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Radiological spectrum of temporal bone, inner ear and brain parenchymal abnormalities in the preoperative cross-sectional imaging of sensorineural hearing loss in cochlear implant candidates: A prospective study

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Abstract
Cochlear implantation is a prudent method of rehabilitation in severe sensorineural hearing loss where other means like hearing aids fail. Not everybody with severe sensorineural hearing loss benefits from implantation, in fact is contraindicated in some. A thorough pre -surgical imaging evaluation of inner ear, temporal bone and cerebral parenchyma is important in decision making, more so as the implants and costs involved are quite expensive. Limited studies exist in the Indian setting. Aim was to evaluate the role of combined computed tomography (CT) and Magnetic Resonance imaging (MRI) in pre operative imaging assessment for cochlear implantation, a prospective study was concluded at the Department of Radiodiagnosis over 30 months (2017 to 2019). Patients with severe hearing loss underwent HRCT temporal bone on 128 slice MDCT and MRI with BFFE, T2/Flair etc. Sequences targeting inner ear, cochlear nerve and brain on 3 Tesla scanner. Data was entered in MS EXCEL and analyzed in SPSS software using cross tabulations or correlation coefficient to compare the two imaging modalities. Chi square and P values were obtained for the cross tabulation data of comparison of CT and MRI in assessment of inner ear structures. The study focused on cochleovestibular malformations, patency of the cochlea-vestibule, cochlear nerve status on MRI and to see if there was any correlation with the bony cochlear nerve canal diameter on CT, isolated or associated brain parenchymal abnormalities and important surgical access criteria like normal variants and altered middle ear anatomy. Abnormal imaging findings were seen in 15 of 32 patients, on the basis of which 5 were rejected for implantation; suboptimal results were predicted in 5 other abnormal cases. Side selection and predicting ease of electrode insertion could also be ascertained in unilateral pathologies. Seventeen cases had normal imaging, twelve of which were operated. Eleven of these had uneventful surgery. All three cases with abnormal imaging, taken for surgery under varied risk of suboptimal results had mild and manageable intraoperative complications. Tailored protocol of MRI with BFFE, T2/FLAIR axials and HRCT temporal bone is an indispensable tool and radiologist plays key role in candidate selection and exclusion, surgical planning and warning surgeon about potential intraoperative complications in cochlear implant surgery.

Keywords: Candidacy, computed tomography, magnetic resonance imaging, cochlear implantation, preoperative imaging

1. Introduction
The problem of hearing loss assumes significance not only from a vocational or economic but also psychological perspective [1] Advances have led to the increasing use of cochlear implantation in subjects with sensorineural hearing loss especially when conventional amplification devices fail to give any benefit [2]. Sensorineural hearing loss can result from a constellation of abnormalities that may involve the labyrinth, internal auditory canal, CPA (cerebellopontine angle), brain stem, or auditory pathways. CT and MR imaging often play a complementary role in its evaluation and postoperative assessment and in ascertaining overall prognosis [3]. Imaging has an important role in deciding candidacy for feasibility of implant, providing realistic preoperative counselling, and predicting postoperative outcomes [4]. Computed Tomography (CT) has been the predominant imaging modality for evaluation of the temporal bone and has previously been the primary modality for evaluation of cochlear implant candidates.

CT may provide additional information in patients with severe middle ear disease like chronic otitis media, otosclerosis and bony wall abnormalities. Preoperative Magnetic Resonance Imaging (MRI) can demonstrate retro cochlear pathology, cochlear nerve abnormality and enlarged vestibular aqueduct (EVA) in evaluation for cochlear implantation. MRI is also crucial for decision making in patients with sensorineural hearing loss (SNHL) after meningitis [5] and imaging especially important in children with previous meningitis as prevalence of hearing loss is higher [6]. Both CT and MRI can identify anomalies in pediatric patients [7], however in post lingually deafened adults without conductive or asymmetrical hearing loss, imaging is unlikely to affect surgical decision making. Abnormalities detected by pre-operative brain MRI scans on cochlear implant candidates are also a common finding. In children evaluated for a cochlear implant, it is important to also screen the whole brain [8].

The abnormalities detected on the whole brain images can be of wide ranging clinical significance ranging from truly incidental findings to abnormalities that are so severe that they may predict a very poor prognosis such that an implant may contribute little [9]. No consistent fixed criteria exist with regards to pre-operative CT versus MRI imaging in determining feasibility for implantation. It has not been possible to unanimously prove the superiority or drawbacks of CT over MRI or vice versa [10, 11]. While CT was found to be better at defining some abnormalities, MRI has been able to detect some other abnormalities. The modality to be used (CT or MRI or both) can vary on a case to case basis and has not been possible to set a definite standard for candidacy assessment [12]. However, a general consideration is that both CT and MRI are complementary to each other [12, 13], however many have advocated the importance of a dual modality based approach in making the preoperative evaluation of CI candidates more accurate and precise [14]. Literature and studies about information regarding cochlear implantation and its pre-operative imaging within the Indian setting are still very limited. Four in every 1000 children suffer from severe to profound hearing loss in our country [15]. An existing Indian Government funded rehabilitation programme also necessitates in its guidelines, the need for a preoperative imaging with CT and MRI in the selection of candidates for cochlear implantation [16]. With worrisome perinatal morbidity statistics, absence of an effective universal screening programme [17] for children and an estimated 2% prevalence of childhood onset deafness in India [15], research effort in this direction assumes great significance and has scope to augment decision making in already existing rehabilitative hearing programmes.

2. Materials and methods

2.1 Study design and population

A prospective observational study was done between June 2017 and June 2019. Infants, children (no specific age cut off), adolescents and young adults formed the primary core of our study. However, all candidates with severe profound sensorineural hearing loss being evaluated for feasibility of cochlear implantation were studied.

2.2 Sample size and sampling technique

Prospectively, all the patients meeting the inclusion criteria during the study period were enrolled. In accordance with time constraint, information from previous Indian studies referenced in literature review and previous records of presentation of such cases to our department, the calculated estimated prevalence of severe to profound hearing loss in children was 2% (Varshney S. Deafness in India. Indian J Otol 2016; 22:73–6) [15].

Formula for calculation of sample size in prospective observational study is Eq (1)

$$n = \frac{Z^2_{(1-\alpha)} \times P\,(1-P)}{E^2}$$

Where

n= Sample size (1)

$Z^2_{(1-\alpha)}$ = 1.96 Z is statistic for a level of confidence (95% level of confidence used; therefore, Z value is 1.96)

P =0.02; as expected prevalence in our case taken as 2%

E=0.05; Precision (margin of error taken as 5%)

Based on formula for calculation of sample size with a confidence interval of 95% and 5% margin of error in a prospective observational study, gave us an estimated sample size of 30.

2.3 Patient selection

Inclusion criteria

1. Presence of unilateral/bilateral severe to profound sensorineural hearing loss established by standard audiometric assessment tests.
2. Presence of mixed type of hearing loss with both conductive and profound to severe sensorineural component.
3. Candidates/ their legally acceptable representative who consented for imaging.

Exclusion criteria

1. Candidates presenting with complaint of deafness but established on audiometric assessment to have pure conductive component or mild to moderate sensorineural hearing loss as cause of deafness.
2. Severe systemic disease or meningitis who could not be imaged under anesthesia or operated upon.
3. Refusal to consent/rejecting participation in study

2.4 Ethics

Institutional Ethical Committee approval and Scientific Committee approval was obtained.

2.5 Imaging procedure and protocol

CT scan was done on a 128-slice scanner. CT was done using a multi-detector scanner, 0.625 mm axial scans of the temporal bone were acquired using a high-resolution bone technique. The scans were retrospectively targeted for right and left side, and subsequently reconstructed in the coronal plane, again targeting the right and left sides individually, as well as the entire skull base. MRI was performed on a 3 Tesla MR system. MRI technique was done with selected sequences. A 16-channel phased array HR Sense NV-16 coil was used.

3. Results and Discussion

Maximum patients in our study belonged to 0-10-year age group constituting 78% of the total sample and almost 88% of study population was less than 20 years of age. Amongst children (<12 years of age), the mean age was 3.4 ± 2.3 years. Overall study population constituted 56% males and

44% females. The overall inner ear abnormalities of the cochlea, vestibule and semi-circular canal individually assessed by both CT and MRI were cross tabulated. Overall abnormalities found in our study were 7/32(21.8%) of the cochlea, 7/32(21.8%) of the vestibule and 8/32(25%) of the semi-circular canals. An abnormality on any or both of the imaging modalities was taken as abnormal.

3.1 Mean IAC and BCNC diameter

The overall mean IAC diameter on right side amongst the 32 patients is 3.81 ± 0.73 mm on right side and 3.82 ± 0.77 mm on left side. The overall mean bony cochlear nerve canal diameter on right side was 2.00 ± 0.51 mm and 1.94 ± 0.61 on left side. We included 32 patients who underwent a combined Magnetic Resonance Imaging and Computed Tomography as part of assessment for establishing cochlear implantation candidacy. Our study focused on inner ear anomalies, patency of the cochlea-vestibule, cochlear nerve status and surgically important criteria like middle ear anatomy and normal anatomic variants.

3.2 Technique, Planning and Post processing

Acquisition of scans was done under sedation for infants and young children who were assessed to not be cooperative for an MRI scan, considering the longer scan time. After this scan, there was a CT scan done. Standard acquisition parameters were used. T1, T2, FLAIR axials, DWI imaging were done in addition to BFFE and DRIVE sequences for high resolution imaging of the inner ear. The BFFE and DRIVE were the main workhorse sequences specific to the inner ear and seventh and eight nerve imaging assessment. These sequences showed far superior detail of the internal acoustic canal, vestibulocochlear, facial nerves within the internal acoustic canal and also superior resolution and signal intensity detail with regards to the cochlear turns, vestibule and semi-circular canals in comparison to T1, T2 and FLAIR sequences. The 3D images viewed in the oblique sagittal plane at the mid internal acoustic canal gave good detail of the four-nerve bundle complex. However, there was a drawback that in the cases where the IAC was narrow, there was also a proportionate decrease of fluid signal from the IAC, thereby causing inadequate visualization of the four-nerve bundle complex where the nerves are otherwise normally seen as rounded hypointense structures against a background of bright CSF signal within the internal acoustic canal. One other drawback was the presence of banding artifacts which can occur on 3.0 T (Tesla) scanners. These artifacts were seen in some of the inner ears imaged and the incidence of banding artifacts is also seen to be higher on 3.0 T scanners. The use of BFFE (Philips)/ CISS (Siemens)/ FIESTA-C (GE Medical systems) in the scanning protocol helped reduce banding artifact. Lane JI *et al.* [18] also commented that CISS technique had an inherent problem of banding artifacts and this can be compensated partially by MIP processing of the two-phase cycles. They added that banding was more problematic at 3.0 T than 1.5 T because susceptibility changes linearly with field strength. Increasing the number of phase cycles from two to four doubled the scan time but at the benefit of reduced banding artifacts. The detailing of the bone anatomy on CT was particularly important from the surgical planning point of view.

The screening CT scans done after the MRI scan helped in better assessment of the bony labyrinth, otic capsule, carotid canal, jugular bulb and other bony structures including the status of pneumatization of the sinuses. Based on the 2D images of CT acquired in the axial plane, coronal and oblique sagittal reformatted images with volume rendering technique obtaining 3D view of the bony labyrinth were also helpful. The 3D VR image is directly dependent on the 2D acquisition of the image. The 3D post processed images helped the surgeon by giving a direct view of the inner ear structures.

3.3 Demographics

Most patients belonged to pediatric age group with 87% of the cases under 20 years of age. Of the children in the 0-12-year age group, the mean age was 3.46 years. The observed male to female ratio was 1.3:1 suggestive of a slight male preponderance. Males were 56% and females constituted 44% of total subjects. The male preponderance in children with SNHL (56% overall and 61.5% in children in our study) has been commented on by several authors like Huygen PLM *et al.* [19] and Bamiou *et al.* [20].

3.4 Role of combined CT and MRI in inner ear malformations

The most common cochleovestibular malformation was vestibular dysplasia in the form of a globular vestibule-semi-circular canal complex. These findings are in concurrence with Johannes P Westerhof *et al.*[21]who investigated 42 inner ears in 21 children and found fusion of the lateral or superior semi-circular canal with vestibule with 12 out of 42 ears(28%) and also Mondini, Mondini variants(28%) as the commonest cochleovestibular malformations. However, Digge P *et al.* [13] found that isolated semi-circular canal malformations were the most common cochleovestibular malformations encountered in their study. Bamiou DE *et al.* [20] conducted a retrospective study with only CT as the imaging modality without the use of MRI and they concluded that dilated vestibular aqueduct was the most common CT abnormality in their study constituting 8.6% (10 out of 116) and abnormalities of the semi-circular canal were second commonest abnormality seen in 7.75% of cases (9 out of 116). In our study we had abnormalities of the vestibular aqueduct in 2 of 32 patients. One of whom had a unilateral dilated vestibular aqueduct as part of the spectrum of Classic Mondini and other with absent vestibular aqueduct as part of the Michel's abnormality. Congenital cochlear malformations were seen in 4.8% (two patients) in the study by Harnsberger H R [22], 2.3% by study in 1994 by Kuhweide R *et al.* [23] and 57% (16/28) in the study by Mucelli RP *et al.* (2009) [24].

3.5 Detection of disturbance of labyrinthine patency

The normal membranous labyrinth is fluid filled and results in a bright signal on T2 MRI sequence. Early fibrosis due to variety of etiologic factors cause initial development of fibrosis eventually landing up in ossification. A Chaturvedi *et al.* [25] found that HRCT of temporal bone missed two cases of luminal ossification and MRI was more reliable in detecting early luminal obstruction.

In comparison to study by Digge P *et al.* [13] where 5% (4/72) patients had labyrinthitis ossificans, the finding of labyrinthitis ossificans on imaging was higher at 12.5% (4/32). MRI was superior to CT in detection of early labyrinthitis ossificans and was able to identify subtle changes in fluid signal not identifiable on CT.

3.6 Isolated or associated brain parenchymal abnormalities

Procter *et al.* [9] retrospectively reviewed MRI brain sequences of 51 patients who were evaluated for cochlear implantation. Of 51 patients, they identified brain parenchymal abnormalities in 21/51(41%) of patients. They concluded that the abnormalities detected in whole brain imaging in the cochlear implant population were heterogenous and the spectrum included findings ranging from being truly incidental ones to abnormalities that could predict poor prognosis indicating that such an implantation could contribute little.

3.7 Cochlear nerve deficiency, correlation between internal acoustic canal (IAC) and bony cochlear nerve canal diameters with cochlear nerve deficiency

In our study 21.8% (7/32) of patients had a cochlear nerve deficiency. Cochlear nerve deficiency includes both complete absence of the nerve (aplasia) and the presence of a thin cochlear nerve (hypoplasia). Of these 7, six had bilateral nerve involvement and 1 case had unilateral involvement. Considering a total of 14 inner ears in question of these 7 patients 9 had hypoplasia or thin nerves, 4 absent nerves and one normal. 3 of these 7 patients had a unilateral cochlear implantation. All the implantations were done on sides with hypoplastic nerves (lesser affected side).

3.8 Correlation of IAC and CNC diameters with nerve status on MRI

Additionally, we also tried to see if there was any significant correlation between the calculated diameters of the internal acoustic canal and cochlear nerve canal on CT with the status of the nerve on MRI. The IAC and CNC diameters on both the left and right side were divided in 3 groups i.e. the ones on MRI with a normal nerve, thin or hypoplastic nerve and an absent nerve.

We could notice a difference in the mean values (obvious decrease in mean value in those with absence of nerve) on both sides in the values of both CNC and IAC values. However, no statistical significance (p value obtained was > 0.05) was seen in the comparative parameters of the internal acoustic canal and cochlear nerve canal measurements on CT in cross-tabulation to the qualitative findings in the nerve on MRI. In our study, this presence or absence of significance could probably be alleviated with a higher sample size with a greater number of patients with absent cochlear nerve status for a statistically significant variation to be appreciated. Similar analysis was carried out by Komatsubara *et al.* [26] where they tried to study the relationship between the cochlear nerve and cochlear nerve canal dimensions. They found that the patients with cochlear nerve canal diameter on CT < 1.5mm had cochlear nerve deficiency on MRI with a sensitivity and specificity of 88.9%. Adunka OF *et al.* [27] however had a different observation that IAC caliber was an unreliable marker of cochlear nerve deficiency. They found that in many cases with cochlear nerve deficiency the IAC diameter was normal. They also found that in two ears, the morphology of the IAC was abnormal but the children had a normal nerve on MRI. They concluded that MRI was superior to CT in the imaging of the cochlear nerve and the CT dimensions of the IAC cannot act as surrogate markers. Based on our findings and the inference from other studies, we conclude that there may be a relationship between severe narrowing of the IAC and CNC with cochlear nerve abnormalities. In cases where isolated CT scans are done as part of work up, a severe narrowing of the CNC and IAC may sometimes help in predicting a nerve abnormality. However, a significant number of nerve aplasia and hypoplasia maybe missed by CT imaging alone and in the presence of equivocal values. Based on our small sample size, we were not able to clearly predict a cut off value of the cochlear nerve canal diameter that should raise concern. But a sub-millimetric value of the cochlear nerve canal on a CT should definitely alert the radiologist about an increased possibility of a nerve abnormality. Combined CT and MRI was performed for all the cases but the relative utility is mentioned as an analysis of which of the two imaging modalities was useful or would have sufficed to ascertain the information obtained from these cases.

3.9 Advantages of combined CT and MRI

The detection of abnormal cochlear and inner ear anatomy could be seen on both CT and MRI, but characterization of inner ear malformations is better seen on MRI. Patency of the cochlea, vestibule and semicircular canals can be assessed both on CT and MRI, but the subtle signal loss or decreased intensity in the fluid filled membranous labyrinth can be better picked up on MRI. White matter abnormalities of the brain, their characterization and evaluation of the degree of involvement of the brain in cases of hearing loss is best seen on MRI. Surgically important findings like disturbances of the otic capsule, aberrant course of the facial nerve, facial nerve canal dehiscence, evaluation of the bony cochlear nerve canal, dehiscence of jugular bulb, sinus pneumatization are best seen on CT scan.

3.10 Disadvantages of combined CT and MRI

MR imaging is more prone to motion artifacts. The use of sedation for prolonged time (45 mins to 1 hour), especially in infants and young children and the side effects and risk associated with anesthetic agents and drugs should be considered. The use of multi-slice 4th generation of CT scanner has significantly reduced doses of radiation exposure. But there is always inherent risk of radiation exposure with a CT study. This assumes greater significance especially when infants, children and young adults form the core group of a study. The costs and logistics involved with combined cross-sectional imaging study is higher than the use of a single imaging study.

4. Tables and Figures

Table 1: Overall inner ear status versus surgical status cross tabulation

		Surgery (Implantation)		
		Done	**Not Done**	
Inner ear (including combined brain parenchymal abnormalities)	Normal	12	9	21
		57.1%	42.9%	100.0%
	Abnormal	3	8	11
		27.3%	72.7%	100.0%
Total		15	17	32
		46.9%	53.1%	100.0%

Table 2: Distribution of abnormalities

Location of abnormal finding on combined CT and MRI imaging	Frequency	Percentage%
Normal	15	46
Normal variants	2	7
Inner ear alone	9	27
Brain parenchyma alone	4	13
Inner ear and brain parenchyma	2	7
Total	32	100

Table 3: Types of inner ear abnormalities

Type of pathology	Frequency	Percentage
Cochleovestibular malformations	5	31
Labyrinthitis ossificans	4	25
Nerve abnormalities	7	44
Total	16	100

Table 4: Labyrinthitis ossificans: Comparison of different studies

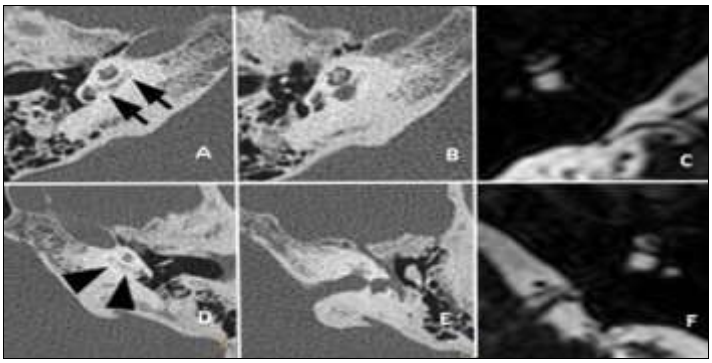
Study	Sample size	Incidence of labyrinthitis ossificans
Harnsberger [6] *et al.*(1987)	42	28%
Caye Thomasen P [7] *et al.* (2011)	34	35%
Digge P [5] *et al.* (2016)	72	5%
Our study	32	12.5%

Table 5: Cochleo-vestibular malformations: Comparison of different studies

Study	Most common abnormality	2nd most common abnormality	Incidence of inner ear malformations/Incidence of overall abnormality on imaging. (NA=data not available)
Bamiou D E *et al.* [1] (2000)	Dilated vestibular aqueduct	Mondini and Mondini variants	NA/28.4%
Johannes P Westerhof *et al.* [2] (2001)	Semicircular canal fusion with vestibule	Mondini and Mondini variants	NA/NA
Tamrazi *et al.* [3] (2011)	EVA (Enlarged Vestibular Aqueduct	Absence of cochlear apex (Mondini dysplasia)	NA/NA
Pooja VD [4] *et al.* (2015)	Common cavity deformity	Mondini and Mondini variants	50%/ 61.53%
Digge P [5] *et al.* (2016)	Isolated semicircular canal dysplasia	Mondini and Mondini variants	NA/25.6%
Our study	Semicircular canal fusion with globular vestibule	Mondini and Mondini variants	15.6%/46.8%

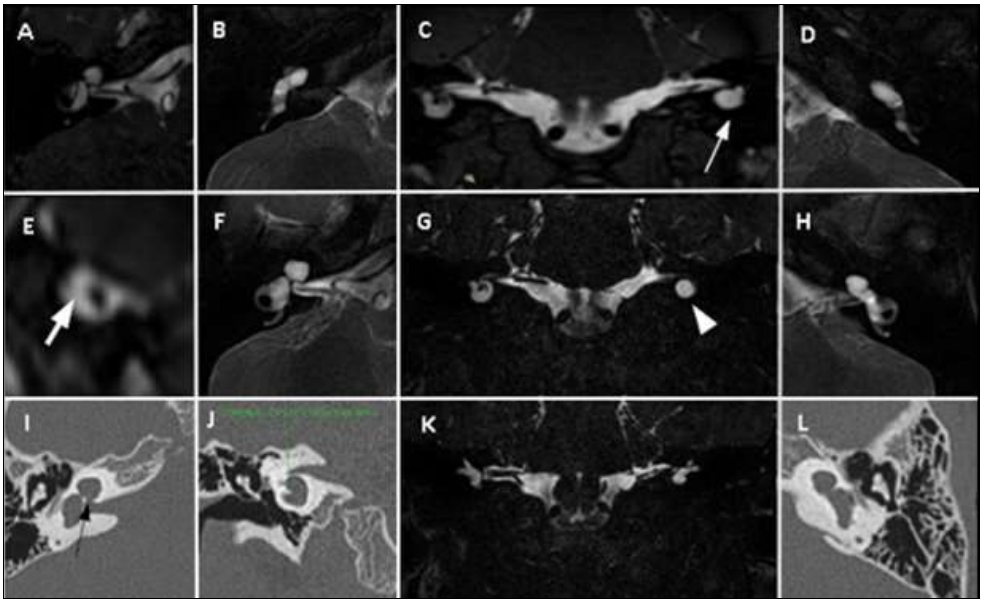
Table 6: Types of various cochleovestibular malformations and their incidence in our study

Cochlear dysplasia	2
Incomplete Partition Type I	1
Incomplete partition type II (Classic Mondini)	1
Globular vestibule- Semi-circular canal complex (Vestibular dysplasia)	3
Common cavity deformity	1
Michel's aplasia	1



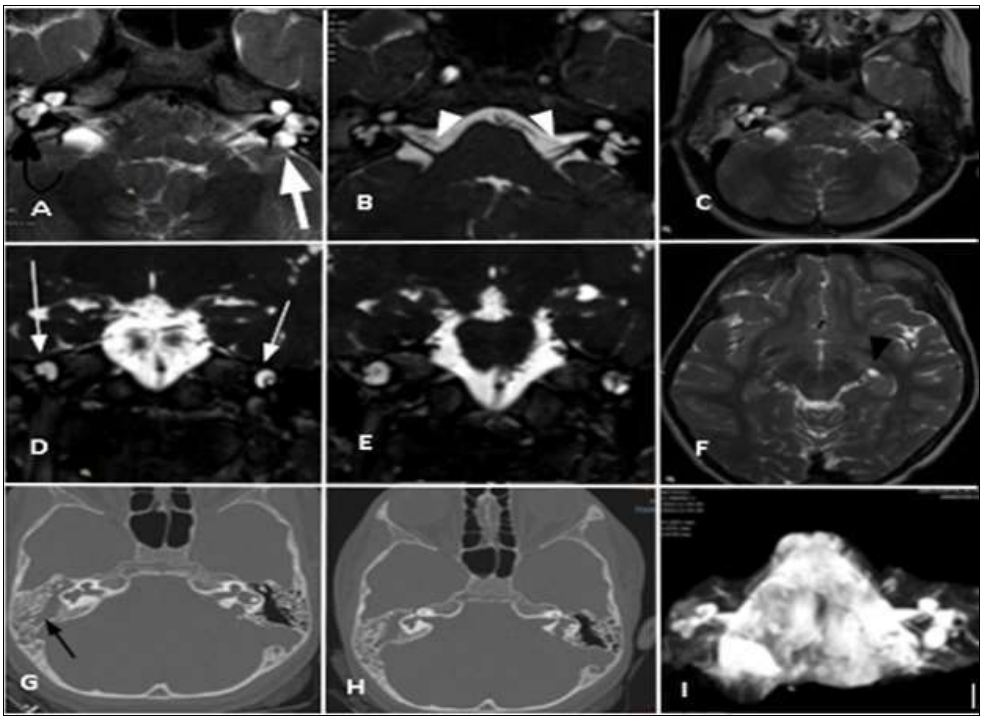
30-year-old male with bilateral profound hearing loss for 10 years and history of meningitis. Axial CT bone reformat images showing ossification in basal turn of cochlea on right side and basal and apical turns of cochlea on the left side. MRI heavily T2W image showing loss of T2 hypointense signal in the cochlea. Case of labyrinthitis ossificans (left >right). Right sided cochlear implantation was done for this patient and mild intraoperative perilymph leak was observed with partial insertion of electrodes

Fig 1: Case of cochlear labyrinthitis ossificans



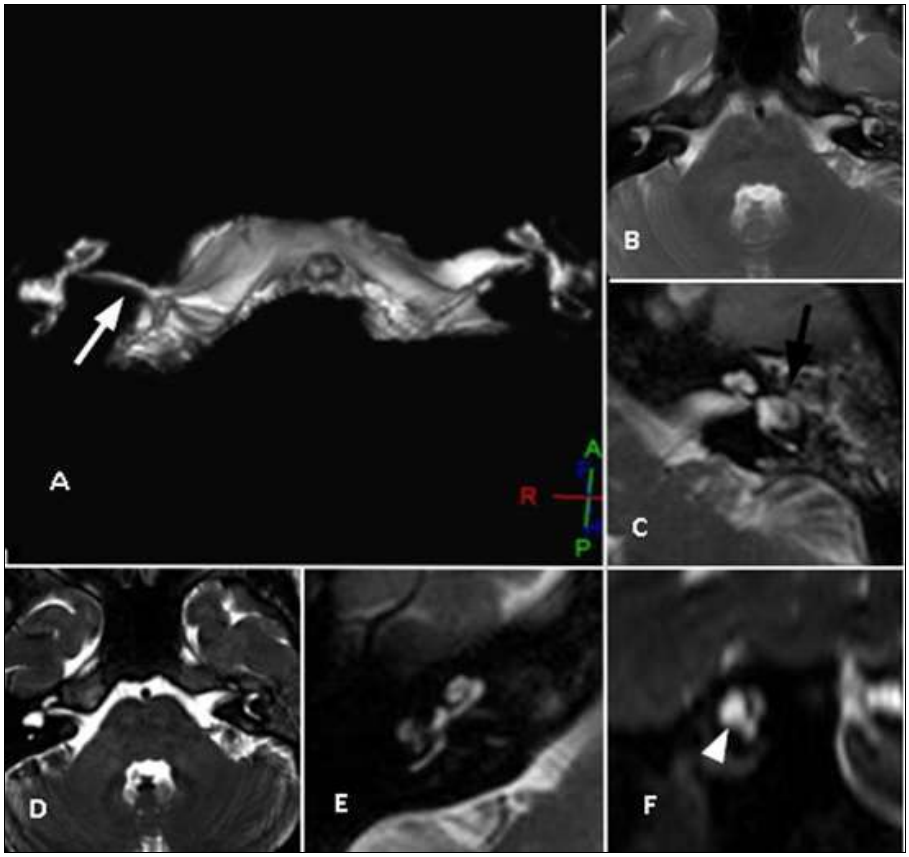
4-year-old male with bilateral profound sensorineural hearing loss since birth. MRI and CT selected sections showing bilateral cochlear dysplasia, absent modiolus on left side (A,B,C,F,H,I,J,L) with bilateral globular vestibule(D,H,K) cochlear nerve aplasia on the left side(E), hypoplastic nerve on the right(F), bilateral cystic cochlear apex(C,J),narrow cochlear nerve canal(I). This was a case of bilateral cochlear dysplasia and globular vestibule with incomplete partition type I on left side. Right sided cochlear implantation with full insertion was done for this child with a mild perilymph leak observed intraoperatively

Fig 2: Case of bilateral cochlear dysplasia with left sided incomplete partition type I



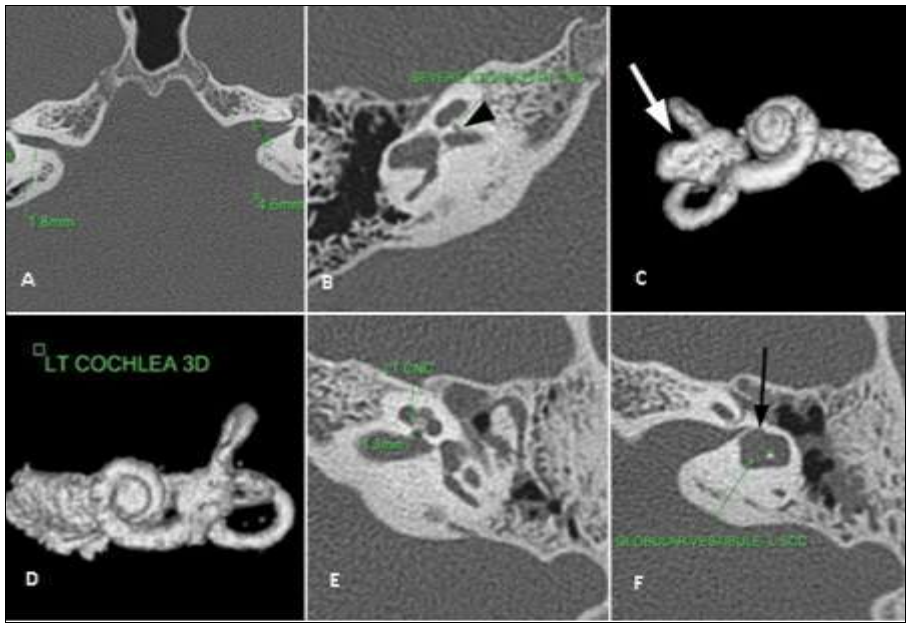
8-year-old female with severe sensorineural hearing loss. MRI and CT sections showing cochlear dysplasia with 1.5 turns on both sides(D,E), hypoplastic cochlear nerves(B), globular vestibule bilaterally(A,G,I), small hippocampal fissure cyst on left side(F), right sided mastoiditis (C,G) 3D DRIVE MIP image depicting the middle ear anatomy on both sides. Incomplete partition type 2 with enlarged vestibular aqueduct on left side – Classic Mondini deformity (IP type II)

Fig 3: Case of bilateral cochlear dysplasia and left sided Classic Mondini deformity



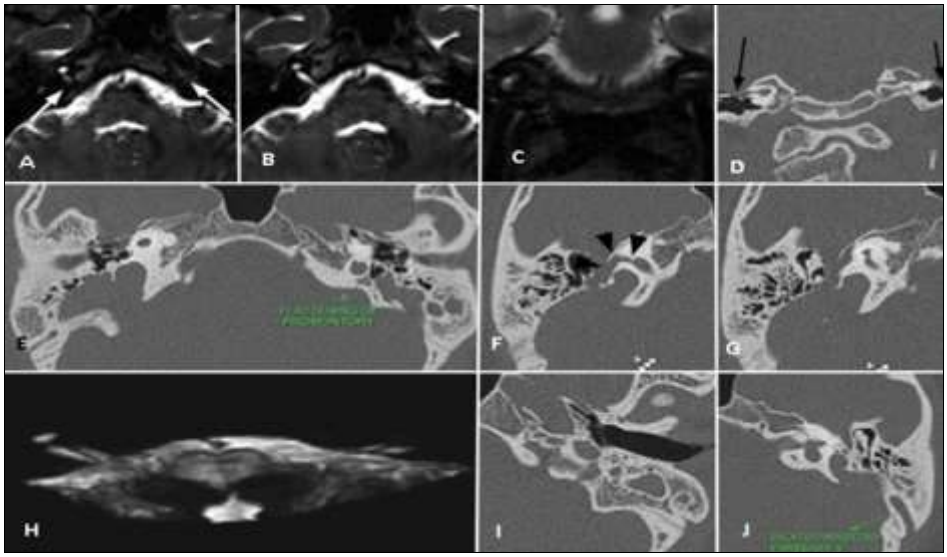
12-year-old female with bilateral profound hearing loss since birth, previously used hearing aids without benefit. Image showing MRI selected sections with narrow IAC on right side (A, B), globular vestibule- lateral semi-circular canal on right side(D), aplasia of right cochlear nerve (D, F), globular vestibule- semi-circular canal on left side(C)

Fig 4: Case of right sided narrow IAC and bilateral globular vestibule- semicircular canal



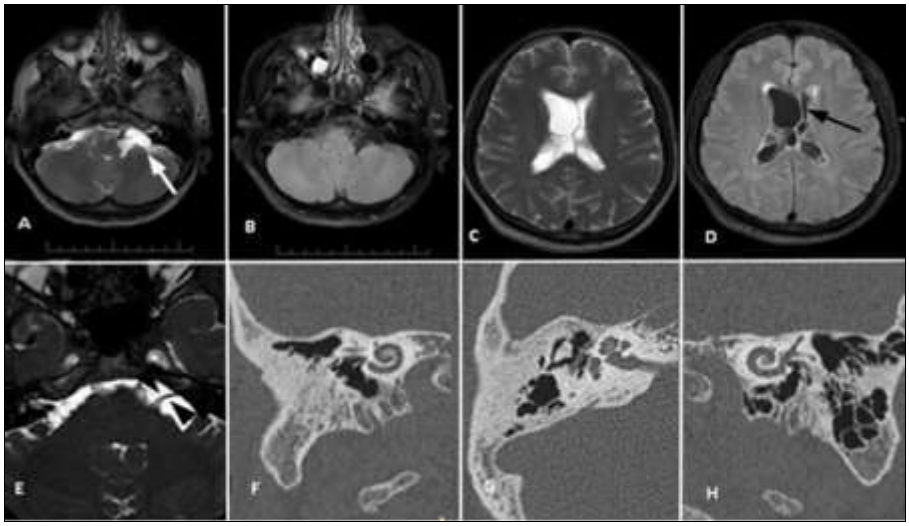
CT sections of the same 12-year-old female showing a better depiction of the narrow IAC on right side(A), severe narrowed cochlear nerve canal on the right(B) compared to relatively less stenotic cochlear nerve canal on the left side. Globular vestibule- lateral semi-circular canal is seen in the axial image in (F) and 3 D volume rendered images (C, D)

Fig 5: Case of severe cochlear nerve canal narrowing with bilateral globular vestibule



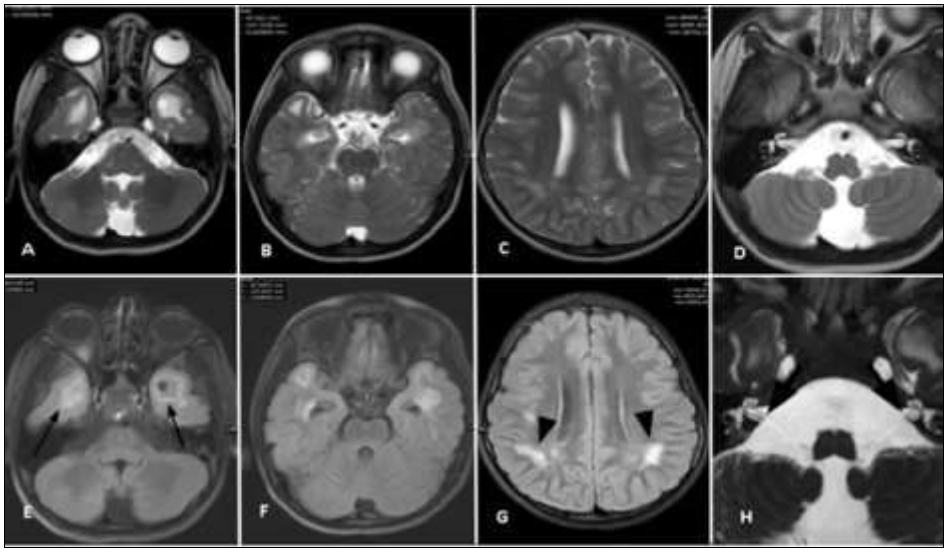
18-year-old female with severe hearing loss since birth. CT and MRI selected sections showing hypoplastic middle ear cavities, with common cavity deformity on the right side(A, B, E, G, H) and complete absence of inner ear structures on the left side (Michel's aplasia) (A, B, C, E, H, I, J). Hypoplasia of the left petrous apex is noted with a dilated mastoid emissary vein (I, J). On the left side aberrant course of the facial nerve was present, compared to a normal course of facial nerve on the right (F)

Fig 6: Case of Michel anomaly and common cavity deformity



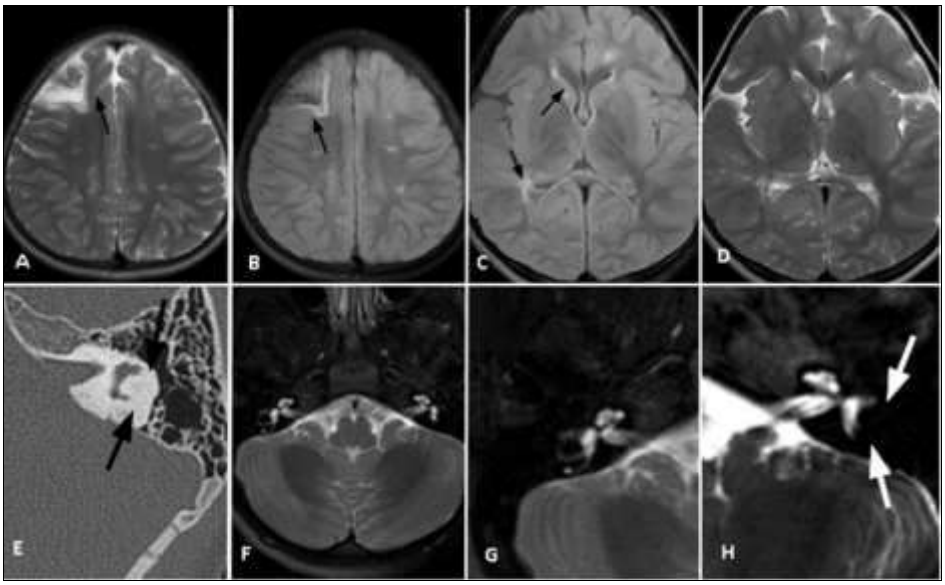
40-year-old man with history of sensorineural hearing loss for 15 years and history of meningitis 20 years ago. MRI and CT sections showing trapped collections within the bilateral cerebellomedullary cisterns (A, B). Asymmetrical dilatation of the body of bilateral lateral ventricles with multiple thin internal septations(C,D) Collection on left side is seen displacing the left VII and VIIIth nerve complex anterosuperior (E), normal cochlear nerve canal, internal acoustic canal with faint ossification within the basal and apical turns of cochlea and in the bilateral lateral semi-circular canals(F,G,H)

Fig 7: Case of Labyrinthitis ossificans with septate collections and asymmetric ventricle dilation



4-year-old male with bilateral profound hearing loss MRI selected sections showing bilateral symmetrical T1 hypo, T2 hyperintense signal changes involving the subcortical white matter of bilateral anterior temporal lobes with well-defined small CSF signal intensity cysts and prominence of temporal horns of lateral ventricles. Multiple patchy and punctate foci of T2 hyperintensities in peri trigonal white matter, deep and subcortical white matter of bilateral cerebral hemispheres -Leukoencephalopathy with anterior temporal cysts. A possibility of congenital Cytomegalovirus infection was considered on imaging. Inner ear structures were normal in this child

Fig 8: Case of Leukoencephalopathy with anterior temporal cysts



4-year-old child with hearing loss and previous history of meningitis. MRI and CT sections showing chronic infarcts involving bilateral caudate nuclei, dorsomedial aspect of thalami, right peri trigonal white matter, corona radiata and centrum semi-ovale and right middle frontal gyrus. Loss of normal T2 hyperintense signal in the lateral aspect of lateral semi-circular canal on the left side. Sections on CT show non visualization of the normal architectural pattern of the above corresponding involved portions of semi-circular canals on left side. Multiple chronic infarcts with labyrinthitis ossificans- sequelae to previous meningitis

Fig 9: Case of young child with chronic infarcts and labyrinthitis ossificans

5. Conclusion

Imaging with combined CT and MRI is an indispensable tool in preoperative assessment of candidates for cochlear implantation. The use of 3 T MRI helped us in providing good detail of the inner ear structures and seventh and eight nerve bundle complexes. The superior resolution and signal from the inner ear helped us in detecting subtle vestibulocochlear anomalies, early labyrinthine fibrosis and also mild hypoplasia of the nerves. In contrast to previous generations of scanners, 4th generation 128 detector CT gives us excellent detail of the middle ear structures, mastoid aeration and surgically important anatomic variants with increased resolution at low doses.

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7. References

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