in impedance for higher frequencies is greater. Similarly a loosening pathology, such as interrupt tion of the ossicles, dramatically lowers the resonant point of the ear. Again, with the frequency probe tone in tympanometry this effect is more dramatic than with the lower frequency, which, while it is affected in magnitude, is not always affected by alteration of the smoothness of the tympanogram. Tympanometric shape is SB important advantage gained with the use of higher frequency probe tones. The following table-1 shows the more common pathologies with their more predictable tympanometric configurations for the high and low frequency probe tones.

Middle Ear Disorders	Tympanometric Snape	
	High Frequency probetone	Low frequency probe-tone
1.Acute Serous Otitis	Flat-slight raising	Flat-falling
2.Serous Otitis resol-ving 'Glue' ear	Flat	Flat-falling
3.Choleateatoma	Flattened	Lower at negative pressure.
4.Incudoatapedial interruption	Peaked-normal	Deep notches peaked and undulating
5.Crural interruption	Peaked-normal	Deep notches peaked and undulating
6.Healed Tympanic Membrane Perforation	Normal-peaked	Notch peaked
7.Perforated Tympanic Membrane	Flat	Flat
8.stapedectomy	Normal	Notched and undulating

(Feldman and wilber 1976)

Colletti (1976) was the first to study systematically the relation between shape of a recorded tympanogram and probe-tone frequency. The probe tone frequencies ranged from 260 to 2000Hz.

Briefly Colletti observed that the morphology of a typical tympanogram progresses through three characteristic patterns as probe frequency is increased. When low frequency probe tones are delivered to a normal middle ear system, the resultant tympano-grams assume the shape of a Lambda with a single peak near a point on the horizontal axis where air pressure in the external auditory meatus is similar to that within the tympanum. The first frequency region described by Colletti is below the resonance frequency (f_o) of the ear under tests It is identified with the notation "SUB f_o" and a "Λ" oa the left side of Figure-1. The second frequency region described by Colletti contains the resonance frequency (f_o) of the ear under test. Tympanograms in the f_o region are characterized by two or more peaks (extreme). The 80 normal subjects studied by Colletti had a mean f_o of approximately 1000Hz with a S.D. of 170 Hz. A range of 2 S.D. about this mean (600 to 1340 Hz), the notation "f_o REGION" and a "W" are used to identify Colletti's normal f_o region in Figure-1. The third frequency region described by Colletti lies above f_o for the ear under test. Tympanograms in this region are characterized by an invasion of the SUB f_o tympanograma and thus, by a single valley (extreaum). This third region is identified with a natation "SUPRA f_o" and a "V" on the left side of Figure-1.


SUPRA
f_o
"V"
REGION
f_o
"W"
REGION
ACOUSTIC ADMITTANCE
SUB
f_o
"Λ"
REGION
NORMS
(COLLETTI)
2000
1400
1000
710
500
355
250
PROBE FREQUENCY (Hz)
-400
-200
0
+200
+400
AIR PRESSURE (daPa)

Several investigators have recommended systems for classifying tympanograms according to amplitude, peak pressure, gradient, and/or shape. The Liden/Jerger classification system ia the moat widely used system. Feldman recommended a descriptive analysis of tympanometric peak pressure, amplitude and shape. All of these classification systems, which were devised largely for describing tympanograma generated with single-component (IYI), single frequency (226Hz) instruments, have been widely used.

(Margolis and Shanks)

At 226Hz, a comparison of peak susceptance and conductance amplitudes shows that suaeeptance is considerably larger than conductance. Stated differently, the amplitude of the admittance tympanogram is only slightly larger than the susceptance tympanogram because the system is so stiffness controlled at this frequency. As the probe frequency increases, notching first of the susceptance, and then of the conductance and admittance tympanograms is noted. Notching first occurs at a higher probe frequency (610 Versus 510Hz) and is less marked for the descending than for the ascending direction of pressure changes. For the descending direction, the conductance and admittance tympanograms on this subject show little notching for probe frequencies upto 910Hz.

(Margolis et al)

Tympanometric shape changes in an orderly manner as probe frequency increases. At the lowest frequency (220Hz) the amplitude of susceptance is approximately twice the conductance amplitude. As probe frequency increases, the peak magnitude of conductance increases rapidly and becomes greater than the susceptance value by 510Hz. As probe frequency increases further, peak susceptance begins to decrease or 'notch'. This result is expected because mass susceptance (-BM) increases and compliant susceptance (Bc) decreases as a function of frequency. The amplitude of admittance tympanogram reflects a combination of the susceptance and conductance tympanograms and typically resembles the shape of the tympanogram with the larger magnitude. Admittance, however will always be positive because it is a magnitude quantity. Notching of the admittance tympanogram generally does not occur unless the probe tone is above middle ear resonance.

(Margolis, Van Camp and Wilson 1984)

Another classification system for simultaneously recorded susceptance (B) and conductance (G) tympanograms using a high frequency probe tone such at 678Hz was developed.

(Vanhuyse et al and Van Camp et al)

Probe frequency is more advantageous than other immittance components in confirming the presence of middle ear disease.

Most middle ear pathologies produce an increase in the stiffness of the middle ear transmission system. The resultant tympanogram frequently shows a reduced peak or flat function. These tympanometric patterns can result from different middle tar pathologies such as middle ear effusion, lateral ossicular fixation.

tympanic membrane perforation, tympanic membrane retraction, and impacted cerumen. When a fiat tympanogram is recorded, a tympanometric estimate of the volume of air medial to the probe may differentiate among some of these pathologies. Volume generally can be estimated from acoustic susceptance (or admittance) at 226Hz and -400 dapa, or the pressure resulting in the minimum admittance.

(Shanks et al,1984)

A volume estimate of approximately 3.5 cm^2 from the 226Hz susceptance (B) and admittance (Y) tympanograms is consistent with a perforation. The fact that combined volume of the ear canal, middle ear space, antrum and mastoid air cell system only approximates an ideal hard walled cavity is evidenced by the 678Hz probe tone. In a hard-walled cavity, susceptance should be three times greater at 678Hz than at 226Hz, and conductance (G) is close to 0 acoustic mmhos at both frequencies.

The 678Hz probe tone, however, shows a much more dramatic change with a small amount of fluid in the middle ear space than does the 226Hz tone. The 678Hz probe tone tympanograms have broad notching, demonstrating the superiority of a high-frequency probe tone in showing the effects of increased mass. Even ia case of otosclerosis tympanometric shape is altered more at 678Hz than at 226Hz by the increase in mass.

(Shanks et al, 1984)

In 1984, Wilson at al, reported that the sensitivity at the reflex-threshold measurements is dependent upon the frequency of the probe-tone etc. The closes the probe frequency is to the resonant frequency of the middle ear, the more sensitive the measurement is. Because the normal middle ear resonance is 800 to 1200Hz, a 678Hz probe yields a 5 dB lower reflex threshold than does a 226Hz probe.

Tympanometry with low-frequency probe tones provides useful clinical information for patients with disorders of the tympanum, the tympanic membrane, and the Eustachian Tube. Low-frequency, single component tympanometry, however is relatively insensitive to many lesions that affect the ossicular chain.

(Lilly 1984)

METHODOLOGY

The methodology of the present study is described under the following headings:

1) Subjects
2) Instrumentation
3) Calibration
4) Test environment and
5) Test procedure.

Subjects:

Totally 15 normal hearing subjects ($\leq$20 dBHL ANSI, 1969) were selected (8 females and 7 males) with age ranging from 16 years to 24 years (Mean age=20 years). None of them had any Middle ear pathology.

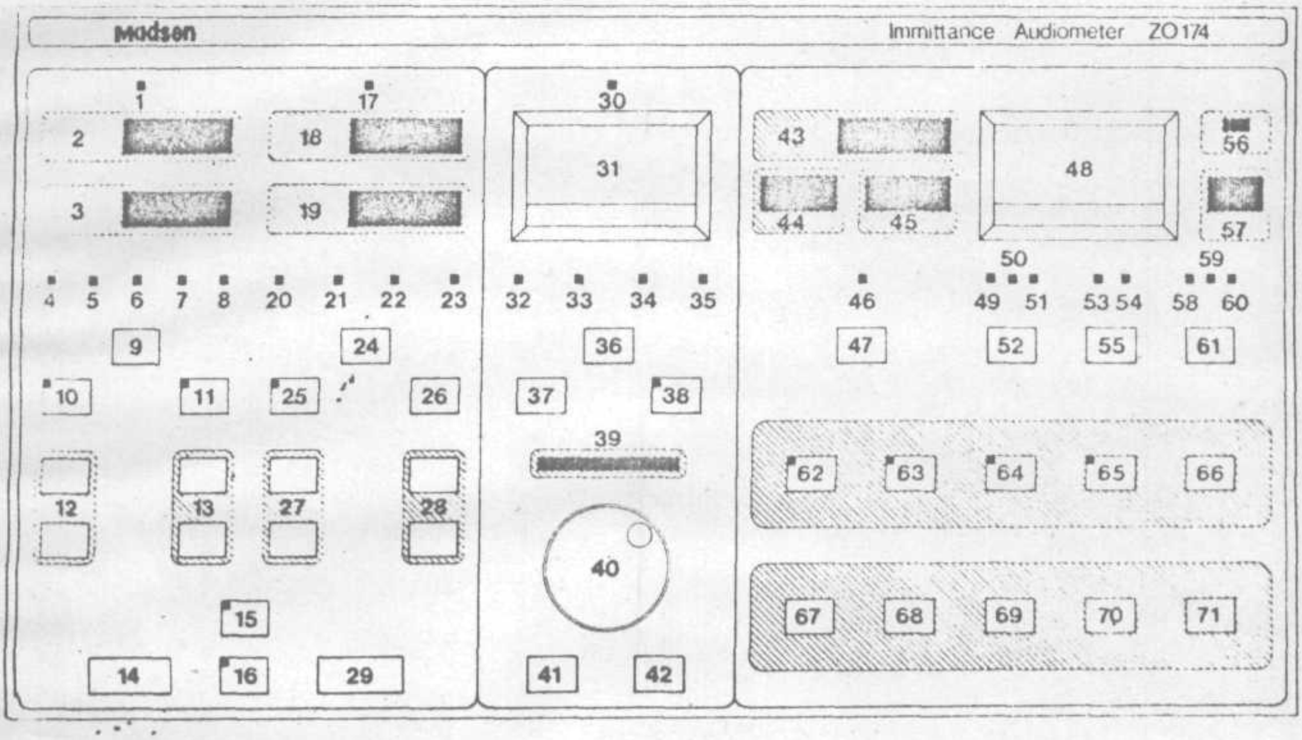
In addition to above, 6 pathological subjects were selected. Two of them had moderate sensori-neural hearing loss, three had mixed hearing loss (otoaclerosis) and one had conductive hearing less (otosclerosis).

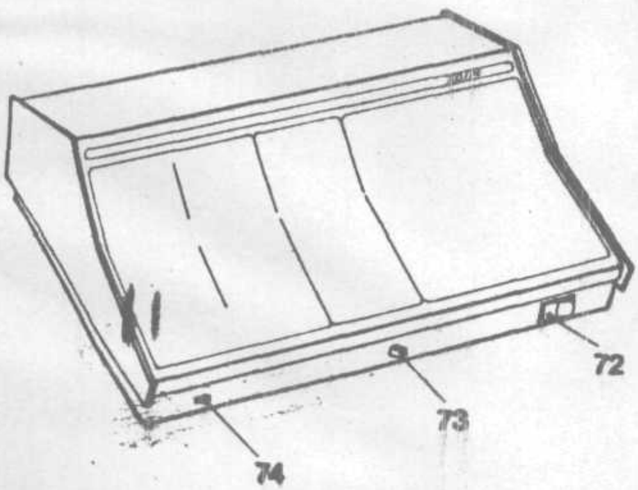
Instrumentation:

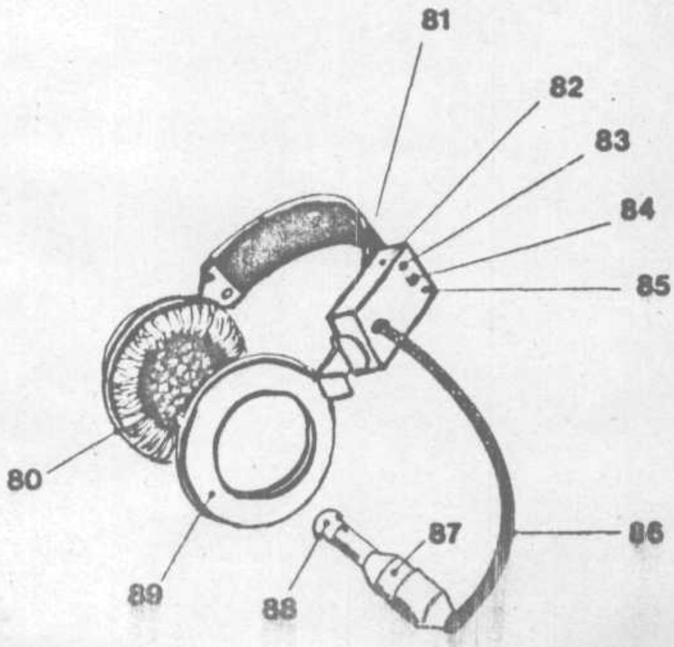
Z0174 Immittance Audiometer was used for testing the subjects. Block Diagram of the instrument is given in Figure-2.

FIGURE-2

9.0. ZO174 KEY NUMBERING SYSTEM







CONTROLS(SWITCHES) IN Z0174 IMMITTANCE AUDIOMETER AS LABELLED IN THE BLOCK DIAGRAM

(1) On

(2) Frequency (Hz)

(3) Level (dB)

(4) (5) (6) (7) (8) - Contra stimuli (indicated by lamps)

- (4) Tone
- (5) Pulsing
- (6) Click
- (7) Noise
- (8) AUX.input

(9) select

(10) Ext.Range (Extended Range)

(11) 1 dB

(12) Level

(13) Frequency

(14) Interrupter

(15) Fast rise and decay

(16) Lock (locks contra and ipsi stimuli)

(17) Ipsi select (indicated by lamp)

(18) Frequency select (for Ipsi and contra stimuli)

(19) Intensity select

(20) Tone

(21) TDM

(22) Clicks

(23) Contra Tone

(24) Select

(25) 1 dB

(26) Option

(27) Level

(28) Frequency

(29) Interrupter

(30) Leak

(31) Pressure

(32) (33) (34) (35) - Pump speed (Indicated by lamps)

(32) - 50 daPa/sec

(33) - 100 daPa/sec

(34) - 200 daPa/sec

(35) - 400 daPa/sec

(36) Select pump speed

(37) Air Release

(38) Extended Range

(39) Red light bar indicator for position of pump

(40) Manual pump control

(41) Air pressure (+)

(42) Air pressure (-)

(43) Pressure Digital Display

(44) Gradient Digital Display

(45) Static compliance Digital Display

(46) 0m

(47) DPM (Digital Pressure Meter)

(48) Compliance Meter

(49) (50) (51) select sensitivity for tympanometry
(indicated by lamps)

(52) TYMP - to change sensitivity of tympanogram

(53) (54) sensitivity for reflex

(55) Reflex

(56) Power (Instrument on)

(57) Compliance Digital Display

(58) (59) (60) - Probe Tone Frequency

(58) — 226Hz probe tone frequency

(59) - 660Hz or 800Hz Probe tone frequency

(60) - 1000Hz Probe tone frequency

(61) Select probe tone

(62) T & R - Tympanometry and Reflex

(63) ER - (Expended Reflex)

(64) AVG Averaging

(65) Decay

(66) Print

(67) Auto Start

(66) Stop/Reset

(69) CONT (continue)

(70) Erase

(71) Data Xmit

(72) switch controls the power to the system

(73) Knob used to set zero on manometer, with probe in free air.

(74) Slow/fast switch (provides damping of the system to provide smooth results)

(80) Ear phone

(81) Head Band

(82) Probe ear select

(83) Red light indicator for right ear probe

(84) Probe switch

(85) Grean light indicator for left ear probe

(86) Probe connection

(87) Probe

(88) Probe-tip

Calibration:

20174 Immittance Audiometer has three elements that require separate calibration procedure. They are probe-tones, ipsilateral stimuli and contralateral stimuli.

The calibration data for these are stored in a user-programmable memory which does not require battery or other power in order to retain the data. The 'Calibrate/Run' switch, in conjunction with certain front-panel push-buttons, allows re-programming.

At any time, during the calibration of probe-tones, Ipsi and contralateral stimuli, pushing the 'Stop/Reset' button will cause Z0174 to exit from the calibration mode. When the calibration is done, pushing 'Aute—start' will transfer the new calibration data into memory. Resetting the 'Calibrate/Run' switch to run and close the cover of the instrument Z0174, makes it ready for use again.

The procedure for re-calibrating probe-tone-compliance as suggested in the manual is as follows:-

a) Push probe into calibration check cavity using 10mm probe tip.

b) Push air-release

c) See that compliance now read 2.0CC ± 0.1

d) If it does not, push and hold probe-tone and then push 'Auto start'. Compliance will now read 2.0 CC.

Ensure that, probe and tip are properly seated while calibration.

There are, three probe-tones present in the Z0174 (i.e. 226Hz, 660Hz and 1KHz). They are calibrated as follows:

226Hz at 85 dBSPL

660HZ at 79 dBSPL

1KHz at 75 dBSPL

The procedure for calibrating probe-tones as suggested in the manual is as follows:

a) Place calibrate/run switch in position 'Calibrate'

b) Place the probe with 10 mm tip in the 2CC coupler of a precision sound level meter.

c) Push probe-tone button once. This selects probe tone calibration mode. Check reading on sound level meter, if not correct.

d) Using Ipsi level buttons, adjust level (dBSPL) for the selected probe-tone.

The transducers also change their characteristics over-time, or as a result of rough handling, and hence they may need recalibration. Recalibration is mandatory if any one of the transducers is changed.

In addition to the calibration cheek cavity, the other instruments required for calibration are, precision sound level meter with octave filter set and 6 CC and 2 CC couplers. A philips head screw driver is also needed.

All calibration checks and calibration changes are performed regularly, before testing the subjects.

Test Environment:

Test was administered in a Sound Treated Room. The noise level in the room was measured using a sound level meter (B&K 2209) with an Octave Filter Set (B&K 1613) and acondenser Microphone (B&K 4165). The noise levels were within the permissible limits.

Test Procedure:

Tympanometric values and contra reflex thresholds were obtained in both the ears, for all subjects, using different probe-tone frequencies (i.e. 226Hz, 660Hz and 1KHz).

Head set was placed and adjusted for the size of the head. Appropriate sized probe-tip was selected and placed in the Indicator Ear. Earphone was placed properly in the opposite ear. Probe-switch was selected to 'Right' or 'Left' accordingly for probe-ear. The probe-tone 1 (i.e. 226Hz) was selected. The display light indicated the selected probe-tone frequency.

Air-tight seal was confirmed. Then automatic tympanometry and reflexometry was done using a step by step procedure, as indicated below:

'T & R' (Tympanogram and Reflex) was selected, when the button 'Auto-start' was pressed, Z0174 conducted an automatic tympanogram at the selected pump-speed as indicated in dapa/sec. The values of middle ear pressure, gradient, static compliance and compliance (PVT) were automatically calculated and displayed by Z0174. These values were noted down.

Contra stimuli were selected for acoustic reflex threshold measurements. After conducting the tympanogram, 20174 automatically sought for the acoustic reflex threshold for 500Hz contra-stimulus beginning at 70 dB level. Stimulus level got incremented automatically in 10dB steps until a reflex waa detected (20% of full scale deflection).or till maximum stimulus level reached. The 'CONT'-inue button waa pressed to select the next frequency that is 1 KHz centra-stimulus and to obtain the reflex automatically. Thus contra reflex thresholds were obtained for 500Hz, 1KHz, 2KHz and 4KHz stimuli by pressing the 'CONTinue

Next, the probe-tone-2 (i.e.660Hz) was selected and the same procedure was employed to obtain tympanometric values and contra reflex thresholds. Finally, the probe-tone-3(i.e. 1KHz) was selected and the same procedure was employed to obtain tympanometric values and contra reflex thresholds. The results were noted down.

The other ear was also tested in the same manner and the results were recorded in a similar fashion.

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RESULTS AND DISCUSSION

Means and Standard Deviations for Gradient, Static Campliance Compliance PVT), Middle Ear Pressure and Contra Reflex Threshold Values were found out using appropriate statistical procedures and they are displayed in the following tables, significances between the mean values for the different probe-tone frequencies (i.e. 226Hz, 660Hz and 1KHz) were found out. The following results were obtained in case of normal subjects.

1) There was significant difference between static compliance values obtained using 226Hz and 660Hz ($P<0.01$) and 226Hz and lKHz ($P< 0.05$) probe-tone frequencies (When the probe was in the right ear).

There was significant difference between static compliance values obtained using 226Hz and 660Hz ($P<0.01$) and 226Hz and 1KHz ($P<0.01$) probe-tone frequencies (when the probe was in the left ear).

2) There was significant difference between compliance (PVT) values obtained using 226Hz and 660Hz ($P<0.01$) 660Hz and 1KHz ($P<0.01$) and 226Hz and 1KHz ($P<0.01$) probe tone frequencies.

3) There was significant difference between middle ear pressure values obtained using 226Hz and 660Hz ($P<0.02$) and 226Hz and 1 KHz ($P<0.01$) probe tone frequencies (when the probe waa in the right ear).

There was significant difference between middle ear pressure values obtained using 226Hz and 660Hz (P<0.01) and 226Hz and 1KHz (p <0.01) probe tone frequencies (when the probe was in the left ear).

4) There was significant difference between gradient values obtained using 660Hz and 1 KHz (P<0.01) probe-tone frequencies.

5) There was significant difference between contra reflex threshold values obtained using 226Hz and 660Hz (P<0.01), 660Hz and 1KHz (P<0.01) and 226 Hz and 1 KHz (P<0.01) probe tone frequencies.

Tables 1 and 2 show the gradient values obtained using 226Hz, 660Hz and 1KHz probe-tone frequencies when the probe was in the right and left ears respectively. Mean gradient values and standard deviations are also given in the tables.

Tables 3 and 4 show the Static Compliance Values obtained using 226Hz, 660Hz and 1KHz probe-tone frequencies When the probe was in the right and left ears respectively. Mean Static Compliance values aad Standard Deviations are also given in the tables.

Tables 5 and 6 show the compliance (PVT) values obtained using 226Hz, 660Hz and 1KHz probe tone frequencies When the probe was in the right and left ears respectively. Mean Compliance values and Standard Deviations are also given in the tables.

Tables 7 end 8 show the Middle Ear Pressure values obtained using 226Hz, 660Hz and 1KHz probe tone frequencies when the probe was in the right and left ears respectively. Mean Middle ear pressure values and standard Deviations are also given in the tables.

Means and Standard Deviations for Gradient, Static Compliance, Compliance (PVT) and Middle Ear Pressure are displayed separately in the Tables 9 and 10.

Tables 11 and 12 dhow the Contra Reflex Thresholds for 500Hs, 1KHz, 2KHz and 4 KHz stimuli obtained using 226Hz probe tone frequency when the probe was in the right and left ears respectively Mean Contra Reflex Threshold values and Standard Deviations are also given the tables.

Tables 13 and 14 show the Contra Reflex Thresholds for 500Hz, 1KHz, 2KHz and 4KHz stimuli obtained using 660Hz probe tone frequency when the probe was in the right and left ears respectively. Mean Centra Reflex Threshold values and standard Deviations are also given is the tables.

Tables 15 and 16 show the Contra Reflex Thresholds for 500Hz, 1KHz, 2KHz and 4KHz stimuli obtained using 1KHz probe tone frequency when the probe was in the right and left ears respectively. Mean Contra Reflex Threshold values and Standard Deviations are also given in the tables.

Means and Standard Deviations for Contra Reflex Thresholds are displayed separately la the Table-17.

In case of subjects with moderate sansori-neural hearing loss, there was significant difference between compliance (PVT) values obtained using 226Hz and 660Hz (P<0.01), 660Hz and 1KHz (P<0.01) and 226Hz and 1KHz (P<0.01) probe tone frequencies. Also there was significant difference between Contra Reflex Threshold values obtained using 226Hz and 660Hz (P <0.01). 660Hz and 1KHz (p(0.01) and 226Hz and 1KHz (P<0.01) probe tone frequencies.

In case of subjects with Otosclerosis, there was significant difference between compliance (PVT) values obtained using 226Hz and 660Hz (P<0.01), 660Hz and 1KHz (P<0.01) and 226Hz and 1KHz (P<0.01) probe tone frequencies. Also Static Compliance values increased progressively from low-frequency probe tone (i.e. 226Hz) to high frequency probe tone (i.e. 1KHz).

In otherwords, the type of tympanogram obtained using 226Hz probe tone frequency was different from the type of tympanogram obtained using 1KHz probe tone frequency. For example, 2 subjects with Otosclerosis exhibited. As type tympanogram When tested using 226Hz probe tone frequency. The same subjects showed B type tympanogram when tested using 660Hz and 1KHz probe tone frequencies

Further, other two subjects with Otosclerosis exhibited. As type tympanogram when tested using 226Hz and 660Hz probe tone frequencies. The same subjects showed. A type tympanogram when tested using 1KHz probe tone frequency.

The present study showed that low frequency probe tone (i.e. 226Hz) provides useful clinical information in diagnosis of Otosclerosis. Confusion may arise when high frequency probe tones(i.e 660Hz and 1KHz) are used. This finding supports the view of Jerger and Northern (1979) Who stated that when higher probe tone frequencies(i.e.660Hz and 800Hz) are used, the clinician must be prepared to see a greater percentage of false positive cases.

Higher reflex thresholds and higher compliance (PVT) values are obtained when the probe tone frequencies are 660Hz and 1KHz in normals and SB loss subjects. However, high frequency probe tones are more sensitive to a few specific lesions such as ear drum pathology and a few abnormalities associated with Ossicular chain.

The present finding is in agreement with the study done by Margolis, Van Camp, Wilson and Creten (1985) who reported that the shape of the tympanogram changes progressively from low frequency probe tones to high frequency probe-tones.

Table-1 Gradient values obtained using 226Hz, 660Hz and 1KHz probe-tone frequencies when the probe was in the right ear (in normals)

226Hz probe tone frequency	660Hz probe tone frequency	IKHz probe tone frequency
.55	.62	.39
.71	.72	.60
.61	.60	.58
.53	.62	.58
.50	.50	.50
.61	.70	.61
.75	.66	.70
.46	.40	.40
.52	.57	.58
.46	.50	.54
.46	.42	.42
.55	.63	.55
.58	.45	.46
.62	.63	.50
.30	.76	.58
Mean - 0.558	Mean - 0.585	Mean - 0.532
SDσn = 0.113	SDσn = 0.106	SDσn = 0.084
SDσn-1 = 0.117	SDσn-1 = 0.109	SDσn-1 = 0.086

Table-2 Gradient values obtained using 226Hz, 660Hz and 1KHz probe tone frequencies when the probe was in the left ear (in normals)

226HZ probe tone frequency	660Hz probe tone frequency	1KHz probe tone frequency
.62	.75	.44
.76	.63	.68
.60	.73	.58
.71	.57	.55
.67	.62	.62
.72	.76	.59
.62	.72	.70
.46	.51	.54
.57	.69	.59
.62	.70	.62
.50	.58	.54
.60	.55	.55
.63	.73	.46
.60	.66	.50
.55	.75	.58
Mean =0.606	Mean = 0.644	Mean = 0.594
SDσn = 0.096	SDσn = 0.106	SDσn = 0.074
SDσ n-1 = 0.099	SDσn-1 = 0.109	SDσ n-1 = 0.076

Table-3 static Compliance Values obtained using 226Hz, 660Hz and 1 KHz probe-tone frequencies when the probe was im the right ear (in normals)

226Hz probe tone frequency	660Hz probe tone frequency	1 KHz probe tone frequency
0.83	0.67	0.54
2.92	2.42	1.67
0.75	0.63	0.58
0.71	0.67	0.79
0.75	0.67	0.67
0.75	0.71	0.75
0.67	0.63	0.71
0.54	0.42	0.63
0.96	0.88	0.79
0.63	0.50	0.54
0.63	0.50	0.50
0.30	0.33	0.38
0.58	0.46	0.63
0.54	0.33	0.42
0.42	0.33	0.50
Mean = 0.804	Mean = 0.676	Mean = 0.673
SDσn = 0.583	SDσn = 0.491	SDσn = 0.292
SDσ n-1 = 0.604	SDσ n-1 = 0.508	SDσ n-1 = 0.303

Table-4 Static Compliance values obtained using 226HZ, 660Hz and 1KHz probe tone frequencies when the probe was in left ear (in normals)

226Hz probe tone frequency	660Hz probe tone frequency	1KHz probe tone frequency
1.21	1.00	0.67
2.96	2.04	1.71
0.83	0.63	0.58
1.46	0.88	0.83
0.73	0.67	0.88
1.04	1.04	0.71
0.67	0.58	0.71
0.54	0.33	0.46
1.17	0.79	0.71
0.88	0.83	0.67
0.67	0.50	0.46
0.42	0.38	0.38
0.92	0.92	1.08
0.63	0.38	1.33
0.68	0.50	0.67
Mean = 0.968	Mean = 0.764	Mean = 0.723
SDσn = 0.606	SDσn = 0.407	SDσn = 0.324
SDσ n-1 = 0.627	SDσ n-1 = 0.421	SDσ n-1 = 0.335

Table-5 Compliance (PVT) values obtained using 226Hz, 660Hz and 1KHz probe-tone frequencies when the probe was in the right ear (in normals)

226Hz probe tone frequency	660Hz probe tone frequency	1KHz probe tone frequency
1.6	1.8	2.5
2.1	2.1	2.9
1.6	1.8	2.4
2.2	2.2	2.5
1.7	1.8	2.4
1.3	1.6	2.4
1.6	1.7	2.2
1.8	2.1	2.7
1.6	2.1	2.9
1.6	1.9	2.6
1.5	1.8	2.5
0.3	0.6	1.4
0.6	1.0	1.6
0.4	0.7	1.4
0.5	0.8	1.5
Mean = 1.36	Mean = 1.60	Mean = 2.26
SDσn = 0.590	SDσn = 0.527	SDσn = 0.507
SDσ n-1 = 0.611	SDσ n-1 = 0.546	SDσ n-1 = 0.524

Table-6 Compliance (PVT) values obtained using 226Hz, 660Hz and 1KHz probe tone frequencies when the probe warn la left ear (in normals)

226Hz probe tone frequency	660Hz probe tone frequency	1KHz probe tone frequency
1.9	2.1	2.6
1.7	1.8	2.8
1.6	1.7	2.2
2.2	2.4	2.5
1.6	1.9	2.3
1.2	1.6	2.4
1.6	1.8	2.4
1.7	1.8	2.4
1.6	2.1	2.7
1.6	1.8	2.7
1.4	1.7	2.4
0.4	0.8	2.4
0.8	1.0	1.8
0.7	0.9	1.5
0.4	0.8	1.4
Mean = 1.36	Mean = 1.61	Mean = 2.23
SDσn = 0.525	SDσn = 0.485	SDσn = 0.461
SDσ n-1 = 0.543	SDσ n-1 = 0.502	SDσ n-1 = 0.477

Table-7 Middle Bar pressure values obtained using 226Hz, 660Hz and 1KHz probe-tone frequencies Whan the probe warn in the right ear (in normals)

226Hz probe tone frequency	660Hz probe tone frequency	1KHz probe tone frequency
- 60	- 45	- 45
- 35	- 20	- 5
- 45	- 20	- 20
- 35	- 35	- 35
- 55	- 60	- 13
+ 10	+ 10	+ 15
+ 10	0	+ 10
- 25	- 10	- 15
- 50	- 10	0
- 50	- 5	- 5
- 10	- 5	0
- 10	+ 5	+ 5
- 95	- 95	- 90
+ 20	+ 30	+ 35
- 10	+ 5	+ 5
Mean = - 29.3	Mean= - 17.6	Mean = -10.66
SD = 32.327	SD = 31.211	SD = 29.336

Table-8 Middle Ear pressure values obtained using 226Hz, 660Hz and 1 KHz probe tone frequencies when the probe was in left ear (in normals)

226 Hz probe tone frequency	660Hz probe tone frequency	1KHz probe tone frequency
-20	- 5	-15
-35	-15	+15
-35	-10	-10
-25	- 5	- 5
-20	-15	-15
+ 5	+10	+25
+15	+20	+15
-035	- 5	+15
-045	-25	-15
0	+10	+25
+ 5	+15	+15
-15	-5	+10
- 90	-80	-70
0	+45	+40
+ 5	0	0
Mean -21.33	Mean -4.33	Mean +2.0
SD 27.723	SD 32.334	SD 25.972

Table-9 Means and Standard Deviations for Gradient and Static Compliance Values obtained using 226Hz, 660Hz and 1KHz probe tone frequencies, in both the ears in case of normal subjects.

Probe tone frequency	Gradient		Static compliance	
	Probe in the right ear	Probe in the left ear	Probe in the right ear	Probe in the left ear
226 Hz	Mean =0.558 SDσn =0.113 SD6n-1 =0.117	Mean =0.606 SDσn =0.096 SDσn-1 =0.099	Mean =0.804 SDσn =0.583 SDσn-1 =0.604	Mean =0.968 SDσn =0.606 SDσn-1 =0.627
660Hz	Mean =0.585 SDfn =0.106 SD6n-1 =0.109	Mean =0.644 SDσn =0.106 SDσn-1 =0.109	Mean =0.676 SDσn =0.491 SDσn-1 =0.508	Mean =0.764 SDσn =0.407 SDσn-1 =0.421
1 KHz	Mean =0.532 SDσn =0.084 SDσn-1 =0.086	Mean =0.594 SDσn =0.074 SDσn-1 =0.076	Mean =0.673 SDσn =0.292 SDσn-1 =0.303	Mean =0.723 SDσn =0.324 SDσn-1 =0.335

Table-10 Means and standard Deviations for compliance (PVT) and Middle Ear Pressure values obtained using 226Hz, 660Hz and 1KHz probe-tone frequencies, in both the ears. in case of normal subjects.

Probe tone frequency	Compliance (PVT)		Middle Ear Pressure (MED)	
	Probe in the right ear	Probe in the left ear	Probe in the right ear	Probe in the left ear
226Hz	Mean =1.36 SDσn =0.590 SDσn-1 =0.611	Mean =1.36 SDσn =0.525 SDσn-1 =0.543	Mean = -29.3 SD n = 32.327	Mean = -21.33 SD = 27.723
660Hz	Mean =1.60 SDσn =0.527 SDσn-1 =0.546	Mean =1.61 SDσn-1 =0.485 SDσn-1 =0.502	Mean =-17.6 SD = 31.211	Mean =- 4.33 SD = 32.334
1KHz	Mean =2.26 SDσn =0.507 SD6n-1 =0.524	Mean =2.23 SDσn =0.461 SDσn-1 =0.477	Mean =–10.66 SD = 29.336	Mean = +2.0 SD = 25.972

Table-11 Contra Reflex Thresholds for 500Hz, 1KHz, 2KHz and 4KHz stimuli, obtained using 226Hz probe-tone frequency when the probe was in right ear (in normals)

500Hz stimulus	1KHz stimulus	2KHz stimulus	4KHz stimulus
90	90	90	100
90	90	90	80
90	90	80	80
100	90	90	NR
90	90	90	90
100	100	100	100
90	80	90	80
90	90	90	80
90	90	90	80
90	100	90	115
100	100	90	95
90	90	100	90
90	90	90	80
80	90	80	90
100	90	90	90
Mean =92 dB	Mean =91.33 dB	Mean = 90 dB	Mean = 89.28 dB
SDσn =5.416	SDσn = 4.988	SDσn = 5.163	SDσn = 10.151
SDσn-1 =5.606	SDσn-1 =5.163	SDσn-1 = 5.345	SDσn-1 = 10.535

Table-12 Centra Reflex Thresholds for 500Hz, 1KHz, 2KHz and 4KHz stimuli, obtained using 226Hz probe-tone frequency when the probe was in left ear (in normals)

500Hz stimulus	1KHz stimulus	2KHz stimulus	4KHz stimulus
90	90	90	100
80	100	100	90
80	90	80	90
80	88	90	80
90	90	90	110
100	100	90	90
90	90	90	90
90	90	90	90
100	90	100	NR
90	90	90	100
90	95	90	90
90	90	90	100
90	90	80	90
90	90	80	100
95	100	90	90
Mean = 89.66dB	Mean =91.66dB	Mean =89.33dB	Mean =93.57dB
SDσn = 5.906	SDσn = 5.055	SDσn =5.734	SDσn = 7.170
SDσn-1= 6.113	SDσn-1= 5.232	SDσn-1=5.936	SDσn-1= 7.449

Table-13 Contra Reflex Thresholds for 500Hz, 1KHz, 2KHz and 4KHz stimuli, obtained using 660Hz probe-tone frequency when the probe was in right ear (in normals)

500Hz stimulus	1KHz stimulus	2KHz stimulus	4 KHz stimulus
100	100	100	100
100	100	100	90
100	100	90	90
100	110	110	NR
110	110	100	110
110	110	110	NR
100	100	100	90
100	100	100	100
100	100	100	110
100	100	110	NR
110	110	115	100
110	110	100	115
100	100	100	90
90	90	90	110
110	110	NR	NR
Mean =102.66dB	Mean =103.66dB	Mean =101.78dB	Mean =100.45dB
SDσn = 5.734	SDσn = 6.446	SDσn = 6.971	SDσn = 9.158
SDσn-1= 5.936	SDσn-1= 6.672	SDσn-1= 7.234	SDσn-1= 9.605

Table-14 Contra Reflex Thresholds for 500Hz%, 1KHz, 2KHz and 4 KHz stimuli, obtained using 660Hz probe-tone frequeacy When the probe was in left ear (in normals)

500Hz stimulus	1KHz stimulus	2KHz stimulus	4KHz stimulus
100	100	110	110
90	100	100	100
100	100	90	90
100	100	90	80
100	100	90	110
100	100	100	NR
110	110	100	100
105	105	105	115
110	110	120	NR
100	110	120	NR
100	100	100	100
100	100	100	NR
100	100	100	100
100	100	100	NR
100	110	NR	NR
Mean =101dB	Mean =103.66dB	Mean =101.78dB	Mean =100.55dB
SDσn =4.546	SDσn = 4.642	SDσn = 9.182	SDσn = 10.122
SDσn-1=4.705	SDσn-1= 4.805	SDσn-1= 9.528	SDσn-1= 10.736

Table-15 Centra Reflex Thresholds for 500Hz, 1KHz, 2KHz and 4 KHz stimuli, obtained using 1KHz probe-tone frequency When the probe was in right ear (in normals)

500Hz stimulus	1KHz stimulus	2KHz stimulus	4KHz stimulus
110	100	100	100
110	110	110	100
100	100	90	90
110	110	110	NR
110	120	110	110
110	115	NR	NR
100	100	100	100
110	100	110	110
100	100	110	NR
100	100	110	NR
115	120	120	115
110	110	110	120
110	100	100	120
100	90	90	NR
110	110	NR	NR
Mean =107dB	Mean =105.66dB	Mean =105.38dB	Mean =108.33dB
SDσn =5.099	SDσn = 8.339	SDσn = 8.426	SDσn = 9.428
SDσn-1 = 5.277	SDσn-1 = 8.632	SDσn-1 = 8.770	SDσn-1 = 10.00

Table-16 Centra Reflex Thresholds for 500Hz, 1KHz, 2KHz and 4KHz stimuli, obtained using 1KHz probe-tone frequency When the probe was in left ear (in normals)

500Hz stimulus	1KHz stimulus	2KHz stimulus	4KHz stimulus
110	110	110	NR
110	110	110	100
100	100	90	90
110	110	100	110
110	110	100	NR
110	110	115	NR
110	110	100	100
110	110	110	120
110	110	NR	NR
110	110	120	NR
110	110	105	110
110	110	100	NR
110	110	110	120
110	110	110	NR
110	110	NR	NR
Mean =109.33dB	Mean =109.33dB	Meam =106.15dB	Mean =107.14dB
SDσn = 2.494	SDσn = 2.494	SDσn = 7.634	SDσn = 10.301
SDσn-1 = 2.581	SDσn-1 = 2.581	SDσn-1 = 7.946	SDσn-1 =11.126

Table-17 Means and standard Deviations for Contra Reflex Thresholds for 500Hz, 1KHz, 2KHz and 4KHz stimull obtained using 226Hz, 660Hz and 1KHz probe tone frequencies, in both the ears in case of normals subjects.

Stimuli	226Hz PROBE TONE FREQUENCY		660Hz PROBE TONE FREQUENCY		1KHz PROBE TONE FREQUENCY	
	PROBE IN THE RIGHT EAR	PROBE IN THE LEFT EAR	PROBE IN THE RIGHT EAR	PROBE IN THE LEFT EAR	PROBE IN THE RIGHT EAR	PROBE IN THE LEFT EAR
500Hz	Mean=92dB SDσn=5.416 SDσn-1=5.686	Mean=89.66dB SDσn=5.906 SDσn-1=6.113	Mean=102.66dB SDσn=5.734 SDσn-1=5.936	Mean=101dB SDσn=4.546 SDσn-1=4.705	Mean=107dB SDσn=5.099 SD6n-1-5.277	Mean=109.33dB SDσn=2.494 SDσn-1=2.581
1KHz	Mean=91.33dB SDσn=4.988 SDσn-1=5.163	Mean=91.60dB SDσn=5.055 SDσn-1=5.232	Mean=103.66dB SDσn=6.446 SDσn-1=6.672	Mean=103.66dB SDσn=4.642 SDσn-1=4.805	Mean=105.66dB SDσn=8.339 SDσn-1=8.632	Mean=109.33dB SDσn=2.494 SDσn-1=2.581
2KHz	Mean=90dB SDσn=5.163 SDσn-1=5.345	Mean=89.33dB SDσn=5.734 SDσn-1=5.936	Mean=101.78dB SDσn=6.971 SDσn-1=7.234	Mean=101.785dB SDσn=9.182 SDσn-1=9.528	Mean=105.38dB SDσn=8.426 SDσn-1=8.770	Mean=106.15dB SDσn=7.634 SDσn-1=7.946
	Mean=89.28dB SDσn=10.151 SDσn-1=10.535	Mean=93.57dB SDσn=7.170 SDσn-1=7.449	Mean=100.45dB SDσn=9.158 SDσn-1=9.605	Mean=100.55dB SDσn=10.122 SDσn-1=10.736	Mean=108.33dB SDσn=9.428 SDσn-1=10.00	Mean=107.14dB SDσn=10.301 SDσn-1=11.126

SUMMARY AND CONCLUSIONS

Aim of the study was to establish normative data for the different probe-tone frequencies (i.e. 226Hz, 660Hz and 1KHz). Study was carried out on normal. as well as on few pathological subjects, Hence, comparison between normals and clinical population was possible.

Totally 15 normal hearing subjects ($\leq$ 20dBHL, ANSI 1969) were selected (8 females and 7 males) with age ranging from 16 years to 24 years (Mean age-20 years). None of them had any middle ear pathology, further, 6 pathological subjects were selected. Two of them had moderate sensori-neural hearing loss, three had mixed hearing loss (Otoscleroals) and one had conductive hearing loss (Otosclerosis).

Z0174 Immittance Audiometer was calibrated and used for testing the subjects. The testing was done in a sound treated room.

Data were obtained and analysed using appropriate statistical procedures. Means and Standard Deviations were obtained. Significant differences between the mean values for the different probe-tone frequencies were found out. The following results were obtained in normal subjects.

1) There was significant difference between Static Compliance values obtained using 226Hz and 660Hz ($P<0.01$) and 226Hz and 1KHz ($P<0.05$ probe-tone frequencies (when the probe was in the right ear).

There was significant difference between Static Compliance values obtained using 226Hz and 660Hz (P<0.01) and 226Hz and 1KHz (P<0.01) probe-tone frequencies (when the probe was in the left ear).

2) There was significant difference between Compliance (PVT) values obtained using 226 Hz and 660Hz (P<0.01) 660Hz and 1 KHz (P <(0.01) and 226Hz and 1KHz (P<0.01) probe-tone frequencies.

3) There was significant difference between middle ear pressure values obtained using 226Hz and 660Hz (P<0.02) and 226Hz aad 1KHz (P<0.01) probe tone frequencies (when the probe was in the right ear).

There was significant difference between middle ear pressure values obtained using 226Hz and 660Hz (P<0.01) and 226Hz and 1KHz (P<(0.01) probe tone frequencies (when the probe was in the left ear).

4) There was significant difference between Gradient values obtained using 660Hz and 1KHz (P<0.01) probe tone frequencies.

5) There was significant difference between contra reflex threshold values obtained using 226Hz and 660Hz (P<0.01) 660Hz and 1KHz (P<0.01) and 226Hz and 1KHz (P<0.01) probe tone frequencies.

In case of subjects with moderate sensori-neural hearing loss, there was significant difference between Compliance (PVT) values obtained using 226Hz and 660Hz ($P<0.01$) 660Hz and 1KHz ($P<0.01$) and 226Hz and 1KHz and IKHz ($P<0.01$) probe tone frequencies. Also there was significant difference between centra reflex threshold values obtained using 226Hz and 660Hz ($P<0.01$) 660Hz and 1KHz ($P<0.01$) and 226Hz and 1KHz ($P<0.01$) probe tone frequencies.

In case of subjects with Otosclerosis, there was significant difference between compliance (PVT) values obtained using 226Hz and 660Hz ($P<0.01$), 660Hz and 1KHz ($P<0.01$) and 226Hz and 1KHz (P <(0.01) probe tone frequencies. Also Static (Compliance values increased progressively from low frequency probe tone (i.e.226Hz) to high frequency probe tone (i.e. 1KHz).

In otherwords, the type of tympanogram obtained using 226Hz probe tone frequency was different from the type of tympanogram obtained using 1KHz probe tone frequency. For example, 2 subjects with Otosclerosis exhibited, As type tympanogram when tested using 226Hz probe tone frequency, The same subjects showed B type tympanogram when tested using 660Hz and 1KHz probe tone frequencies,

Further, other two subjects with Otosclerosis exhibited As type tympanogram when tested using 226Hz and 660Hz probe tone frequencies The same subjects showed, A type tympanogram When tested using 1KHz probe tone frequency.

From the above results, the following conclusions can be drawn.

1. Static Compliance, Middle Bar Pressure, Gradient, Compliance (PVT) and Contra Reflex Threshold Values are influenced by the different probe-tone frequencies (i.e. 226Hz, 660Hz and 1KHz).

2. Probe tone frequency has an effect on Impedance Audiometric Measurement in normals as well as Clinical population.

3, Low frequency probe-tone (226Hz) provides useful clinical information in terms of diagnosis of many pathological conditions of the middle ear. However, high frequency probe-tones are more sensitive to a few specific lesions that affect ossicular chain and ear-drum pathology.

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