DIAGNOSTIC HEARING TESTS

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Diagnostic hearing tests are especially important in the differential diagnosis of cochlear versus retrocochlear lesions. The typical diagnostic test battery consists of pure tone audiometry, loudness function tests, and SISI tests, speech discrimination tests, and tone decay tests (Bakesy and tone decay).

A new and important addition to the diagnostic test battery is impedance audiometry. The principles of impedance audiometry are not new, but the inclusion of this procedure within the full battery of tests is fairly recent in development.

The purpose of this paper is to consider the use of diagnostic tests in confirmed cases of acoustic tumors and in known cases of Meniere's Disease.

Test Results in Acoustic Tumors

Data is presented for a total of 384 cases. All but four per cent of these cases represent unilateral hearing impairment. There was sufficient residual hearing in 325 of the patients to enable us to obtain some audiometric data (Table 1). A study of the audiometric configuration in all of the cases revealed that more than 65 per cent of the cases consisted of a high frequency type of loss (Table 2). Approximately seven per cent of the cases were classified as low frequency type configurations.

TABLE 1
Meniere's Disorder
Speech Discrimination Scores
N—92

0%—30%	6
32%—40%	1
42%—50%	3
52%—60%	8
62%—70%	6
72%—80%	14
82%—90%	30
92%—100%	24

TABLE 2
Meniere's Disorder
Bekesy
N—72

Type I	12
Type II	60
Types III and IV	0

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The results of speech discrimination tests were similar to previous studies (Johnson 1968, Johnson 1969). Fifty-five per cent of the patients had extremely poor speech discrimination scores in the zero to 30 per cent range and slightly over 25 per cent had relatively good speech scores of 62 per cent to 100 per cent. This data is presented in Table 3. Speech test scores are significantly different in the acoustic tumor cases as compared with the patients with Meniere's Disease.

Bekesy tests were accomplished in 286 cases (Table 4). Sixty per cent of the patients produced Type III and Type IV patterns with 40 per cent producing Type I or Type II tracings.

The results of SISI tests are given in Table 5. More than 60 per cent scored in the zero to 35 per cent range in this test. Approximately 30 per cent of the patients achieved high SISI scores in the 75 per cent to 100 per cent range. The auditory fatigue that is frequently present in patients with acoustic neuromas (as measured in Bekesy and SISI tests) produced significantly different diagnostic test results in tumors as compared with Meniere's Disease.

TABLE 3

Meniere's Disorder

SISI

N—72

75%—100%	66
35%—70%	4
0 — 30%	2

(83 per cent scores 100 per cent)

TABLE 4

Acoustic Tumors

384 Cases

69—No Residual Hearing
325—Audiometric Data
368—Unilateral Hearing Impairment

TABLE 5

Acoustic Tumors

Audiometric configuration

N—325

High Tone Loss	213
Flat Loss	60
Low Tone Loss	24
Trough-shaped Loss	6

The large series of neuroma cases reported in this study confirm the trend established in a much smaller series of cases (Johnson 1964). There are however, some changes in the results for speech discrimination tests, Bekesy patterns, and SISI test scores. This larger series of patients shows approximately 10 per cent fewer cases with extremely poor speech discrimination and approximately 5 per cent more with good speech discrimination. Similar results are noted for the Bekesy and SISI test findings. There are fewer cases of Bekesy tracings with

Type III and Type IV patterns in the larger series of cases and there are 12 per cent fewer SISI test scores in the zero to 35 per cent range in the larger series. The changes in auditory test results are probably due to the fact that diagnosis was made at a much earlier stage in the development of the tumor. As a result of early diagnosis, the acoustic tumors were removed when they were quite small and before the cochlear branch of the VIII nerve became so intimately involved with the tumor.

Test Results in Patients with Meniere's Disease

Auditory test data was available for a total of 92 patients with Meniere's Disease. Speech discrimination test scores are presented in Table 6 for 92 cases. There was a small number of cases with extremely poor speech discrimination, but it is significant that almost 60 per cent of the cases had good discrimination scores of 62 per cent or better. This is in marked contrast to the auditory findings for the acoustic neuromas.

Table 7 gives the data for Bekesy tests. All of the ears afflicted with Meniere's Disease that were given Bekesy tests produced either a Type I or a Type II tracing. In contrast to the acoustic tumor studies, none of the patients with Meniere's Disease produced a Type III or a Type IV Bekesy pattern.

Seventy-two patients received SISI tests as reported in Table 8. The auditory findings for SISI tests in patients with Meniere's Disease was more than 90 per cent of the cases producing high SISI scores of 75 per cent to 100 per cent. There were only two cases where low SISI scores were elicited. The audiometric data in acoustic neuromas was quite different with more than 60 per cent of the cases showing low SISI scores.

Audiometric test results in patients with Meniere's Disease and patients with acoustic tumors produced significantly different results. The basic test battery is a good tool in differentiating cochlear from retrocochlear lesions. The recent addition of impedance audiometry to the full battery of tests provides an additional important measuring device.

TABLE 6

Acoustic Tumors
Speech Discrimination Impairment
N—321

PB Score	*Number*
0—30%	176
32%— 60%	59
62%—100%	86

TABLE 7

Acoustic Tumors
Bekesy Configuration
N—286

Type I	17
Type II	100
Type III	100
Type IV	69

TABLE 8

Acoustic Tumors

SISI Test

N—281

65%—100%	79
35%—65%	26
0—30%	176

Impedance Audiometry

Metz (Metz 1946) twenty-five years ago introduced impedance audiometry to Europe and it has been widely used in Europe during the past two decades. It was not until the development of the electro-acoustic bridge that this procedure received widespread clinical application as part of a special hearing test battery.

Equipment for impedance testing requires a pure tone audiometer and the acoustic impedance bridge. The electro-acoustic bridge contains a probe tip with three tubes. A 220 Hz probe tone is delivered through one tube. A second tube monitors the sound pressure level of the probe tube and is connected to a balance meter. An air pump that permits a range of air pressure of plus or minus 400 mm is connected to the third tube. It is essential to seal the probe tip with the ear canal. The probe tip is mounted on one side of the head band with an earphone mounted on the opposite side. The three basic measurements of impedance audiometry are acoustic impedance, tympanometry, and acoustic reflex threshold. Acoustic impedance is expressed in acoustic ohms and measures the degree of immobility at the tympanic membrane. Impedance scores that range between 1000 to 3000 ohms are generally conceded to be normal. Occasionally however, normal middle ears will score as low as 800 or as high as 4000 ohms (Jerger 1970, Feldman 1963).

Tympanometry is a measure of compliance change related to air pressure variation. It may be visually sighted or recorded on graph paper. Linden (Linden 1969) has labeled and Jerger (Jerger 1970) has further classified tympanometry curves into three basic types. Type A curves are considered to have a maximum peak at or near zero millimeter. The curves labeled Type B are flat with little or no maximum peak. Curves that are caused by negative pressure in the middle ear are called Type C and the peak of the curve is shifted to the left of zero millimeter. We anticipate that normal ears and ears with cochlear impairment will produce Type A curves. The Type B and C curves occur in most middle ear problems except for otosclerosis. Otosclerosis generally produces a modified Type A with a reduced peak.

Measurement of the acoustic reflex requires insertion of the pure tone into the contralateral ear. A signal strong enough to elicit the acoustic reflex is detected by the deflection of the needle on the balance meter. Patients with normal hearing or with sensorineural loss without recruitment will produce an acoustic reflex at a hearing level of 85 to 95 dB. The acoustic reflex threshold may be recorded for any of the central frequencies. The bilateral absence of acoustic reflex in middle ear (conductive problems) is the anticipated response.

It is advisable to do routine impedance testing in young children. It is sometimes very difficult to obtain valid bone conduction measurements when masking is needed on the non-test ear in a young child. Impedance audiometry may confirm the presence of a conductive impairment when it is not possible to establish bone conduction thresholds.

The following specific examples will illustrate applications of impedance audiometry in differential diagnosis. Figure 1 consists of an audiogram showing a bilateral mixed type hearing loss with a significant conductive component. Excellent speech discrimination was established for both ears and the otologic history and examination indicated bilateral otosclerosis. Figure 2 shows the tympanometry curve classified as a Type A that was established by means of impedance audiometry. Acoustic impedance scores of 3200 and 3600 ohms are somewhat above normal impedance range. The anticipated results of otosclerosis is a higher than normal impedance. There was also an absence of the acoustic reflex bilaterally and this is the expected result for conductive loss.

Another mixed type hearing loss with substantial conductive component and good speech discrimination is shown in Figure 3. The air bone gap on the right ear is slightly larger than that on the left side. A Type B tympanogram was established with impedance audiometry showing a flat response for both ears but with little or no maximum peak reached and with compliance unchanged throughout a considerable range of pressure variation. This is illustrated in Figure 4. An acoustic reflex could not be produced in either ear. The very high acoustic impedance, over 5000 ohms bilaterally, is typical of a case with bilateral serious otitis.

The audiogram for the patient illustrated in Figure 5 is a diagnosed case of Meniere's Disease. This patient had a unilateral sensorineural loss on the left ear with a flat configuration, a threshold of 45 dB and excellent discrimination of 92 per cent on the PB word lists. The unconnected lines for each frequency of the audiogram illustrate acoustic reflexes consistent with normal hearing levels for both ears although the hearing loss averages 45 dB on the left ear, the acoustic reflex occurs at the same level on that ear as on the normal side. The reduced sensation levels at which the reflex occurs on the impaired ear may be attributed to loudness recruitment on that ear. Tympanometry is shown on Figure 6 for this case and established Type A curves as expected in normal ears and in cochlear loss. The impedance scores in this case were within normal limits on both sides.

Figure 7 shows a confirmed acoustic neuroma on the right ear. Audiometric configuration indicates a high tone hearing loss in that ear with excellent discrimination for speech. Impedance audiometry established impedance scores within normal range and tympanometry curves classified as Type A in both ears. It should be particularly noted that the acoustic reflex levels were higher in the affected right ear than in the normal left ear. It was also discovered that there

Ear	SRT	PB Max
R		
L		

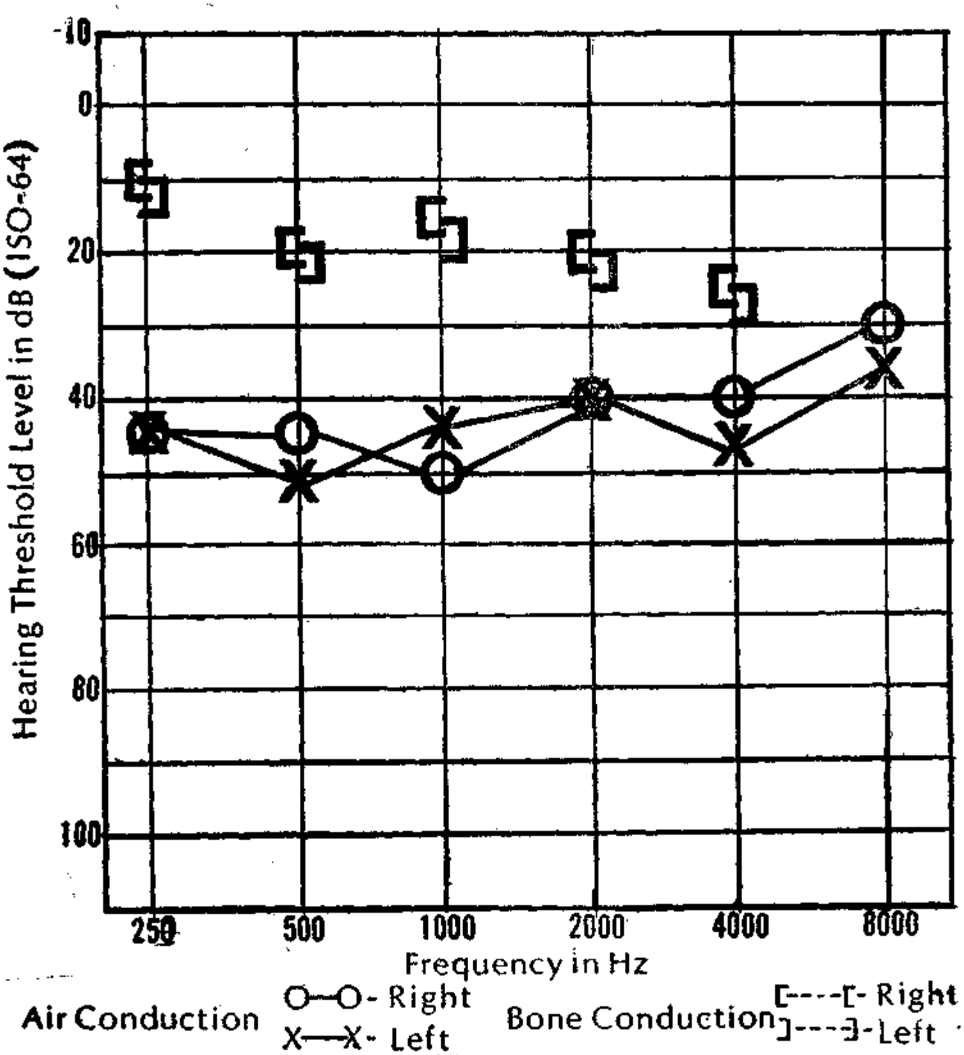

Figure 1: Audiogranx for patient with Otosclerosis

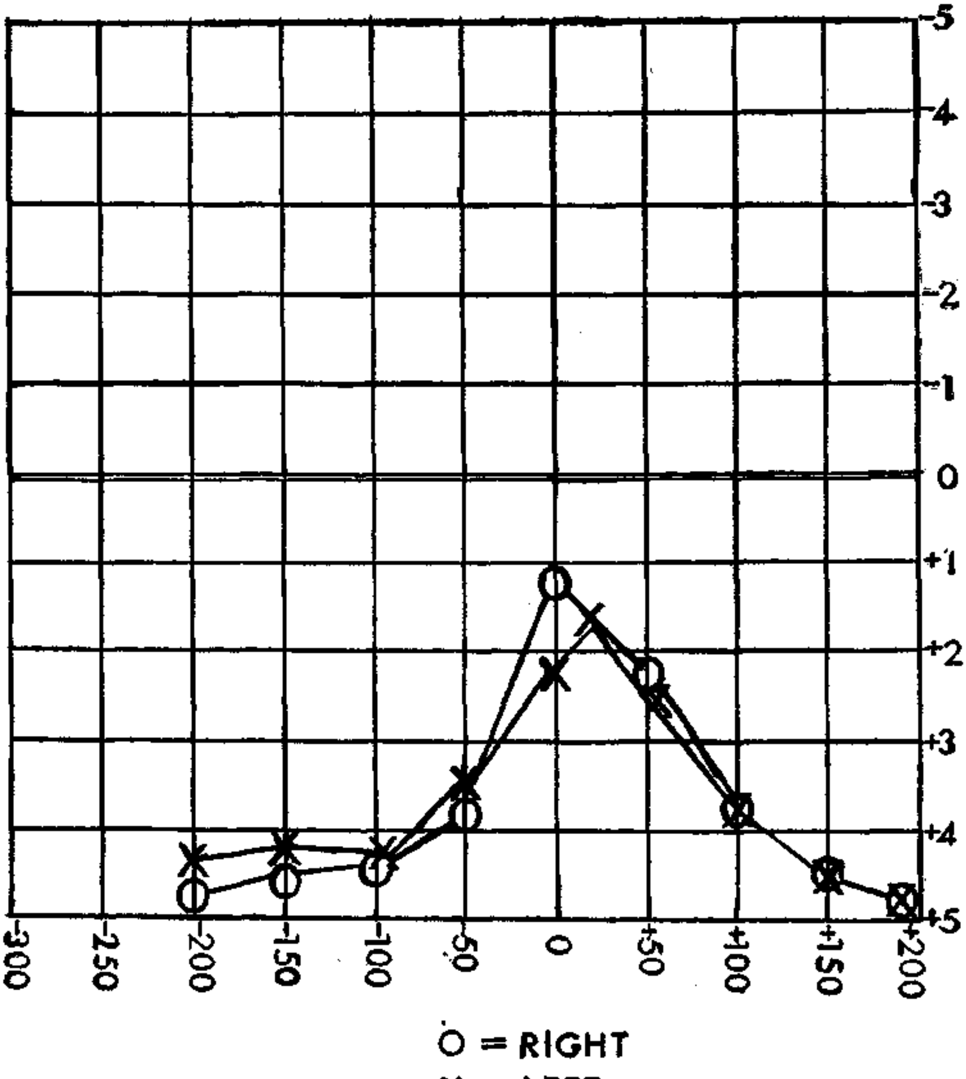

Figure 2: Type A Tympanogram

Ear	SRT	PB Max
R		
L		

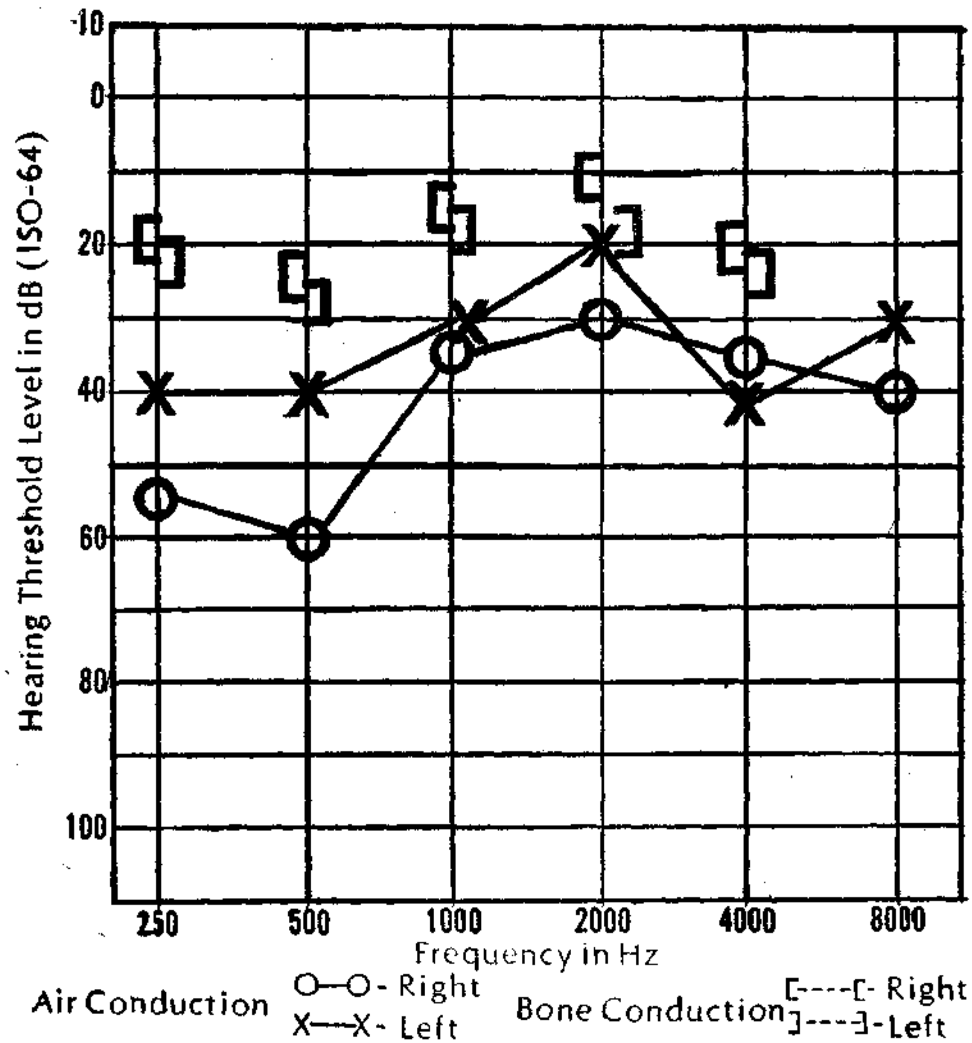

Figure 3: Audiogram for patient with bilateral serious otitis.

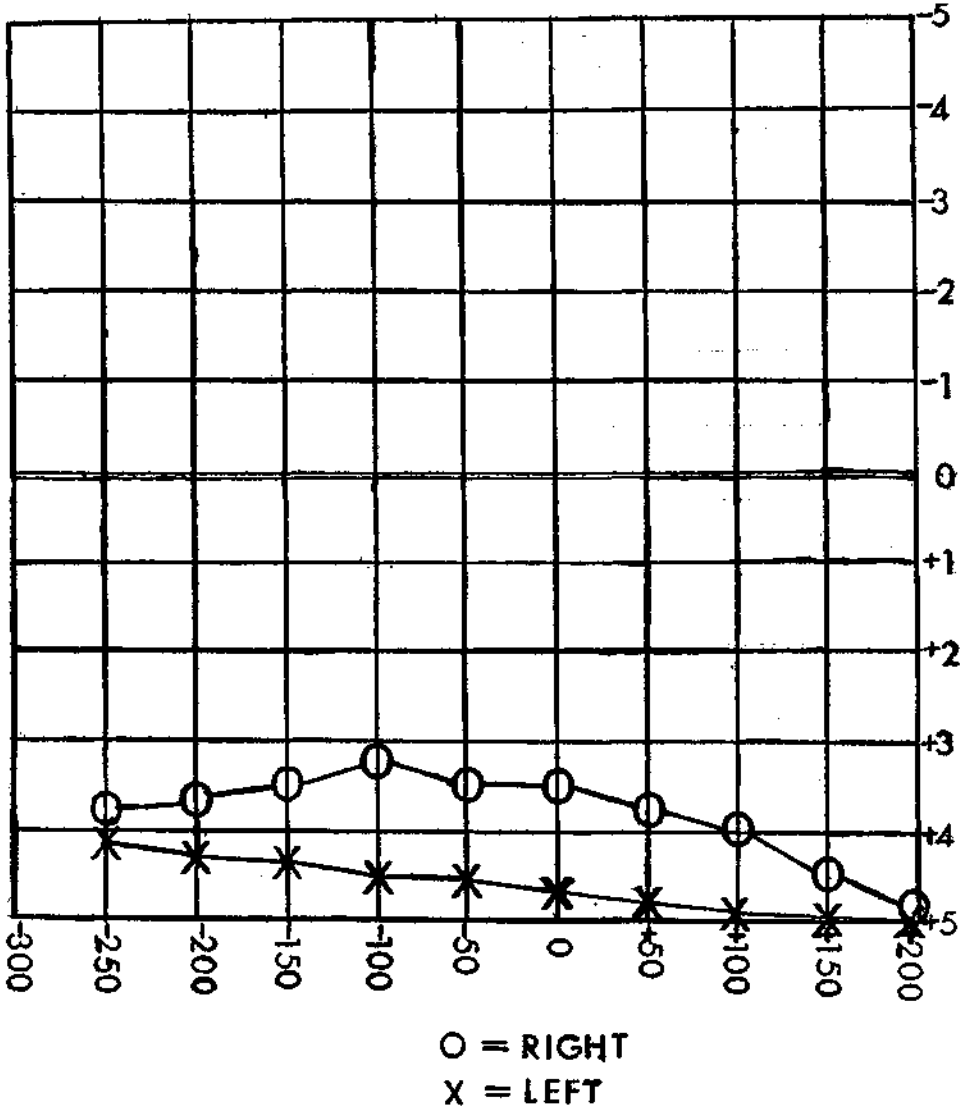

Figure 4: Type B Tympanogram

Ear	SRT	PB Max
R		
L		

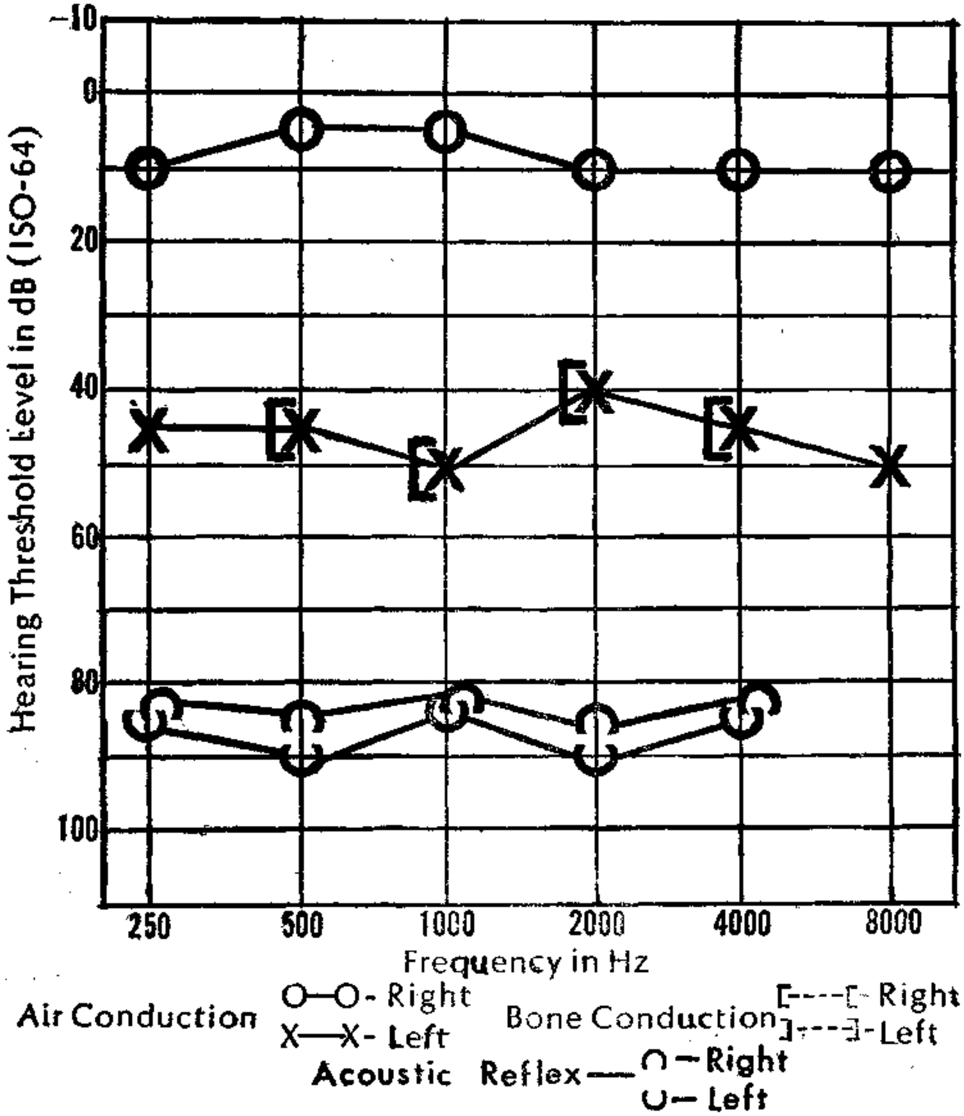

Figure 5: Audiogram for patient with Meniere's Disease

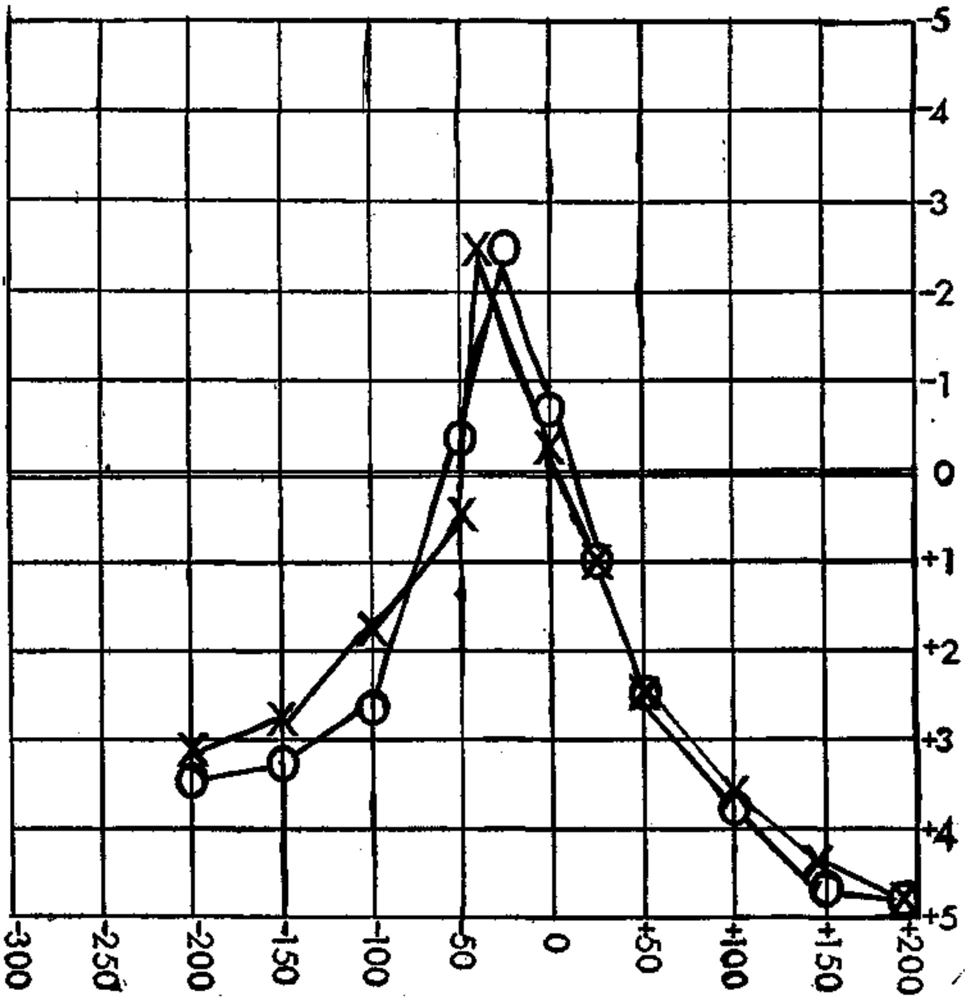

Figure 6: Type A Tympanogram

Ear	SRT	PB Max
R		
L		

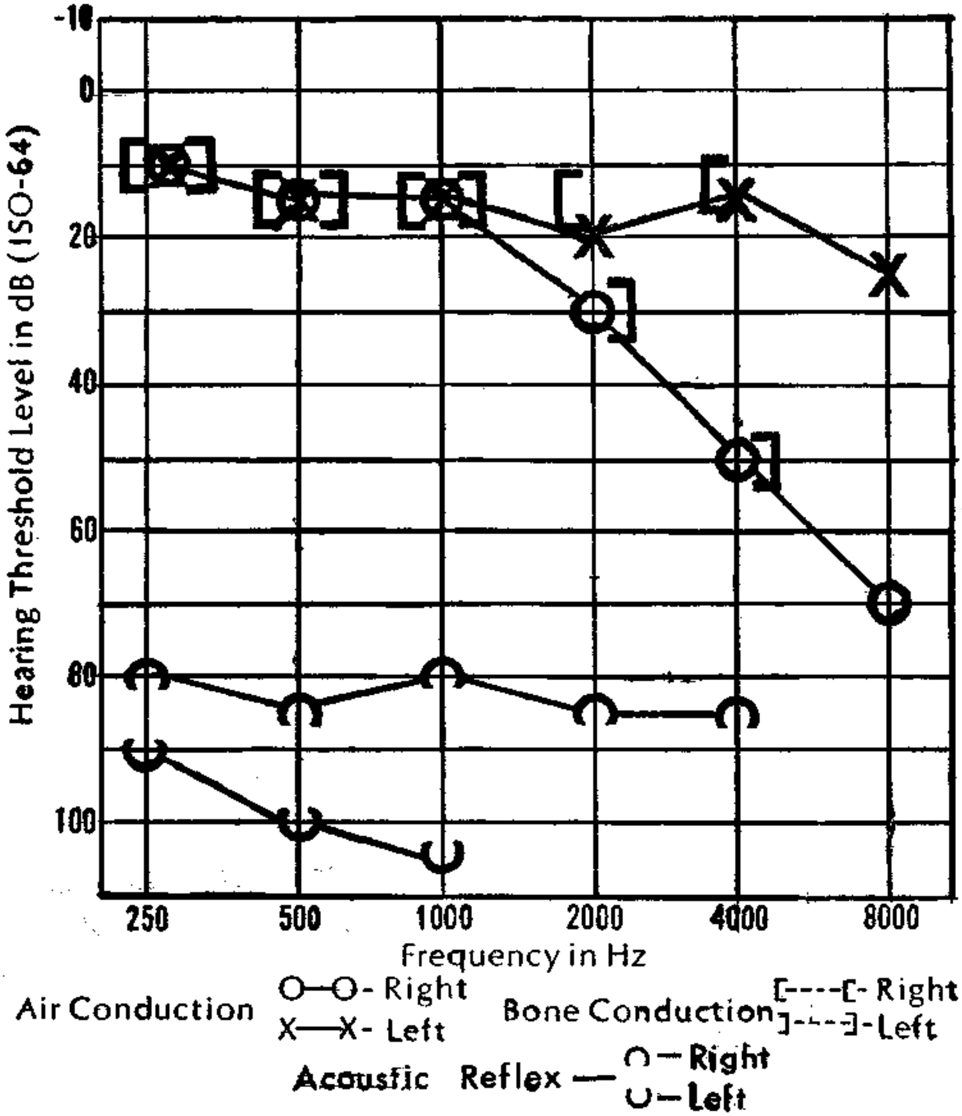

Figure 7; Audiogram for patient with acoustic neuroma.

Was considerable reflex decay on the right ear as compared to the left ear. Acoustic reflex decay in acoustic neuromas usually occurs when the hearing loss on the impaired ear is relatively mild. Approximately 25 per cent of the tumor cases that we have studied have an acoustic reflex with significant reflex decay. The more common finding is a complete absence of acoustic reflex on the affected side. More than half of the cases with confirmed acoustic tumors have no acoustic reflex response. If we combine the cases with reflex decay and no reflex response, then approximately 80 per cent of the cases will produce positive acoustic reflex measurements. It is particularly significant if there is a normal reflex response on the good ear and there is no acoustic reflex present on the impaired side.

It may be concluded that the traditional battery of special hearing tests with the addition of impedance audiometry results in significant information aiding in the differential diagnosis of hearing problems.

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