"A REVIEW OF NONAUDIOLOGICAL TESTS USED IN DETECTION OF HEARING LOSS"

REG. NO. M9720

AN INDEPENDENT PROJECT SUBMITTED AS PART FULFILMENT OF FIRST YEAR M.Sc. (SPEECH AND HEARING) TO THE UNIVERSITY OF MYSORE

ALL INDIA INSTITUTE OF SPEECH AND HEARING
MYSORE - 570 006

MAY 1998

DEDICATED
TO MY
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CERTIFICATE

This is to certify that the Independent Project entitled **"A REVIEW OF NON AUDIOLOOICAL TESTS USED IN DETECTION OF HEARING LOSS",** is a bonafide work in part fulfilment for the First year M.Sc, in Speech and Hearina of the Student with Reg.No.M9720.

Mysore
May 1998

Director
All India Institute of
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CERTIFICATE

This is to certify that the Independent project entitled "A REVIEW OF NONAUDIOLOGICAL TESTS USED IN DETECTION OF HEARING LOSS" has been prepared under my supervision and guidance.

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May 1998.

DECLARATION

I hereby declare that this Independent project entitled "A REVIEW OF NONAUDIOLOGICAL TESTS USED IN DETECTION OF H **EARING LOSS",** is the result of mv own study under the guidance of Mrs. Vanaja *C.S..* Lecturer in Audiolocry, All India Institute of Speech and Hearing, Mysore, has not been submitted earlier to any university for any other Diploma or Degree.

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May 1998

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INTRODUCTION:

The hearing mechanism constitutes a major link between man and its environment. One must therefore try to protect it from damage. Audiologists ascertain the existence of hearing impairment and make judgements concerning its severity, its influence on the patient's life, the locus of the lesion, etiology and the possible areas of remediation. No single test yields sufficient information to answer all these questions. Some tests helps in identifying the site of lesion in the auditory system while others have their primary purpose, in the with determination of the existence of an auditory deficit. By performing numerous overlapping examinations a picture eventually emerges that is great deal clearer than that presented by results of a single examination.

Multiple judgements and the utilization of different approaches and techniques to the same aspect of behaviour lend credence to its interpretation as a statistical entity. Basic examination is the utilization of different examinations in order to make a single statement concerning hearing. This test battery consists of both audiological and non-audiological tests. Audiological tests contribute in the determination of the existence of the hearing impairment and locus of the pathology in the auditory system where as non audiological tests validate the results of tests used for detecting the site of lesion and confirm the diagnosis.

Basic audiological evaluation consists of the pure tone audiometry and speech audiometry. Pure tone audiometry tells about the type and degree of hearing loss. To diagnose lesions at various levels in the auditory pathway a test battery which includes a variety of special tests is needed. These special tests include psycho-acoustic tests such as test for recruitment, tone decay test and objective tests such as immittance evaluations, electrophysiological tests and measurement of oto acoustic emission.

Non audiological tests have equal importance in confirming test results and in diagnosing patients especially those with suspected retro-cochlear pathologies and central hearing loss cases. Neuro-radiological tests such as tomography can diagnose the presence of tumors and also the - size. Small tumors are detected by air-contrast tomography. Magnetic resonance imaging (MRI) has better efficiency than CT-scan. Electronystagmography can quantify and demonstrate pathology of the vestibular system with great precision. Other non-audiological tests used in diagnosis of auditory disorders are histopathological tests, sonotubometry, protein test, CSF test. Non audiological test helps in the diagnosis of pathologies in outer ear, middle ear, inner ear, auditory nerve, CNS lesions and also vestibular system lesions which can lead to hearing loss. A test battery which includes audiological and non-audiological tests are required to confirm the diagnosis and plan the interventions. There is a need for the audiologists to know about both audiological and

non audiological tests to make a decision and diagnose the case accurately.

AIM OF THE STUDY:

There are various studies and journals giving information about the non audiological tests used in detection of hearing. At times it may be difficult for audiologists to read the studies which are scattered in various journals. The main aim was to study all these investigations carried out in the last 20 yrs and compare the results.

Thus the present study was carried with the following aims:

1) The various non-audiological tests which can be used for diagnosis of auditory disorder.

2) The most important and efficient non-audiological test/tests used for detection and diagnosis of a specific auditory disorder.

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METHODOLOGY

Aim of the study: To review the various studies that have used non-audiological tests in diagnosis of auditory disorders and analyse the following:

1. The various non-audiological tests which can be used for diagnosis of auditory disorder.
2. The most important and efficient non-audiological test/tests for detection and diagnosis of a specific auditory disorder.

Articles from various Journals, dealing with non-audiological test used to detect hearing loss were collected. Studies of last 20yrs were reviewed. The Journals reviewed were:

1) Acta - Oto. laryngologica (Acta-Otolaryngol)
2) Archieves of Oto Laryngology (Arch-Otolaryngol)
3) Annals of Otology, Rhinology, Laryngology
4) Audiology (Audiol)
5) British Journal of Audiology (BJA)
6) Ear and Hearing (E & H)
7) Hearing Journal (Hg. J)
8) Journal of Acoustic Society of America (JASA)
9) Journal of Speech and Hearing Disorders (JSHD)
10) Journal of Speech and Hearing Research (JSHR)
11) Journal of Laryngology and Otology (JLO)
12) Journal of Oto Laryngology (JOL)

13) Laryngoscope

14) Scandinavian Audiology (SA)

The information and the results from the articles are classified and then tabulated under the following headings as

1. Author (year)
2. Subjects
   - Number
   - Age
   - Sex
3. Tests used
4. Results
5. Discussion.

Each auditory disorder is presented separately. Conclusion was made based on the results of the articles. The efficacy of different non-audiological tests in diagnosis of various auditory disorders was highlighted.

A brief description of all the non-audiological tests discussed in the studies are given in the Appendix I.

DISORDERS OF EXTERNAL EAR:

Non audiological tests are not used much in the detection of disorders of external ear. Non audiological tests are important in the diagnosis of malignant external otitis and also carcinoma of external ear, auditory canal dysplasia.

Malignant external otitis is a bacterial infection of the external ear canal skin. It results in a dry canal skin with swelling and discharge. Non audiological tests helps in the accurate diagnosis of malignant external otitis and also gives information regarding over all extent of the inflammatory process.

In this review, 9 studies are discussed which have used various, non audiological test for the detection of malignant external otitis (MEO) and also differentiate it from benign form of external otitis.

TABLE (1) NON AUDIOLOGICAL TESTS USED TO DETECT DISORDERS OF EXTERNAL EAR.

Author	Subjects	Test used	Results	Discussion
1. Gold. Sou and Lucente (1984)	23 cases with malignant external otltls (MEO)	Radionuclelde scans and CT scans	CT results demonstrated subtie foci of involvement in the skull base. central skull base erosion lndicates advanced disease, soft tissue thickening of parapharyngeal space and roof of nasopharyrx. Radionuclelde scans provide an information regarding overall extent of inflammatory process.	ALL pts. with necrotizing external otitis should have an initial CT scan for evaluation of central skull base disease. Serial CT scan helps to know the progress and the effects of treatment.
2. Gherini & Brackaan (1986)	4 pts with external otiti3 (MEO)	Malignant MRI, CT scan, 99 bone scanning, galllum-67 citrate	Tc-Galliua-67 citrate unable to detect deep seated Infection in 2 of 4 cases.CT scan identified soft tissue involvement in the clinically affected side in 4pts, but failed to Identify contra involvement, seen in MRI in 2 out of 4pts. Extent of Involvement of the soft tissue in and around temporal bone appeared greater in MRI than CT.	MRI is scyserior to CT scan. Tc~99 bone scanning and galliim-67 citrate in evaluating the anatomic extent in soft tissue changes in MEO
3. Stokkel, and Boot., (1996)	3pts (2M, IF) 46yrs, 66yrs, 17yrs with severe external otitis.	Singe photon emission CT (SPECT)	Increased uptake of gallium -67 at site of the ear with malignant external otitis.	High sensitivity of Ga-67 SPECT confirm initial recognition of MEO.

4. Shary, Nichols, & Lucente., (1986)	12 patiets with severe external otitis compared to known cases of MEO.	Technetium Methylene diphosphate bone scanning.	9 of the 12 patients had positive bone scans with many scans resembling those reported with malignant external otitis. No correlation found between the severity of clinical presentation and amount of Technetiua uptake.	Results show that a positive bone scan should not be alone interpreted as indicative of MEO, though bone scanning with Tc 99 can add information to nccrotizing malignant external Otitis.
5. Bernhelm & Sade, (1989)	45 skin biopsies from 40 MEO pts. 23 skin from the osseous part of ear, 7 from cartllagenous part of external canal, 15 from both skin and cartilagenous part of canal.	Histophathological Test.	Epidermis was normal in nine, thickened in 16, acantholic thickening and pseudoepitheliaatous in 20. In dermis amount of collagen was normal but infiltrated by the inflammatory process. Acute inflammation in 16 biopsies, subacute in 23, chronic in 6. Mixture of acute and chronic changes present in 18 biopies.	Hlstopathologic studies determine the inflammation but no relevant changes in blood vessels. It helps in diagnosis of malignant external otitis and distinguish them from the benign form.
6. Parlsier, Lucente, & Som, (1982)	18 pts with MEO with ages with in 61 to 89 yrs.	Nuclear scanning 1) Technetium bone scan Tc 99-M 2) Gallium scan ga-67.	Tc 99 - M bone scan showed infections involving temporal bone and skull bone. Ga-67 scan indicated that the infections were contrlied in 6pts.	The results indicate that Tc 99-M is an early test for the detection of the presence of malignant external otitis. Gallium scan determine when infection has been controlled,
7. Ostfeld, Aviel and Pelet (1981)	3 patients of age 68 yrs, 73 yrs, 73 yrs, respectively with malgnant external otitis g (MEO)	Bone scintlgraphy	Pathological uptake of the radio-isotope in the mastoid region was found in early stages of (MEO).	Bone sclntigraphy is a reliable diagnostic method during early stages of HEO.
8. Wolf son & Popky (1988)	17 pts. 8M, 9F with external auditory canal dysplasia.	Computerized Tomography	The results showed that 4 of the cases had bilateral dysplasia. In other 4 ears the atresia was membranous and	CT is able to detect abnormalities associated with external canal dysplasia and thus helps in the diagnosis of External auditory

				in two of the cases in which atresia was bony, the atretic plate was incomplete. Out of the cases. 12 ears had ossicular deformity; 1 pt. had inner ear defornity. 10 ears were found to have small tympanic cavity.	canal dysplasia.
9.	Maru and Anand (1980)	28 yrs F, pain, discharge and hearing impairment in left ear.	'X' ray and histopathological test.	The histopathological test results show a eosinophilic cytoplasm and occasionally appearing double layered glands. 'X' ray results reveal presence of granulations extending from Ext auditory canal into ME and mastoid air cells. The Tympanic membrane and ossicles were completely destroyed by the tumor.	'X' ray and histopathologic test are equally efficient in diagnosing adenocarcinoma of the external ear which extends to ME and the mastoid air cells.

COMMENTS

Bone scanning, has been used mainly. Technetium bone scan i.e. TC 99-4 and gallium scan i.e. Ga-67 was used. One of the studies investigated the role of bone scintigraphy method. It has been indicated that both Tc 99-M and bone scintigraphy act as a reliable diagnostic method during early stages of malignant external otitis and Ga-67 determines the control of the infection (Aviel, 1981, Parisier et all. 1982).

Histopathological test has also been used to detect malignant external otitis. Histopathological test helps in diagnosing MEO in terms of presence and extent of inflammation. This non audiological test also distinguishes MEO from the benign form of infection. (Berheim et all. 1989).

CT scan helps to detect the progress and the effect of treatment in malignant external otitis where as radio nucleide scans provides information regarding the overall extent of inflammatory process (Gold et all., 1984).

Results of a study by Stokel, (1996) indicated that Ga-67 SPECT helps only in the initial recognition and diagnosis of MEO. Gherini (1986) compared the efficiency of CT scan, TC-99 bone scanning, Ga-67 bone scan and MRI to detect MEO. It was concluded that MRI was the most efficient test in

diagnosing MEO as it evaluates the anatomic extent of soft tissue changes in MEO.

So from the above discussed studies it can be concluded that bone scintigraphy, bone scan, SPECT are important nonaudiological tests in detecting MEO in early stages, but the most effective and valuable tool for diagnosis is MRI. CT scan helps to know the effect and progress of treatment of MEO.

Computerized tomography was administered in cases with external auditory canal dysplasia. CT scan is important in the detection of abnormalities associated with external canal dysplasia and thus helps in the diagnosis of external auditory canal dysplasia (Swartz and Wolfson, 1985).

Diagnosis of adenocarcinoma is done by X-rays and histopathological tests efficiently. It also helps to detect the extent of the carcinoma to middle ear and the mastoid air cells (Maru et al., 1980).

MIDDLE EAR DISORDERS:

The various disorders of the Middle ear (ME) discussed in this review are:-

1. Otitis Media
   - Acute Otitis Media
   - Chronic Otitis Media
2. Cholesteatoma
3. Tumors of the middle ear.
4. Otosclerosis.
5. Osteogenic imperfecta.
6. Osteogenic congenita.
7. Tubercular Osteomyelitis.

OTITIS MEDIA:-

Acute otitis media is associated with respiratory infection and also eustachian tube dysfunction. If acute otitis media is not treated completely or a complete resolution does not take place complications may occur. Chronic otitis media is one such complication" which may result in a perforated tympanic membrane. Other complications are tuberculous otiti3 media, cholesteatoma.

Cholesteatomas are cyst like structures, which are squamous lined and begin in attic of the ear extending to the mastoid antrum, and sometimes to mastoid tip. Cholesteatoma erodes away bone they make contact with and can produce intracranial complications.

Audiological along with nonaudiological tests are done for achieving accuracy in diagnosis and also to identify the type of disorder and their extent.

In this review, 12 studies are discussed which have used various nonaudiological tests for the diagnosis of different, types of otitis media, cholesteatoma and also to detect eustachian tube dysfunction.

TABLE (2) NON-AUDIOLOGICAL TEST USED TO DETECT OTITIS MEDIA.

Author	Subjects	Test used	Results	Discussion
1., DeCosta, Paparella & Kimberley (1992)	14 temporal bones with CSOM. Out of this 28 with perforated TM, 116 with non perforated TM. Mean age, 51 years.	Temporal bone histopathology	Granulation tissue was the most prominent feature, present in 115 out of 116 in non perforated TM, 27 out of 28 in perforated TM. Ossicular changes found in 27 cases with perforation, 105 with out perforation.Cholesteatoma seen in 6 with perforation and in 14 without, cholesteatoma seen in 10 cases with perforation and in 5 without perforation. Tympanosclerosis present in 12 of the perforated group and in 23 without perforation. Most important site of tympanosclerosis was TM in both groups	From the results it can be suggested that incidence of chronic otitis media is high in intact TM. Histopathological results are efficient in detecting chronic otitis media
2. Hosino and Miyashita (1994)	9 cases with Tuberculous otitis media. Mean age being 56 yrs. Among 9 cases 6 pts had large TM perforation and the rest 3 without perforation.	Histological examination ,computed Tomography.	Histological examination revealed a tuberculous granulation confirming the diagnosis. CT in 4 cases with profound SN loss showed bone destruction of otic capsule around oval window and promon-	Tuberculous otitis media tends to cause fistulization around hook and promontory of otic capsule. Such bony lesions were readily apparent on CT scans of 4 cases with severe SN hg. loss out of 9pts

			tory. Changes noted include a knotch in one case, disappearance of the bony contour around the hook in 2 cases and distinct fistula in one case.	examined.
3. Jonathan and Chalmers (1986)	50 cases with normal hg and upper respiratory tract infection.27F 23M. Age range I8-60 yrs.	Sonotubometry compared with Tympanometry.	7%of the cases had eustachian tube dysfuction according to results of both tympanometry and sonotubometry.	Sonotubometry is able to detect eustachian tube dysfunction. There is a high correlation between tympanometry and sonotubometry results. Sonotubometry and tympanometry are equally efficient in detection of ET dysfunction.
4. koltai, Eames and Parnes (1989)	lopts with clinical evidence of chronic otitis media with suspected cholesteatoma	Computed Tomography, MRI	In 9 of the 10 cases CT accurately predicted the extent and destructiveness of the disease but did not differentiate between cholesteatoma & associated granulation tissue. In 2 of the 10 cases MRI suggested cholesteatoma. In 1 case MRI predicted cholesteatoma based on bony destruction. However in 7 out of 10 cases MRI was nonspecific for cholesteatoma.	High resolution computed tomography is the primary and important imaging modality for chronic otitis media when compared to MRI.
5. Lewis, Thompson, Fetter and Mocnik	52 pts with chronic otitis media and with suspected cholesteatoma.	Poly tomography and computerized tomography.	Softmass tissue in attic detected by CT (65%), (29%) by polytomes. Erosion on the buldge	CT for diagnosis was more efficient than polytomography.

(1985)			of semicircular canal in 80% by polytomes. ME soft tissue mass detection by CT (54%), polytomes (17%)	
6. Mcgill, Merchant & Healy (1991)	41 pts with cholesteatoma age range 6 weeks to 13 yrs.	CT scan and Histopatho1ogical Tests.	CT reveals a symptomatic white mass beyond the normal intact tympanic membrane. CT useful in detecting extension beyond mesotyrapanum. Histopathologic studies reveal a closed Keratocytic cyst in anterior mesotympanum and an open infiltrative type in which there is no containment of keratotic debris.	Histopatholocial tests are more important in the diagnosis of cholesteatoma in children than CT scans.
7. O'Reilly and Cheurelton (1991)	36 cases with CSOM	CT scan [compared axial scan and coronal scan]	CT results showed presence of soft tissue disease and bone erosion The results are moderately sensitive to presence of lateral canal fistulae but less sensitive to presence of small areas of exposed dura, ossicular continuity and facial canal dehiscence. Axial scan able to demonstrate lateral canal better but otherwise coronal scan is superior when other above results are concerned .	CT can detect soft tissue disease in ME & mastoid. Result showing negative scan excludes the possibility of CSOM

8. Rajendra and Anand (1992)	45 yr, F, with mod. conductive loss in Rt ear	Histopathologic test	Histopathotogy reports of granulation tissue from the ear showed chronic inflammatory cells and clusters of epitheloid cells and necrotic bone. While the cervical lymph node showed caesation and giant cells with necrosis	Histological teats are important and efficient in the diagnosis of Tuberculous otitis media.
9. Savic, Herak and Djeric. (1987)	The control group had 10 healthy mallei, incudes 50 diseased mallei and incudes taken preoperatively from patients with atticoantral otitis,	X-ray diffraction test.	X-ray diagrams of normal ossicles were shown as granular hydroxyapatite. In diseased ossicles changes were found in crystallinity of hydro-xyapatite in form of mild crystallization, amorphous phase or abse-nce of any type of crystal phase.	The results 3how that chronic otitis leads to changes in the crysta-lline phase of hydroxy-apatite of the malleus and incus which can be detected by X-ray.
10. Schwartz and Rodriguez (1980)	69 children[40 boys 29 girls], ranging in age from 1 month otitis to 12 yrs.	Purulent exudates were cultured	Potential pathogens such as H.inf1uenzae,S.pneum-oniae and S.Pyogenous were recovered from 2/3 rds of the patient.	Reliable bacterial cultures can be otained from purulent discharge of patients with acute otitis media who suffer spontaneous perforation of their tympanic memberanes. Direct culture of purulent material from spontaneous otorrhea into media supportive of the ME, pathogens appears useful in cases of Acute otitis media.

11. Tovi, Lantsberg & Hertzanu (1992)	l)19yr, M, with reccurent attack of facial palsy. The first occured during an attack of Acute otitis Media 2)60y, F, with meningitis and Rt ear pain. 3) 19yr, F, with Rt sided headache occuring after Rt acute otitis media.	Bone Scanning, CT scan.	Sub(l) Bone scanning showed increased intake of isotope in right mastoid. CT showed a soft tissue mass filling the right antrum. Sub(2) CT showed oto-mastoiditis with no bony changes. Bone scanning indicated increased uptake of isotope in Rt mastoid. Sub(3) CT featured sclerotic right mastoid, Bone Scanning indicated increased uptake of isotope in Rt mastoid.	By CT bone erosion cannot be demonstrated, the increased uptake of isotope suggests presence of osteitis. Bone scan permits identification of the bone invading nature of ME cleft infection, and so plays a important role in treatment, prevention of serious complications.
12. Voorhees, Johnson and Kufkin (1983)	24 pts previously operated for cholesteatomas.	High resolution CT scan	Scans predicted no significant mass in 6pts and cholesteatoma reoccurence in 11. The remaining 6 with diffuse soft tissue were incorrectly diagnosed. Focal areas of bone erosion were detectable in 3 cases indicating active or potential complications.	CT scans has a important contribution in the management of chronic ear problems. CT scans were reliable in detecting cholesteatoma.

COMMENTS

Jonathan (1986) in his study used sonotubometry, a nonaudiological test, to assess eustachian tube dysfunction. Sonotubometry was able to detect eustachian tube dysfunction and its results also correlated with the audiological test results.

Results of investigations on Tuberculous otitis media, showed that both CT scan and histological examinations are equally efficient and accurate in diagnosing tuberculous otitis media independently. But CT scan along with histopathological test gives information about the site and extent of bony destruction caused by the disorder (Tomoyuki, 1994; Rajendra, 1992)

It was found that CT scan was most efficient in detecting cholesteatoma (Lewis et.all., 1985) but in children, histopathological tests are the most important and valuable tool in diagnosing cholesteatoma when compared to CTscan and polytomography (Mcgill, 1991).

In diagnosis of acute otitis media, culturing, CT scan and Bone scaning have been used. Culturing of the purulent exudates helps in the diagnosis of Acute otitis media (Swartz, 1980). By CT scan bone erosion cannot be detected, but bone scanning helps in detection of bone erosion and so plays a important role in treatment and prevention of serious complications (Lovi and Lantsberg, 1982).

Histopathological test, CTscan have been used in diagnosis of chronic otitis media. CTscan was found to be the most important test in diagnosing chronic otitis media (Koltai et.all, 1989) when compared to MRI and histopathological tests. (Costa et all., 1992). Savic, (1987) reported that x-ray diffraction test is capable of detecting chronic otitis media based on the chemical changes taking place in malleus and the incus.

Thus, the review of literature suggested, cholesteatoma is best diagnosed by CTscan but in children diagnosis done with help of histopathological tests. CTscan is important diagnostic tool in diagnosing chronic otitis media where as culturing and bone scanning helps in detecting acute otitis media and also prevents serious complications.

TUMORS OF MIDDLE EAR

Middle ear (ME) tumors are of various types, Glomus tumors arise from glomus bodies and are extremely vascular. Based on their location they are called glomus tympanicum or glomus jugulare tumors. Glomus jugulare tumors are usually extensive arising in region of the jugular bulb. They may erode through floor of middle ear and present as middle ear tumors. They may also invade temporal bone as well as vessels of the neck.

In some cases of chronic otitis media with perforation, the ME mucosa may become thick, hypertrophied and polypoid changes can occur and actual polyps may be formed. In cases of polypoid, chronic otitis media there may be severely damaged middle ear with damage to the ossicular chain.

Non-audiological tests detects the exact site of tumors its extension and relationship to other structures and also the type of the tumor.

Investigations which have used various non-audiological test in diagnosing the ME tumors have been discussed here.

TABLE (3) NON-AUDIOLOGICAL TEST USED TO DETECT TUMORS OF MIDDLE EAR.

Author	Subjects	Test used	Results	Discussion
1. AbduliaAbbar, Abdalla and Bahrain (1994)	A 64 year old Qatari female with one year history of right otorrhoea and hearing loss.	Histopathological examination, High resolution computerized tomography.	A reddish white mass projecting into right ear canal through TM that proved histopathologically to be a paraganglioma. CT of temporal bone showed extensive destruction of right mastoid bone, the posterior ear canal wall, with total desruption of the ossicles.	--Paragangliomas are commonest HE neoplasms. Radiological evidence of bone destruction in ME tumors neccesarily not be against paragangliomas Review of literature shows Radiographical bone destruction can occasionally occur with glomus tympanicum tumors.
2. Bergstedt and Lind (1980)	Ten patients aged 30 to 73 with carcinomas of the ear.	Scintigraphy	All scintigrams showed an increase in the abnormal accumulation of isotope in the particular area. Accumulation of isotope gives information on regression/ progression of malignant growths.	The results indicate high value of bone scintigraphy in the malignant tumour influence on bone tissue and evaluating the prognosis of cancer of the ear.
3. David, Anthony and Cheesman (1990)	20 pts with jugulotympanic glomus tumor. The tumor arise in ME in 10 cases (glomus tympanicum) and 10 in jugular bulb (glomus jugulare).	MRI and computed Tomography.	1 case had a polyp in EAM and 18 had red mass behind lower part of TM. All pts had depressed VIIlth nerve function. 10 glomus tumors produced erosion of jugular fossa. Intra cranial extension occured in 3 jugular tumors confirmed by MRI.	CT and MRI gives information about diagnosis, situation extension of the jugulo-tympanic glomus tumors. A combination of CT and Gadolinium MRI helps in imaging small and large glomus tympanicum tumors.

			All 10 glomus tympanicum tumors showed enchancement which was marked in 8, enabling easy differentiation of tumor from associated serous otitis media.	
4. Milroy & Phelps (1989)	28yr old, M, with fluctuating hearing loss in the Rt ear	CT scan	CT scan revealed round soft tissue mass in the Rt mesotympanum. Incus could not be identified and it was felt that the mass had replaced the ossicle.	CT scan is able to detect osteoma of the incus as seen in this study.
5. Overton & Ritter (1983)	189 histologically prepared temporal bones	Microscopic study of the temporal bone.	In 13 temporal bones, jugular bulb extended into ME space above the inferior rim of bony annulus.	Microscopic studies are efficient in detecting highly placed jugular bulb in the ME.
6. Parnes and Sun (1995)	6 yr old, M, with conductive hearing loss in the Rt ear	CT scan	Scan revealed complex hetrogenous mass involving soft tissues anterior and superior to the pinna of Rt ear with deformity of the tympanic portion of the temporal bone. Roof of external Auditory canal (EAC) was absent and the softtissue compressed the central portion of the EAC.	CT scan was efficient in diagnosing teratoma and also gave precise anatomic localization of the tissues.

7. Parisier and Som (1978)	3 patients with meningiomas in the middle ear space with conductive hearing loss.	Computerized Axial Tomography	Pt.(l) eroding through petrous apex extending in infratemporal fossa pt.(2)large mass near the left temporal bone pt.(3)Large left middle cranial fossa mass.	CT with contrast enhan= cement is reliable in detecting intracranial meningiomas. Addition= ally it permits the observation of areas of calcification with in the meningioma and hyperostolic changes that may occur adjacent to the tumor. It is recommended that pts with meningioma to be diagnosed with compu= terized tomography.

COMMENTS

Overton (1993) used histopathological test and observed that it was able to detect paragangliomas and the high placed jugular bulb in the middle ear(ME)

Computerized tomography done in 4 cases reveal that CTscan not only helps in diagnosis of tumors of ME like teratoma (Parnes and Sun, 1995), glomus tympanicum tumors (David et. all., 1990), Osteoma of the incus (Milroy 1989) but also indicates the extension of the tumor and also the destruction caused to the neighbouring structures. CTscan when done along with histopathological test is important in diagnosing and also indicates the extension of tumor (Bahrain et.all, 1994); David et.all, (1990) reported CT scan done along with gadolinium enhanced MRI helps in diagnosing large and small glomus tympanicum tumors and also gives information about extension and situation of tumor.

Bergestedt, (1980) did bone scintigraphy and it was found useful in diagnosing tumors of not only the middle ear but in any part of the ear.

CT scan and histopathological tests are efficient in diagnosing various ME tumors but gadolinium enhanced MRI helps in diagnosis of very small tumors.

OTOSCLEROSIS, OSTEOGENIC IMPERFECTA AND OTHER MIDDLE EAR CONDITIONS:

Otosclerosis is a disease process characterized by resorption of the normally hard bone and replacement with a newer, softer bone tissue that is highly vascularized and spongy. This spongy bone growth eventually turns into a dense sclerotic mass.

In osteogenesis imperfecta the bones are extremely brittle and easily fractured. Other middle ear conditions are osteogenesis congenita, tubercular osteomyelites.

Nonaudiological tests are effective and important in the detection of otosclerosis, osteogenesis imperfectas, osteogenesis congenita and Tuberculous osteomyelitis. In this review 6 studies are discussed exhibiting the above diseases.

TABLE (4) NON AUDIOLOGICAL TESTS USED TO DETECT ©TOSCLEROSIS AND OTHER (MS) CONDITIONS

Author	Subjects	Test used	Results	Discussion
1. Berger, Hawke, Johnson & Proops (1985)	8 temporal bones from 5 patients with osteogenesis congenita.	Histbpathological. studies.	The otic capsule, bony walls of HE and ossicles showed evidence of both deficient and abnormal ossification. Micro fractures found in the otic capsule and in anterior process and handle of alleus, crura of stapes.	Pathological changes in temporal bones of pts with OIC provided with an oppurtunity to hypothesize the kind of hearing equilibrium impairments of the pts.
2. Mital, Singh and Katiyar (1977)	40 yrs M, with aural discharge since 5 months, painful swelling behind Lt ear, impaired hearing.	Histopathological test, 'X' ray.	Histopathological investigations revealed moderate polyMorphonuclear leucocytosls with raised erythrocyte sedimentation rate and low haemoglobin. 'X' ray of the skull revealed small areas of rarefaction of the bone In temporal region.	Histopathological test and 'X-ray' are both required and is efficient to detect Tubercular osteomyelitis of the Mastoid Temporal bone.
3. Pedersen, Melsen & (1985)	14pts (9F, 5M) aged 15-47 yrs with conductive or mixed hearing loss with stapedial fixation.	Histologic examination	The entire stapes footplate appeared to be thick and in some soft consistency. Histologic examination revealed otospongiotic tissue in only one crus, normal or immature osteogenic bone structure with altered size and polarity of osteocytes in remainder. In 2 of the cases large cavities were seen in the head of the stapes.	Histologic studies are imporatant for the diagnosis of osteogenesis imperfects.

4. Robison, Ford & (1986)	39 yr old male, with 2 yr status of Post-odontogenic infection.	Single photon emission computerized tomography (SPECT) and CT.	(SPECT) revealed differential uptake in the left maxilla with a hot focal anterior bony focus. CT revealed a focal hypodense 2.5 cm area with a central bony spicule in the anterior left maxilla.	(SPECT) and CT results correlation is more accurate for localization of osteo myelitis sequestra, especially in areas of temporal bone, skull base paranasal sinuses and mandible and thus helps in diagnosis.
5. Ross, Berlis and Reinhardt (1995)	Human temporal bone model.	Tympanocochlear scintigraphy (TCS)	Correlative Imaging of 'X-ray' photographs and the scintlgrams or superpositioni with marks of the temporal bone drawn from the 'X-rays can facilitate the localization of small foci of about 6-1 mm.	High resolution TCS is a useful tool for visualizing changes in labyrinthine bone metabolism in active otosclerosis.
6. Hong, Stoney & Hawke, (1991)	Total 46 specimen examined, 17 normal, 29 diseased, of the diseased 14 were otosclerotic stapes and 15 had eroded mallei and incudes.	Scanning electron microscope (using a solution of hypoclorite).	Otoselerotic foci were well demarcated on the tympanic surface of foot plates by fibrous arrangement lost. Eroded mallei, incvdes also showed changes in patterns of erosion.	Scanning electron microscope helps in detecting cholesteatoma. Also helps in studying otosclerotic stapes paying special attention to stapedovestibular joint and cartilagenous lamina of the stapes.

COMMENTS

Investigators have used Tympanocochlear scintigraphy and scanning electron microscope. Scanning electron microscope helps in studying otosclerotic staps with special attention to the cartilagenous lamina of stapes in diagnosis of otoselerosis (Wong and Stoney, 1991). Ross, (1995) reported that Tympanocochlear scintigraphy is a useful tool for visualizing changes in labyrinthine bone metabolism in active otosclerosis and thus helps in diagnosis of otosclerosis.

Pedersen and Melsen (1985) used Histopathologic examination for the diagnosis of osteogenesis imperfecta and found it effective and important for the diagnosis. Histopathologic test was also a valuable tool for osteogenesis congenita in terms of hypothisizing the kind of hearing impairment and equilibrium impairments (Berger et al., 1985).

In patients with Tubercular osteomyelitis SPECT, CT and histopathological tests were administered. All the tests-were equally efficient in diagnosing tubercular osteomyelities and CT gave information about the site of the lesion (Robinson, 1986).

So it can be concluded that histopathological examinations are important for diagnosing osteogenesis imperfecta, osteogenesis congenita and Tubercular osteomyelities. CT scan gives additional information

regarding site of lesion in Tubercular osteomyelitis. Scanning electron microscope and Tympanocochlear scintigraphy helps in the diagnosis of otosclerosis and also can differentiate cochlear and stapedial otosclerosis (Ross et al., 1995).

INNER EAR DISORDERS:

The various disorders of the Inner ear (IE) discussed in this review are:

- Meniere's disease
- Vestibular disorders
- Progressive sensori neural hearing loss.

INNER EAR ANOMALIES EXHIBITING PROGRESSIVE SENSORY NEURAL HEARING LOSS:

Sensori neural hearing loss (SNHL) though has a gradual onset with slow progression it may also exhibit a sudden onset. Sudden hearing loss without apparent etiology has been explained by two hypothesis. The first is viral labyrinthitis, producing changes in inner ear and secondly that of vascular occulsion causing abrupt interruption of blood supply.

A detailed evaluation is needed for the diagnosis which includes both audiological and nonaudiological tests. Non audiological test reveals the labyrinthine changes and thus can be correlated with audiological findings.

In this review, 5 studies have been discussed in which various non-audiological tests have been used for the detection of the site of lesion for progressive sensorineural hearing loss (SNHL).

TABLE (5): NON AUDIOLOGICAL TESTS USED TO DETECT PROGRESSIVE SEMSORI NEURAL HEARING LOSS

	AUTHOR	SUBJECT	TEST USED	RESULTS	DISCUSSION
1.	Applebaun Clemis (1977)	A patient with progressive SN hearing loss and advanced Paget's disease involving skull. Low frequency conductive hearing loss present.	Histopathological test	Histopathological test revealed Pagetic bone invading internal auditory canal. (IAC) and compressing the cochlear division of the VIII cranial nerve resulting in severe neural degeneration. No histopathologic correlate could be identificed for conductive loss.	Histopathological test & helps in the detection of the narrowing of the IAC which is a characteristic feature of Paget's disease causing a SNHL.
2.	Mark and Sheltzer (1992).	12 pts with hearing loss & vertigo, was compared with 30 normals.	Gadolinium enhanced HRI.	Results revealed enhancement of the cochlea and/or vestibule in all the patients. In 4pts, the enhancement limited to basal turn of the cochlea, in 2 pts in the middle and apical turns of the cochlea. Vestibular enhancement seen in 5 of the 12 cases. In 2pts enhancement in the semicircular canal in addition to enhancement of cochlea and vestibule. No labyrinthine enhancement in 30 controlled pts.	Gadolinium enhanced HRI is important in detecting labyrinthine diseases. It differentiates retrocochlear lesions from the abnormal process in labyrinthine and the brain stem.
3.	Okumura, Takahasi, & Honjo (1995)	181 pts with SNHL of unknown etiology Age range from 11 months to 75yrs. 25 pts with idiopa-	Computed Tomography	Image of large vestibular aqueduct visible as a large aperture (4 mm). Large vestibular aqueduct in 13 ears (17%), hypoplastic	Large vestibular aqueduct (VA) is a relatively frequent inner

		thic facial palsy with out SNHL as controls.		cochlea in 33 ears, (10.1%) in all the ear anomalies detected.	ear anomaly among pts. with SNHL of unknown etiology. CT scan is efficient in the detection of large (VA).
	Shusterman & Handler (1992).	70 children with SNHL. Average age of 6.76 yrs.	Computed Tomography	9 of the CT results revealed a significant intracranial abnormality, In 8 other scans minor unrelated abnomalities detected such as slight assymetry of skulls, mild enlargements of 4th ventricle or inflammatory changes in ME or sinuses.	CT scan may not play a important role in the examination of children under 16 yrs of age with stable SNHL in absence of other findings.
5.	Umang and Khetarpal (1993).	74 pts with progressive SNHL.	Histopathologic test	Hair cell, mild stria vascularis degeneration was seen in all the cases. Deposition of homogenous acidophilic substance with loss of cellularity was observed in the spiral ligament and spiral limbus, of all 3 cochlear turns, in stroma of maculae and cristae, and also in the channels that transmit the dendritic innervation to the cochlea and vestibular sense organ.	The presence of these unique histopathologic findings in the vestibular and cochlear systems suggested classification of adult or early onset of autosomal dominant SN hg loss into two histologies subtypes, cochlear and cochleo vestibular.

COMMENTS

In , 2 of the studies histopathological tests were used Histopathological tests are important in detecting changes in cochlea and vestibular system. It also gives information about neural degeneration due to the compression of cranial nerve (Clemis, 1977).

In 2 of the studies CT scan was used. Computerized tomography is efficient in revealing cochlear anomalies and also large vestibular aqueduct in adults (Okumura et all., 1995). However Shusterman, (1992) reported that CT-scan does not play a important role in the diagnosis of progressive SN hearing loss in children.

Mark, (1992) administered gadolinium enhanced MRI which revealed that it is important in detection of labyrinthine diseases and can also differentiate retrocochlear lesions and abnormal process in labyrinthine or in brainstem.

So it can be concluded that though CT scan is a valuable test in detecting lesions in adults it is not helpful for children. Gadolinium enhanced MRI and histopathological tests helps in diagnosing labyrinthine diseases.

MENIERE'S DISEASE:

Meniere's disease (MD) is a disorder of the inner ear and falls under the category of acquired hearing loss. The typical characteristic exhibited by Meniere's diesease are:

a) Vertigo
b) Tinnitus
c) Fullness or sense of pressure
d) Nausea, vomitting
e) Fluctuating hearing loss.

(Katz, 1992)

The cause of the disease is unknown as a result of which both audiological and nonaudiological tests should be done to confirm the diagnosis and for better treatment.

In this study a review of the various non audiological tests and their importance in the diagnosis of Meniere's disease has been discussed.

TABLE (6): NON AUDIOLOGICAL TESTS USED TO DETECT MEKIERE'S DISEASE

AUTHOR	SUBJECT	TEST USED	RESULTS	DISCUSSION
1. Albers and Casselman (1994).	20pts with Meniere's Disease having SN hearing loss, vertigo, tinnitus, 50 normals	MRI	It indicates visualiztion of the membranous endolymphati csac and duct in 72.5% in normal, 26% cases with minures Disease Nonvisualization or narrowed endolymphatic duct & sac seen in 74%. The distance between the posterier semicircular canal and the fossa posterior was significantly shorter in Meniere's group.	Based on the visualization of endolymphatic sac and duct distance between semicircular canals and posterior fossa during MRI the presence of meniere's disease can be confirmed.
2. Bouccara, Coudert and Ferry (1997)	4 groups of subject 1st group - 7(N) 2nd - 9 (SN) sensorienural hg loss 3rd group - 8pts with fluctuating hearing loss. 4th group - 25 pts with meniere's Diesease	Cerebral and cochlear pressure analyser (CCPA).	Analysis done of Vi(mean inward displacement) & Vm (mean displacement) Normal pressure in first group. Most of the pts of 2nd group and half patients of last group showed normal pressure in inner ear fluids. 3rd group and for the second half pts of the last group results show a elevated pressure in the inner ear fluids.	CCPA a noninvasive techinique is a important technique for confirming the diagnosis of meniere's disease and also management of IE pathologies.
3. Brodley & Mark (1996)	12pts with MD (3 men, 9 women age 18 - 64yrs) and control group	Magnetic resonance imaging	In MD pts 7 of the 24 endolymphatic ducts were visualized where as in contral groups 20 of 22	The results revealed that MRI helps confirming the diagnosis of

	of 11 normal subjects (5men, 6 women age 23-64 yrs)		ducts were visualized. Non visualizationof endolympatic ducts correlates with smaller temporal bone widths between posterior semi-circular canal sub-arachnoid space and between vestibule and subarachnoid space. Temporal bone measurements in region of endolympatic sac in MD showed smaller dimensions than normals.	MD.
4. Gordon, Sam and Barbara (1983)	10 patients with bilateral Meniere's disease, compared with normal cntrol subjects	Autoimmenm Test 1) Lymphocyte migration inh-ibition. 2) Lymphocyte transformation test. 3) Radioimmun-oassay	Results of lymphocyte transformation test were positive. Radio-immunoas-say studies were negative. Two patients had abnormal cellular immune responses to skin antigen stimu-lation. One patient had abnormal circulating immune complexes. Similiar tests performed on control subjects were negative. Lymphocyte migration inhibition would not be done due to reduced cell count.	The autoimmune MD diagnosis is supported by cell mediated immune responses to inner ear membrane antigen stimulation. Diagnosis of the autoimmune MD should be confirmed by appropriate autoimmune tests for treatment planning.
5. Richard (1979)	67yr 'M' with 3yr history of episo-dic vertigo with SN hearing loss.	Electronystag-mography (Calo-ric test).	This demonstrated a direc-tion - changing, ageotropic positional nystagmus without a spontaneous nys-tagmus or change in calo-ric response.	There is a significant incidence of direction changing positional

				nystagmus among Meniere's disease patients. Thus ENG helps in diagnosis of meniere's Disease.
6. Saito, Kitahara & Yazawa (1977)	8pts diagnosed as having meniere's disease.	Histopatho1ogical tests.	Two types of abnormality in the endolymphatic sac was present. One was deep brown pigmentation in the sub epithelial connective tissue. The pigment did-not react to Prussian blue thus ruling out hemosiderin. The other, in seven out of eight specimens, wa3 the perisaccular fibrosis.	Histopathological tests helps in confirming the presence of meniere's disease.
7. Takeda and Saito (1997)	30 normals 25 meniere's disease pts. of which 14 had bilateral involvement	Po1ytomography	Vestibular acqueduct was identified in normals and Meniere's disease group. Normal vestibular aqueduct were tubular and width of external aperture was 6mm where as a hypoplastic narrow external aperture was seen in Meniere's disease of 2.2mm. Bilateral Meniere's disease group had a hypoplastic vestibular aqueduct but with a wide external aperture compared to unilateral Meniere's disease grooup.	Po1ytomography is able to diagnose Meniere's disease cases based on the hypoplastic vestibular aqueduct

8.	Vijay, Joseph and Betty (1983)	25 normals, 25 cases with menie-re's disease, 2Opts with vestibular neuroniti s, 15pts with acoustic neuroma.	Hot, cold, bithermal caloric tests.	Results showed presence of spontaneous, positional nystagmus and directional preponderence of all patients	Hot caloric test useful1 in serial tests required to monitor vestibular ototoxicity from drugs. Bithermal test gives better indications for the evaluation of Meneire disease, vestibular neuronitis and acoustic neuromas.

COMMENTS

2 of the above discussed articles have made use of the electronystagmography (ENG.) mainly the caloric test and both the results indicate that Meniere's disease cases show a direction changing positional nystagmus. Bithermal caloric-tests have greater efficiency in the diagnosis of Meniere's disease than hot or cold caloric test alone (Joseph et all., 1983).

MRI was used in 2 of the studies. Non visualization of the endolymphatic duct and smaller temporal bone measurements in the region of the endolymphatic sac are characteristic features of Meniere's disease and are detected by MRI (Bradley, 1996; Albers 1994). MRI thus helps in differentiating normals from Meniere's disease.

Gordon et all., (1982) have reported the use of autoimmune tests like lymphocyte migration inhibition test, lymphocyte transformation test and Radioimmunoassay test for the diagnosis of autoimmune Meniere's disaease.

Takeda and Saito (1997) showed that Polytomography was efficient in diagnosing Meniere's as disease at it was capable of detecting hypoplastic vestibular aqueduct seen in Meniere's disease.

Histopathological test done in one study was able to diagnose Meniere's disease.

Cerebral and cochlear pressure analyser (CCPA) which is a non-invasive measurement of the cerebral and cochlear fluid pressure has also been carried out. Results indicated that it is an important technique for confirming the diagnosis of Meniere's disease (Bouccara, 1997).

Thus it can be concluded that ENG," and MRI are frequently used to confirm the diagnosis of Meniere's disease. Histopathological tests helps in the detection of Meniere's disease. Autoimmune test though helps in diagnosis has a major drawback i.e., it cannot be tested in cases with a low cell count. Cerebral and cochlear pressure analyser is important for the diagnosis and management of Meniere's disease.

VESTIBULAR DISORDERS:

The vestibular system is more complex than the auditory system. Thus the evaluation and interpretation of disorders in this system are also more complex. The various functions of the vestibular system are:

1. To rapidly correct any inadvertent displacement of the body's centre of mass from its equilibrium position over the base of support (the feet when standing) to prevent a fall from occuring .

2. To provide accurate perceptions of the position of the body in its environment and perceptions of direction and speed of movement.

3. To control the eye movements in order to maintain a clear visual image of the external world while the individual, the environment, or both are in motion.

(Katz, 1994).

Nonaudiological tests used in the diagnosis of the balance disorders, include electronystagmography, MRI, CT scan, histopathological tests.

Results of non audiological tests used in subjects with various vestibular disorders is tabulated below.

TABLE (7): NON AUDIOLOGICAL TESTS USED TO DETECT VESTIBULAR DISORDERS

	AUTHOR	SUBJECT	TEST USED	RESULTS	DISCUSSION
1.	Afzelius, Henrikson & Wahlgren	338 pts with vertigo	Electronystagmgr-aphy -> Tracking test -> Spontaneous eyti movement -> caloric nys tagmus respo-nses	Results show 119 pts out of 338 having irregular tracking patterns sugges-ing central disturbance 13pts had slight, and 7 pronounced saccadic trac-ting patterns. 38 pts revealed spontane-ous nystagmus. Caloric nystagmus present in 204 pts indicating central disturbance. 87 pts showed difference in caloric response exceeding 20%.	ENG is important in the diagnosis of certral vestibular disorder and also different-ates between functional symptoms and central vestibular disorders.
2.	Dieterich H. and Buchele (1981)	1.46 yr old patient with vertigo, » ataxia with a tendency to fall to the left, nausea, vomiting 2.40 yr old F, suff-ering from acute ataxia	Electronystag-mography, CT scan, MRI	Sub 1.Electronystagmography revealed spontaneous nyst-agmus to right and lypore-sponsiveness of left laby-rinth. CT scan was normal. MRI showed distinct lesion in tegmentum of left pont-omedullary junction. Sub:2. ENG revealed acute unilateral loss of perip-heral vestibular function attributed to vestibular neuritis. CT showed mult-ipe supratentoreal white matter lypodensities MRI showed low intensity lesior on the left lateral floor of 4th ventricle and other focal changes.	ENG helps in detecting vestibular abnormalities where as MRI pointed out the exact site of lesion more efficiently than CT scan.

3.	Kohut, Hinojosa Thompson and Ryu (1995)	68, M with hearing loss and vertigo	Histopathological Test	Results reveal a patency of the labyrinth capsule large polyp like growth extending from membranous wall into the lumen of sac.	Histopathological tests helps in distinguishing the presence or absence of labyrinth capsule patencies in pts with cochlear or vestibular disorders.
4.	Kitamura et al., (1995)	54 pts of which 24 M, 30F mean age 51 yrs.	Infrared/video ENG (Caloric testing)	Results reveal horizontal nystagmus to be the most common but torsioval, vertical and oblique nystagmus were also demonstrated in these pts. There was a high incidence of oblique nystagmus closely related to a significant right-left difference of the caloric response in benign positional vertigo.	Infrared-ENG (caloric testing) is useful in the detection of peripheral vestibular diseases,
5.	Manabe and Kurokawa (1995)	36 NIHL pts. divided in 2 groups Vertigo - 20 pts Non vertigo-16 pts	ENG (caloric test) ENG test done only on vertigo group.	Results showed abnormal positional nystagmus in all cases. Reduced caloric responses (max.slow phase velocity less than 10%) were noted in 47.1% of the ears.	Electronystagmo-graphic results helps in confirming and involvement of vestibular functions in NIHL cases.
6.	Man & Segal (1980)	326 males having moderate. SN hearing loss. The	Electronystag-mography (Caloric test)	Among control group one case of vestibular pathology was found. In the	Electronystagmography can detect

		subject were divided into groups based on severity of acoustic trauma and complaints about vertigo.		remaining groups a graded increase in percentage of vestibular pathology observed from 7% in slight acoustic trauma group without complaints of vertigo, to 26% in severe acoustic trauma with comp-taints of vertigo.	vestibular involvement in acoustic trauma i.e. cochlear damage.
7.	Rubin and Metairie (1981)	Tested 3 subjects 1) 61yr male with acute dizziness 2) 49 yr male with mild bilateral high tone SN hg loss 3) 31 yr male 4) 55 yr male.	SHA Test + (Sinusoidal harmonic acceleration test).	The results were as follows Pt-1) Phase lag - central abnormality Pt-2) Phase lag-peripheral Pt-3) Phase lag-peripheral Pt-4) Phase lag-central	The addition of SHA test in vestibular evaluation has improved capability for identifying subtle abnormalities and monitor patient progress.
8.	Suonpaa (1991)	144 deaf children (75M, 69F) with avg. age 12.9yrs.	Electronystagm-ography. (Caloric Test)	Results revealed spontaneous or positional nystagmus in 62 (43%) of 144 profoudly hg loss children. Uni. or bilaterally depressed caloric reactions were found in 78 subjects. Caloric reactions lower when the cause is of perinatal or postratal origin. Depressed. caloric reaction in 81% in poorest hearing.	The use of electro nysta-gmography reveals more vestibular disturbances in the profound hg loss and as a result helps in diagnosis.
9.	Takeda, Tanaka-Tsuji & Sawada (1995)	2 subjects, M, man age 80yrs with nystagmus sensation	SPECT, Caloric test, MRI	In both cases Bithermal caloric test suggested right canal paresis with normal visual suppression	It was sugges-ted from the results that parietal-

		dissociation		on caloric nystagmus. MRI revealed multiple infarction in cortical and subcortical areas in both cases. SPECT revealed decreased regional cerebral blood flow in right parietal temporal lobe in both cases.	temporal lobe in the non dominant hemisphere contains the vestibular cortex which is centre for the perception of vertigo due to vestibular disturbances and a lesion in that area can be diagnosed by SPECT, caloric test, MRI.
10.	Yamasoba et all., (1995)	35 vertiginous pts mean age 62, 18M, 17F. Among the total pts 15 had slow vertebro basilas blood flow (SBF) and 20 without.	MRI, Magnetic resonance angiography (MRA)	MRI results indicated lacunae of hindbrain in SBF pts. Vertebrobasilar dolichoec-tasia, segmental stenosis with elongation and diffuse narrowing of the vertebro basilar arteries (VBA) found in 4, 4 and 2 pts with SBF respectively In lpt. of SBF the thrombi that induced SBF have embolized to distal arteries. These abnormal-ities not detected in pts without SBF.	MRI along with MRA is helpful in the diagnosis of arterial wall lesions in vertebral artery and basilar artery which may result in vestibular dysfunction.

COMMENTS

In 5 of the discussed studies electronystagmography (caloric test) has been used. Electronystagmography is a useful test in detection of vestibular disturbances in NIHL cases (Manabe, 1995) and also in acoustic trauma patients (Segal, 1980). ENG also differentiates central vestibular disorders from the functional symptoms (Afzelius and Henriksson, 1978).

Rubin, (1981) in addition to other vestibular evaluation used sinusoidal harmonic acceleration (SHA) test. It was found to be effective in diagnosis of vestibular disturbances as it improved the capabilities of detecting subtle vestibular anomalies.

MRI and CT scan was used in one of the studies along with ENG. It was found that though ENG had main role in diagnosing, MRI detected the site and type of lesion causing vestibular disturbances in the subjects. CT scan didnot have a important role in the diagnosis of vestibular disorders (Dieterich, 1989).

Thus it can be concluded that ENG is the most valuable and important test for the diagnosis of vestibular disturbance. Where as MRI along with ENG help in detecting site and type of lesion.

CEREBELLOPONTINE ANGLE TUMORS

The diagnosis of cerebellopontine angle (CPA) tumors is based on results of audiological and non-audiological tests. Audiological tests do not indicate the site of lesion and the description of the lesion. Non-audiological tests determines the site of the pathology, the extent of lesion, and also size of tumors. Cerebellopontine angle tumors cannot be diagnosed with out non-audiological tests.

Traditionally radio nucleide brain scanning, X-rays were used to confirm the presence of these tumors. They were the primary diagnostic tools used since 1950's. Later CT scan was used for the diagnosis and it was found to have a diagnostic accuracy of 90%. The recently used technique is gadolinium enhanced MRI which provides remarkable visualization and thus helps in diagnosis of small sized tumors.

TABLE (8) NON AUDIOLOGICAL TESTS USED TO DETECT CEREBELLOPONTINE ANGLE TUMORS.

Atithor	Subjects	Test used	Results	Discussion
1. Been and Thomsen (1978)	CSF protein from S3. Males and 45 Females.	CSF protein test	CSF from the subjects revealed higher protein values than that observed in normals.	CSF elevation is seen in large acoustic neuromas and thus helps in diagnosis of the acoustic neuromas.
2. Donnelly, Dally and Brlggs (1994)	24 year old man with acoustic neuroma.	CT scan and HRI	High resolution CT scan of temporal bones and internal auditory canal (IAC) were normal. MRI showed intra cochlear schawannoma with a involvement of IAC.	Results show the inability of CT scan to pick up small acoustic neuromas. MRI imaging is necessary to demonstrate this type of intracochlear lesion, even with intra canalicular involvement.
3. Ferguson, et al., (1996)	237 pts under going audio-vestibular investigations	CT, MRI and ABR	MRI results revealed that 18 pts had cerebello ponti angle tumors. CT missed two of the 18 tumor pts. CT scanning alone would have missed one small intra-canalicular tumor which was picked up on MRI triggered by abnormal ABR.	MRI is effective in detecting cerebellopontine angle tumors. MRI scanning with gadolinium enhancement will identify vltually all tumors.
4. Goravaling-appa and Guruaurthy (1982)	4yr,F,with history of ear discharge from Rt ear. Painful swelling in the Rt side region of mastoid. Facial nerve palsy in Rt side.	Histopatholgical examination	Histological examination showed loose embryonic mesenchyme covered partly by stratified squamous epithelium and partly ulcerated. Thin spindle cells and polygonal acido philic cells were also seen,	Embryonal rhabdomyosarcoma is diagnosed mainly based on the histological examination.

5. Harner Rochester & Reese (1984)	131 pts	All pt had CT, on 82% pts petrous apex tomography, 18% angiography, 18% positive contrast rhoabe-ncephalography	CT scan results reveal the indentification and size of the tuaors in all patients. CT scan was able to detect tuaor in the internal auditory canal.	CT scan is the most Important test in diagnosing acoustic neurinoaa. Petrous toaograas useful in surgical planning. Angiogr&phy and rhoabecephalography as per results is not necessary for diagnosis of CFA Bass. '
6. John and Robert (1986)	44 patients with sus-pected retrocochlear pathology (RCP)	Magnetic resonance Imaging CT scan	Lesions were Identified successfully with MRI and CT in 21 pts.Size of tumor ranged from 4-5 ma. In 23 non tumor patients the normal audio-vestibular nerve bundles were visible. Air contrast CT was palse positive in 2 cases.	NRI suitable for primary anatomic investigation in patients having RCP., NRI is effective in viewing the IAC, cerebral cortex, structures of brain stea. The results suggest MRI is efficient than CT-scan in diagnosing tuaors.
7. Millen, Daniels & Meyer (1989)	4 pts with hearing loss	Gadolinium enchanced MRI	Results reveal tumor isotense to the adjacent brain, tumors extending into temporal bone, tumors adjacent to geniculate ganglion and also facial nereve enhancement in case of Bell's palsy.	Gadolinium enchanced NRI is important in defining small temporal bone lesions and neuromas.
8. MasIan, Latack & Kemink (1986)	7pts (3F, 4M) age range - 7yrs to 70yrs	Nuclear magnetic resonance (NMR)	Detected enlargement of neurovascular bundle. Revealed the actual size of the cerebellopontine angle lesions, demonstrated acoustic neuroma in relationship with surrounding structures.	MMR is sensitive in detection of intra cranial lesions. Tissue contrast allows NMR to depict intracranial anatomy so displacement or distortions of the normal anatomy are easily recognized.

9. Parnes, Lee and Peerless (1991)	3 pts (F) with progressive SN hearing loss	Gadolinium enchanced Magnetic Resonance imaging.	In one subject tumor extended into the CPA, middle cranial fossa and middle ear. In another subject tumour filled the IAC and extended to CPA to brain stem, and the third case had numerous intra cranial tumor.	Gadolinium enchanced HRI provides the most useful information in the preoperative assessment of this disorder. This helps to find the 2 extent, possible tuaor type and most important to *Assess* tumor's relationship with the surrounding structures.
10. Shane, Noyek and Chapnik (1986)	56 yrs old, F, with Acoustic schwannoma.	Computerized Tomography and histopathological tests.	CT result interpretation showed lesion is intrinsic to sternomastoid muscle. It was hypodense compared to surrounding tissues. Histopathological examination showed it to be a schwannoma.	Neurogenic tumors of cervical portion of cranial nerves are rare and often misdiagnosed CT scan gives idea of size, shape and anatomic relation to adjacent tissue and along with histopathologic results helps in diagnosis and better management.
11. Thomsen and Reiter (1981)	115 with normal inner ear function. 48 pts who were suspected of having acoustic neuromas.	Computerized Tomography.	In normals the size of the vertical diameter of the meatus on two sides measured by tomography only differed by lmm. In suspected cases, also showed a difference of more than lmm indicating pathological process in internal acoustic meatus. Therefore a normal meatus do not exclude presence of tumor.	Tomography of the temporal bone, demonstrate the condition of internal acoustic meatus. It should be performed as a routine examination in diagnosis of acoustic neuroma.
12. Tali, Dolan and Safadi (1994)	40 yr, F, with tinnitus in Rt ear	HRI	Results showed a mass in the right cerebellopontine angle and internal auditory canal. A enchancement of vestibular aqueduct contents and endolymphatic sac.	HRI helpful in the diagnosis of CPA tumors.

13. Tees, Lofchy and Rutka (1992)	29 yrs, F, with neurofibroaatosis type 2 (NT 2).	Contrast comput-erimed tomography and MRI with gadolinium enchancement.	Both CT and HRI revealed the presence of multiple intracranial intraparenchy-mal and extra-axial tuaors. But on MRI a tuaor mass was identified in Rt IAC extending to the cere bello-pontine angle compatible with a small acoustic neuroma. On the Lt side gadolinium enchancement suggested the presence of small intracanalicular acoustic trauma. MRI also revealed a calcified Mass arising from petrous apex invading ME presumably representing meningioma.	HRI with gadolinuim enchancement has a important role for the diagnosis of NF2 when compared to CT scan.
14. Thomsen and Glynsted (1977)	53 pts suspected of cerebellopontine angle pathology.	Computerized Tomography	17 CT scans revealed tuaor. One of which result false-positive. 36 revealed no tumors, aaong which 2 revealed false-negative.	The results reveal that CT is able to detect cerebellopontine angle pathologies. The smallest tumor demonstrated by CT extended 7mn into the angle.
15. Vlahos, Papalliou & Alhanaso-poulon (1993)	43 yrs, F, with nausea, pain on Lt side of neck.	MRI. angiograa	MRI showed large mass at region of jugular bulb which extended upwards towards lower part of CPA and downward as far as 2nd cervical vertebra. Anglograa demonstrated highly vascular lesion at the region of jugular bulb.	Angiogram and MRI helps in diagnosing malignant glomus jugular tuaor but MRI alone is efficient to diagnos as HRI with gadolinium enhancement can demonstrate tumors of few millimeters in size.

16. Wayman, Dutcher & Nelson (1989)	6 pts (3 males, 2F) with assymetrical SN hgloss suspected of having CPA Tumors.	Gadolinium DTPA enchanced magnetic Resonance scanning	2pts had unequivocal tumors 2pts showed large CPA tumor extending to IAC. In 2pts MRI was interpreted as negative.	Gadolinium DTPA-enhanced MRI by confirming tumors or added useful information DTPA enchnaced HR scans are sensitive In detecting small CPA tuaors, and -ve results rules out CPA tumor. No adverse side effects were seen when used on patients.

COMMENTS

Magnetic resonance imaging was done in 5 studies. Among the 5 studies, in 3 studies, gadolinium enhanced MRI was used. Maslon and Latack (1986) reported that MRI detects intracranial lesions and thus is helpful in diagnosing cerebellopontine angle tumors. Gadolinium enhanced MRI not only detects tumors but also reveals the extent of tumor, tumor type, and assess tumor's relationship with surrounding structures. It has greater accuracy in defining small temporal bone lesions and neuromas (Millen et al., 1989).

Computerised tomography was used in studies carried out by Thomsen and Reiter, 1981; Harner et al., 1984. The results of these investigations showed that C.T. scan helps in the visualization of the internal acoustic meatus and thus helps in the detection of tumors present there. CT scan was efficient in diagnosis of cerebellopontine angle tumors, where as petrous tomograms was useful in surgical planning.

Bech, (1978) observed that in patients with Acoustic neuroma, CSF protein level is higher than the normal value. He concluded that CSF protein test also helped in the diagnosis of large acoustic neuromas. Studies have also compared the efficacy of MRI and CT scan to detect acoustic neuromas. It was found that MRI was more effective and valuable test in diagnosing acoustic tumors than CT scan (Ferguson, 1996; David et al., 1992; Martin, 1994).

Vlahos, (1993) used MRI and angiogram to diagnose malignant glomus jugular tumor. It was found that MRI alone was efficient to diagnose glomus jugular tumor and gadolinium enhanced MRI can demonstrate tumors of even few millimeters size. Angiogram along with MRI helped in increasing the accuracy of diagnosing glomus jugular tumor.

Thus it can be concluded from the above studies that gadolinuim enhanced MRI is the most effective non audiological test which helps in the diagnosis of cerebellopontine angle tumors when compared to CT scan, CSF protein test, which are unable to detect very small tumors.

SYNDROMES:

Syndrome is a disorder consisting of specific characteristic features. Syndromes have a combination of abnormalities which include deformities of the ear. These deformities may result in hearing loss of various degree and type depending on the structure involved. Non-audiological tests are used to identify the structures which are abnormal.

In this review syndromes were studied in terms of their diagnosis by various non-audiological tests. The various syndromes discussed are

- Goldenhar's syndrome
- Mondini's dysplasia
- Treacher Collin's syndrome
- Rubella syndrome
- Fanconi's anemic syndrome
- Ramsay hunt syndrome
- Alagille's syndrome
- Cogan's syndrome
- Usher syndrome

TABLE (9) NON AUDIOLOGICAL TESTS USED TO DETECT SYNDROMES

Author	Subjects	Test used	Results	Discussion
1. Aaarem and Creeaers (1995)	Bilateral temporal bones of 84 years M with bilateral severe hg loss.	Histopathological test.	Results reveal degeneration of the organ of corti most profound in basal region also degenaration of cochlear neurons in all the turns of cochlea. Severe loss of the spiral gangrion present in both the cochleas. Malformation in the macular, utricle observed in RT cochlea. Atrophy of stria vascularies also observed.	The histopathologic abnormalities in this patient corresponded with severity of hg loss characteristic of usher syndrome and thus histopathologic test helps in diagnosis of usher's syndrome.
2. Chan, and Furman (1991)	Family of 8 members with mother, the youngest female sibling, and youngest male sibling having sensori neural hearing less	High resolution CT Scan and vestibular testing (caloric test, postugrography)	CT reveals various degrees of bilateral congenital inner ear anomalies like small horizontal semi-circular canal. hypoplastic upper turn of cochlea in all the subjects. The vestibular testings revealed non-specific abnormalities.	Monini dysplasia represents a spectrum of osseous and membranous dysplastic changes with in the temporal bone. This study tells a multidisciplinary clinical approach to study of genetic and congenital deafness and management of it. Based on all the tests the diagnosis of Mondini's dysplasia was done.
3. Haroda, Sando and stool (1980)	7yr, F, with Fanconi's anemia syndrome	Histopathologic test	1) Haemorhage in cavity of ME, mastold in Rt ear. 2) Hypo cellularity of bone narrow 3) Minor but multiple anomalies of ME 4) Hypodevelopment of hook of cochlea and	Results show that congenital anonmalies external, middle inner ear may be causes of Fanconi's anemic syndrome and the anomalies can be detected by histopathological tests.

			reduced overall length of cochlear duct.	
4. Kuo, Drago and Proops	47 yr, F, with left otalgia, rotatory vertigo, SN hearing loss and acute facial nerve palsy.	Magnetic Resonance imaging	HRI Scan showed discrete enhancement of the facial and vestibulocochlear nerves in left internal auditory canal as well as of the labyrinth.	The results was compatible with that in Ramsay Hunt syndrome MRI is important tool for intra and extra crenial examination as in diagnosis of Ramsay Hunt syndrome.
5. Okuno et. al., (1990)	6 temporal bones from 4 individuals aged 4 months, 3yrs, 6yrs 7 yrs, with Alagille's syndrome.	Histopathological test	The results showed, in the HE, anomalies include bulky stapes in 4 ears. The incudo maleal and incudo-stapedial joints were under-developed. Various forms of inflammatory reaction seen in 5 of the ME. Among inner ear anomaliess, bony and membranous structures of post semicircular canal (SCO was partially/totally absent in all cases. Cochlea was shortened in one case.	Histopathologic studies helps in detecting the anomalies of the ear resulting in hearing loss in Alagille's syndrome
6. Olson, Dorwart and Frant (1982)	17 patients with in 3-6 years with cngenital hearing loss C(3 pts) had unknown cause, lpt congenital Rubella, 2pts with Ext ear canal. atresla, 3pts with Hemifacial atrophy, epts with Treacher collin's syndrome, Mondlnl's malformation in 4pts, Goldenhar's	CT scanning of petrous bone.	Inner ear abnormalities, large vestibule, large fenestra Into the IAC, poor cochlear formation. ME and external ear deformities were also encountered. Demonstrated ossicular deformities, nature of canalatresias.	Thin section CT compares favourably with polytomography in temporal bone anomalies. Small inner ear structures, size and shape of ME cavity, mastoid, information of ossicles can be got. CT is highly useful in evaluation of congenital ear abnormalities.

		syndrome lpt, Nager's aerofacial dystosis in lpt.)			
7.	Schuknecht, and Nadol (1994)	31yrs, F, with progressive hearing loss,vertigo, tinnitus, nausea.	Histopathological Test.	Results reveal that the new bone filled the scala tympani of both the cochlea. (IE) shows severe hydrops of cochlear ducts and the vestibular labyrinths. Walls of anpullae and utricle distended and show numerous ruptures. Spiral ligaments are atrophied.	Cogan's syndrome is not mistaken due to its unique temporal bone pathologies and is efficiently detected by the histopathological tests.
8.	Yanagihara (1979)	15yr, Female, with severe SN hearing impairment in Rt ear and normal hearing in left ear.	Computerized Tomography.	Tomographic results revealed that the right internal auditory meatus was very narrow. No abnormalities were observed in the cochlea or the semicircular canals. No abnormalities of the external auditory-canal and middle ear were shown in these films.	Tornographic examination of the temporal bones showed evidence of an abnormal internal auditory meatus a characteristics of Goldenhar's syndrome.

COMMENTS

The above studies show the importance of CT scan in detecting abnormalities and thus diagnosing Mondini's dysplasia, Goldenhar's syndrome, Treacher collin's syndrome. CT-scan mainly detects bony changes of the middle ear, inner ear and also mastoid region which may be the characteristic feature of a particular syndrome (Chan, 1981; Olson et al., 1982).

Histopathological test was found efficient in detecting anomalies of ear in Fanconi's anemic syndrome, Alagilli's syndrome, Ramsay Hunt syndrome and also revealing unique temporal bone pathatogies in Cogan's syndrome (Haroda, 1980; Kuo et al., 1995; Nadol, 1994). Histopathological test is also capable of detecting abnormalities in the ear which corresponded to the severity of hearing loss a, characteristic of Usher syndrome and thus helps in the diagnosis of usher syndrome (Annelies, 1995).

TRAUMA:

Various degree of damage to the hearing mechanism results from mechanical trauma, which results in a damage to the tympanic membrane, middle ear, ossicular chain. Severe head trauma may cause damage to the cochlea causing a irreversible hearing loss.

The site and the extent of lesion caused due to the trauma can be detected by non-audiological test. Non audiological test indicate the site of lesion and also the relationship of the damaged region with other structues.

In this review 4 studies have been dicussed which ahve used nonaudiological tests to detect traumatic hearing loss.

TABLE (10) NON AUDIOLOGICAL TESTS USED TO DETECT TRAUMA.

Author	Subject	lest used	Results	Discussion
1. Dubey, Mehra and Mann (1987)	19 pts with Tempera1 bone trauma exhibiting hearing loss and facial nerve palsy	CT -Scan	10 cases showed hazines of the mastoid air cell system, 8 cases showed longitudinal fractures, 1 case showed cerebral aerocele	CT Scan is important in diagnosing temporal bone trauma and in indicating the type of temporal bone pathology.
2. Laucks et. all. (1986)	6 cases of acquired incus dislocation, 6 cases of surgical incus interposition of. the acquired dislocation 3 were traumatic, 1 post inflammatory, 2pts underwent prosthetic stapedectomy.	Computed tomography	In all cases except one the relationship of dislocated incus to other ossicles was clearly discerned. In one of the cases incus was catapulted in EAC and in other case incus had disintegrated.	CT is a valuable tool in diagnosing preoperative location of the incus and determination of the status of ossiculoplasty.
3. Swartz and Hampel (1985)	10 pts with post traumatic hearing less	CT Scan	Incus dislocation at the incudo stapedial joint or in malleo-incudal articulation showing a conductive hearing loss. Those wtih SN hearing loss revealed a broken seal of the oval window. Reveals malleus fracture associated with other ossicular derrangements.	CT scan valuable in detecting the effects of trauma for evaluation of temporal bone and HE.
4. Zalzal, Shott, and Towbin. (1986)	124 children who were divided into six categories a) Trauma b) Congenital aural atresia c) Dizziness	CT Scan	8 pts evaluated for either acute trauma, or history of trauma to temporal bone. Fracture lines seen in acute cases. 13 pts evaluated to have congenital aural atresia, 9 pts with dizziness for tumors,	CT helps to examine temporal bone in children due to its superiority in detection of soft tissue masses which makes it impor--tant for evaluation of ME disease. CT gave informa-

d) Facial nerve abnormality
e) Hiddle ear disease
f) SN hearing less.

perilymph fistula's, meniere's disease, llpts were evaluated for facial nerve abnormality. 28 pts with middle ear disease because of CSOM, ME mass, cholesteatoma, 54 evaluated to have SN hearing loss either idiopathic or hereditary.

tion about tumors and other etiologies of hearing loss. CT can evalulate facial nerve palsies. Drawback of CT in children is that oval and round window are poorly visualized.

COMMENTS

All the studies have used computerized Tomography as the diagnostic tool. It is able to detect dislocations of the ossicular chain and temporal bone lesions (Swartz, 1985) Shott et all. (1986) reported that CT was effective in detecting temporal bone defects in children.

So it can be concluded that computerized Tomography is a valuable and important tool in detecting the effects of trauma in temporal bone and middle ear, but a drawback is that, CT is unable to visualize oval and round window in children.

SUMMARY AND CONCLUSION:

Nonaudiological tests helps in the detection of site and extent of lesion and type of pathology. In this review various non-audiological tests have been used for diagnosis of auditory disorders. The conclusion has been done based on the importance and efficacy of each test in diagnosing disorders of external, middle, inner ear.

I. Table (11) lists the the frequency of usage of non-audiological tests to diagnose external ear disorders.

TABLE 11: THE FREQUENCY OF USAGE OF NON-AUDIOLOGICAL TESTS TO DIAGNOSE EXTERNAL EAR DISORDERS:

	CT-SCAN	MRI	HISTOPATHOLOGICAL TEST	X-RAY
N=9	45%	11%	22%	11%

SCINTIGRAPHY	BONE SCAN	SPECT
11%	11%	11%

N-indicates the number of studies reviewed.

Investigators have used computerized Tomography most frequently for the diagnosis of External ear disorder followed by other non audiological tests such as MRI, Histopathological test; x-ray, SPECT, Bone scan, scintigraphy.

II. Table (12) lists the frequency of usage of non-audiological tests to diagnose middle ear disorders.

TABLE 12:: THE FREQUENCY OF USAGE OF NON-AUDIOLOGICAL TESTS TO DIAGNOSE MIDDLE EAR DISORDERS:

	CT-SCAN	MRI	HISTOPATHOLOGICAL TEST	SCINTIGRAPHY	BONE SCAN
N= 25	58%	8%	36%	8%	4%

MRI	SONOTUBOMETRY	CULTURIING	SPECT	SCANNING ELECTRON MICROSCOPE
8%	4%	4%	4%	4%

N-indicates the no. of studies reviewed.

CT-scan was the most frequently administered non-audiological test for the diagnosis of middle ear disorders. Investigators have also used histopathological test for the diagnosis of middle ear pathology followed by MRI, X-ray, scintigraphy, Bonescan, sonotubometry, culturing, SPECT, scanning electron microscope.

III. Table (13) lists the frequency of usage of non-audiological tests to diagnose inner ear disorders.

TABLE 13: THE FREQUENCY OF USAGE OF NON-AUDIOLOGICAL TESTSTO DIAGNOSE INNER EAR DISORDERS:

	CT-SCAN	MRI	ENG	HISTOPATHOLOGICAL TEST
N= 23	22%	25.5%	44%	4%

*N = Indicates the number of studies reviewed.

CT-scan and MRI are equally used tests, used by investigators for the diagnosis of Inner ear disorders followed by histopathological test. ENG is commonly done in detection of Meniere's disease and vestibular disorders. CCPA a non-invasive technique is also used by investigators for the detection of Meniere's disease.

IV. Table (14) lists the frequency of usage of non-audiological tests to diagnose retrocochlear pathology.

TABLE 14: THE FREQUENCY OF USAGE OF NON-AUDIOLOGICAL TESTS TO DIAGNOSE RETROCOCHLEAR PATHOLOGY.

	CT-SCAN	MRI	NMR	CSF - TEST
N=16	25%	56%	.6.2%	6.2% .
	Histopathological test			Angiography
	12%			12%

* N = Indicates the number of studies reviewed.

MRI especially gadolinium enhanced MRI, was more commonly used test by investigators followed by CT-scan. A few investigators have used, Histopathological test, Angiography, NMR, CSF test, to confirm a retrocochlear lesion.

V. Table (15) lists the frequency of usage of non-audiological tests to diagnose syndrome

TABLE 15: THE FREQUENCY OF USAGE OF NON-AUDIOLOGICAL TESTS TO DIAGNOSE SYNDROME.

	CT-SCAN	MRI	HISTOPATHOLOGICAL TEST
N=8	37.5%	12.5%	50%

* N = Indicates the number of studies reviewed.

Histopathological test was the most frequently administered test used for the diagnosis of various syndromes followed by CT-scan and MRI.

VI. Table (16) lists the frequency of usage of non-audiological tests to diagnose trauma.

TABLE 16: THE FREQUENCY OF USAGE OF NON-AUDIOLOGICAL TESTS TO DIAGNOSE TRAUMA.

	CT-SCAN
N=4	100%

* N = Indicates the number of studies reviewed.

Researchers have generally used CT-scan for the diagnosis of auditory disorders due to trauma.

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APPENDIX - 1

ANGIOGRAPHY:

The x-ray using a dye is injected in the vertebral or carotidartery in diagnosing vascular abnormalities and tumors in angiography. The practical application of digital subtraction in angiography requires a more rapid rate of imaging than is possible using the scanned projection technique. This is done by digitising the images from a high quality television camera used in recording the output of an image intensifier. Any differences in density between the digitized images of the organ taken in exactly the same projection can be augmented electronically. Hence lesser concentrations of iodine can be used and diagnostic quality arteriograms can be achieved with intravenous injection of contrast medium. In any temporal subtraction technique patient movement can produce significant artifact. Because of time delay the problem is much greater with intravenous than intra-arterial infections. This can be overcome by comparison of multiple images. Intraveinous angiography avoids the hazards of arterial catheterization.

BONE SCANNING:

Bone Scanning demonstrates hyperactivity of bone secondary to any insult even when margined type mineralization is low.

Technetium 99 methylene diphosphate (Tc - 99 MDP) bone imaging is able to detect bone injection far earlier better than is possible with radiography. This method is safe and highly sensitive TC-99 MDP is the most commonly used isotope in bone imaging.

It concentrates in the area of ostiogenesis, hence it depicts the osteoblastic actively secondary to osteits, osteomyelitis, fracture, primary bone tumor, bone metabolism etc. When the nature of is not obvious, the sequential use of bone-scanning with gallium scan is useful for diagnosis of active bone infection. Hence they play an important role in indicating the appropriate treatment and timely surgery that can prevent further development of serious complications.

COMPUTERIZED TOMOGRAPHY:

CT scan provides a three dimensional representation of the brain. CT scan works on the principle that a three dimensional object can be reconstructed from the infinite set of all its projections. A narrow beam of x-ray is passed through the brain from one side of the head and the amount of radiation is not . absorbed by the interveneing tissue, is absorbed by radiation detectors. The x-ray tube is moved laterally across the patient's head and the amount of radiation detected is recorded at 160° equally spaced positions. These data is stored in a computer. The x-ray beam is then rotated 1° and the procedure is repeated. In

all, the beam is rotated through 180°. When all the projections are completed, the resulting x-ray sums (160 x 180) are processed by the computer. CT scan allows a simple non-invasive examination of the patients brain in about 25 min. Its greatest potential lies in locating tumors, assessing vascular accidents, head injuries and in locating a variety of intracranial lesions and brain atrophy.

A CT scan may reveal an abnormality in two ways:

- By identifying densities beyond the limits of the normal range in a particular region.
- By displacement or deformity of intra cranial structures and/or enlargement or decreases in size of CSF spaces.

Tomography show structures and eliminate interference of surrounding tissue. It helps in the visualization of ossicles and also identification of VIII nerve. For the study of a particular area in the ear, contrast material can be used to enhance the images and so abnormal tissue is easily recongized. The use of contrast in the CT has developed, and is called as contrast Tomography. Nowadays high resolution CT scan (HR-CT) is used more popularly which gives a better resolution than the regular tomography.

SPECT:

Single photon emission computed tomography is a scanning technique that uses the technology and principle of CT scan

reconstruction, but instead of detecting x-rays it detects single photon that are emitted from some externally administered tracer.

SPECT can make use of commercially available tracers so are less expensive and easily available.

CEREBROSPINAL FLUID ANALYSER

Analysis of cerebrospinal fluid (CSF) provides only method of looking at the subarachnoid space with out opening the skull. CSF is most easily obtained through a puncture made in the lumbar, or lower portion of the spinal column. It is removed for a variety of purposes.

1) To relieve intracranial pressure and to remove toxic, inflammatory, or other substances in the fluid, as would be found in disorders such as encephalitis or meningitis.

2) To allow an analysis of the CSF for the presence of blood (indicating *a* vascular accident), or a variety of other substances (such as glucose, white blood cells, or various proteins) that might indicate a variety of central system dysfunctions.

3) To introduce therapeutic substances into the subarachnoid space.

4) To introduce air or opaque media for radiographic studies.

CEREBRAL AND COCHLEAR PRESSURE ANALYZER

It has been proved that motion of the tympanic membrane changes with changes in cochlear pressure. CCPA is a non-invasive measurement of the cerebral and cochlear fluid pressure.

A number of sources of low frequency activity exists with in the ear. The tympanic membrane displacement analyser (TMD) listens to this activity using a patented transducer which can measure tympanic displacements smaller than a nanolitre. This allows to study the ear and deep into the subarachnoid space in a manner not possible with conventional clinical apparatus. TMD analyser provides a indirect method of measuring the cochlear fluid pressure by analyzing changes in the resting position of the inner most ossicle of the middle ear. This resting position with change will cochlear fluid pressure and intracranial pressure since a connecting pathway normally exists.

Cardiovascular pulse synchronous activity from the middle ear or possibly from the intracranial fluid via the cochlear aqueduct, stapedius and tensor tympani muscle contractions, and ET ventilation of the ME may all be investigated (Samuel et al., 1997).

CCPA allows clinician to diagnose and treat raised cerebral pressure as the underlying cause of certain combinations of dizziness, tinnitus and hearing loss. These

patients are either wrongly diagnosed as having Meniere's disease or some non-specific disorder. CCPA helps in assessment of intracranial pressure in such disorders (Densert et al., 1997; Rosingh, 1997).

It is reassuring for the clinician to have a quick and reliable method of assessing intracranial pressure so as to confirm the diagnosis of normal intracranial pressure.

ELECTRONYSTAGMOGRAPHY: (ENG)

ENG is a clinical tool which involves the acquisition of a permanent quantifiable record of eye motion. The assessment of ENG recordings has become an important element in the complete neuro-oto-audiologic diagnostic procedure specially for those with unilateral hearing loss, tinnitus, vertigo. It is a process that provides a means of tracking eye movements behind closed lids or in darkened environment.

Du-Bois Reymond (1849), discovered that a potential difference exists between the cornea and retina in man (corneoretinal potential). The cornea is positively charged and the retina was found to be negatively charged. The eye therefore functions as a rotating dipole and this characteristics is used in skin electrode technique known as electronystagmography. ENG helps in deceiding:

- Normal vestibular mechanism
- Disease of one or other labyrinthine end organs
- Retro labyrinthine or central nervous system disease.

Nystagmus is an involuntary rhythmic movement of the eyes. Two successive movements occur at regular intervals. If the movements are equal nystagmus is oscillating or it is undulating. If unequal, there is jerky diphasic or directed nystagmus. Nystagmus of the unequal type is a non voluntary movement. The technique of recording nystagmus is called as nystagmography.

EN6 test battery consists of varies test such as

1) Sinusoidal harmonic acceleration tests
2) Positional test
3) Rotation test
4) Caloric test
5) Neck torsion test
6) Gaze nystagmus test
7) Optokinetic test
8) Eyetracking test
9) Torsion swing test
10) Parallel swing test
11) Sono-ocular test

SHA: (Sinusoidal Harmonic Acceleration Test):

It is the sinusoidal harmonic acceleration test. Vestibular functions, like the auditory system has frequency specific characteristics over which it functions. The use of SHA testing has been developed as a means for stimulating the horizontal semicircular canal over a broad range of

frequencies and acceleration. Also known as the rotational chair SHA. SHA is a physiological rather than functional evaluation. It provides information about the vestibulo-ocular system that is not obtained from ENG. It is useful in patients with chronic balance disorders. This evaluation is critical in individuals whose calorics are either significantly reduced, absent or ambiguous due to asymmetrical anatomy. This can be useful in paediatric patients and others with mental age under 10 and in patients requiring pre and post treatment evaluation. The commercially available devices provide for computer controlled movement, recording of eye activity, and analysis of eye movements relative to chair (head) movement. The typical mode of chair movement is sinusoidal, hence the name sinusoidal harmonic acceleration.

HISTOPATHOLOGICAL TEST:

The specimens collected from the tissues or organs are processed by conventional techniques and then studied with the light microscope. With the set of known histological pattern and attention to the recognized characteristics of swelling, nuclear changes etc, the histopathological alterations of disease or the experimentally created lesions can be ascertained.

MAGNETIC RESONANCE IMAGING:

It provides high resolution anatomical imaging. This has a magnetic source. The image is generated by varying the magnetic field surrounding of an object. The magnetic pulse of a certain frequency will excite only one cross-sectional plane through the body. The thickness of this cross sectional plane is related to the frequency of the magnetic pulse. A radio-frequency magnetic pulse is used to excite the nuclei in the subject, and a radio frequency receiver coil picks up the signal emitted by the nuclei. This signal is then amplified and mixed with a frequency synthesizer output to produce an audio frequency signal containing the same information as the original sound received by the radio-frequency coil. This information is then digitized and stored in a computer for retrieval and image production. MRI computer image displays, can utilize color to show minute differences in signal intensity and thus depict small changes more efficiently.

MRI can detect bone-marrow, while disregarding the bone structure, determine chemical changes associated with neoplasms identify, and trace blood flow.

Gadolinium DTPA enhanced magnetic resonance imaging was introduced since 1980's. Gadolinium DTPA is a paramagnetic imaging agent intended for intravenous use in MRI. This paramagnetic material decreases the spin-lattice relaxation

time of nuclei in 'tissues where it accumulates. This accumulation results in improved contrast enhancement.

Nuclear magnetic Resonance Imaging (NMR) employs radio frequency radiation in providing a cross-sectional display of body anatomy with excellent resolution of soft tissue detail. The images are essentially a map of the distribution density of protons and parameters relating to their motion in the water and lipids of the body tissue.

RADIONUCLEIDE SCANNING:

In radionucleide scan an intravenous injection of a radio-isotope is given and the cranial surface is then scanned. Any alteration in blood supply can be detected, including the alterations associated with the growth of the tumor.

ROENTGENOGRAPHY (X-rays):

X-ray are a form of electro magnetic radiation similiar to visible light but with much shorter wave lengths and higher energies (visible light, 400-700 nm x-rays 0.5-5 nm). These wave lengths and energy characteristic allow x-rays to penetrate substances they encounter (extent depending on the density and atomic number of material). A photosensitized film place in the parts of the radiation after it has passed through an object is differentially exposed to the degree that x-rays have been unimpeded in the travel1.

Standard radiographs are obtained when x-rays are generated in the roentgen ray tube and focused on a photographic film, with the patient positions between the two.

Roentgenography has been modified in a number of ways to serve in nervous system diagnosis. Routine x-rays are used to scrutinize the skull for evidence of fractures, erosion of bone or calcification. Contrast x-rays can be obtained after a special radio-opaque dye or air is injected into the ventricles or dye is injected into the arteries. Having a different density from surrounding areas these substances can be visualized, along with the outline of the arteries or ventricles (indicative of presence of tumor), and sometimes it is actually possible to visualize a tumor.

SONOTUBOMETRY:

Introduced by Politzer in 1869. The principle of sonotubometry is to record changes of sound intensities ir. the external ear canal when a constant sound source is applied to the nostril. The hypothesis is that eustachian tube opening will increase the sound intensities in the middle ear and thus also in the ear.

In this technique higher frequencies for the sound source in the nose were used. This eliminates disturbances due to swallowing thus making interpretation easier. It is a test of eustachian tube patency under normal conditions with

air pressure equilibrium across the tympanic membrane. A positive response of this test indicates tubal patency under the normal conditions. Sonotubometry is not of frequent use in recent days.

SCANNING ELECTRON MICROSCOPY: (SEM)

In (SEM) a scanning beam, about 200 *&* in diameter, bombards the surface of the specimen, creating an emission of secondary electrons. The excited secondary electrons are then assembled by a lucite collector and electronically amplified and projected onto a cathode ray tube. The SEM is equipped with special scanning coil which regularly deflects the beam, in turn "scanning" the surface of the biological specimen.

SEM is capable of presenting a view of entire surface of specimen and thus is a useful tool in the study of inner ear. Three dimensional views obtained of the sensory-hairs, nerve endings and tunnel space. SEM does not help in studying minute changes in intracellular structures.

TYMPANO COCHLEAR SCINTIGRAPHY:

This method was developed to study the metabolic activity of the labyrinth bone.

This system consists of scintillation camera with a pinhole collimator and special montage connector for exchangeable tungsten made ear specula of different aperture

size (2.5 - 4mm). Therefore it is possible to place the aperture plans level into the external auditory meatus without overshadouring of soft tissue structure, so that the critical resolution reaches the value of the pinhole apertures diameter (2.5 - 4mm). This apparatus is connected to the evaluation system where the images of both ears to the evaluation system where the images of both ears is evaluated using the activity level of the background as reference for those of the labyrinthine capsule.