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Original Research Paper

Radio-Diagnosis

"A COMPARATIVE STUDY OF MRI AND HRCT OF SENSORINEURAL HEARING LOSS"

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ABSTRACT

Background: In 2012, the World Health Organization (WHO) estimated that 360 million people, that is 5.3% of the world's population had hearing loss. In India, 63 million people (6.3%) have a significant hearing loss. High-resolution computed tomography (HRCT) of the temporal bone and magnetic resonance imaging (MRI) of the inner ear have been used in this group of patients with some advantages and disadvantages of each modality. **Aim:** To compare both imaging modality in the evaluation of sensorineural hearing loss and to create a systemic approach for cochlear implant candidacy. **Materials and methods:** This observational study was conducted in the Department of Radiodiagnosis comprising of 80 ears of 40 patients who having congenital moderate to profound SNHL and were potential candidate for cochlear implant surgery. All patients underwent combined HRCT of temporal bone and MRI inner ear including brain. **Results:** The mean age of the patients was 3.30 ± 1.49 years with male predominance (57.5%). HRCT found abnormality in 19 ears while MRI picked up abnormality in 22 ears. The number of ears with cochlear (10), vestibular (8) and semi-circular canal (8) abnormalities were similar by both imaging modalities. However, MR additionally detected abnormalities of endolymphatic duct system (12) as compared to vestibular aqueduct (10) on HRCT. Narrow internal auditory canal was found in 5 ears detected by both imaging modalities and all were associated with abnormal cochlear nerve. However, 2 additional cochlear nerve abnormalities associated with normal IAC. **Conclusion:** We found MRI slightly superior in detection of cause of SNHL. MRI better depicts the fluid-filled structures of the inner ear and cochlear nerve, retro-cochlear and cerebral pathology that leads to determination and feasibility of candidacy for cochlear implantation. HRCT is mandatory to rule out any bony anatomical variation and facial nerve course to determine side of implant and minimize intraoperative complication. Therefore, we advocate use of both MRI and HRCT in cochlear implant candidates.

KEYWORDS : SNHL: sensorineural hearing loss, EDS: Endolymphatic duct system.

INTRODUCTION

In 2012, the World Health Organization (WHO) estimated that 360 million people in the world that is 5.3% of the world's population'(1) had hearing loss. In India, 63 million people (6.3%) have a significant hearing loss. 1 out of every 1000 children suffer from severe to profound deafness '(2). If patients have congenital Hearing loss, it can affect language development, academic skills, and social and emotional development. Therefore, necessitate the detect the abnormality at a very early age.

Sensorineural hearing loss is hearing loss that occurs as a result of damage to the cochlea or beyond, either along the eighth cranial nerve or in the brain(3). In children with profound bilateral SNHL, delayed neural auditory development may occurs. Cochlear implantation is a well-accepted and widely available tool for the treatment of SNHL in patients who did not benefit adequately from hearing aids.

Imaging plays an important role in the evaluation of inner ear malformations, its normal variants, pathology of temporal bone, auditory pathways and selection of candidate for cochlear implant. HRCT can clearly demonstrate the anatomy of outer ear, middle ear & mastoid, inner ear, bony labyrinth and internal auditory canal. Whereas MRI allows better evaluation of the vestibulocochlear nerve, brain and auditory centre in addition to membranous labyrinth and inner ear structural abnormality.

The study was done to compare the imaging features of both imaging modalities for the detection of inner ear abnormalities particularly the pathology related to SNHL. Furthermore, the efforts are being made to highlight the future potential of these modalities and deciding the best approach in the evaluation on SNHL.

MATERIALS AND METHODS

A hospital-based, Ambidirectional observational study was done in the Department of Radiodiagnosis of Mahatma Gandhi Memorial Medical College & M.Y Hospital, Indore, Madhya Pradesh, India, after getting approval by the Ethics and Institutional Scientific Review committee (ISRC). The duration of this study was from April 2020 to September 2021.

A total of 40 patients aged up to 6 years with congenital moderate to profound SNHL and potential candidate for cochlear implant were Studied in our study, in which 30 patients were evaluated retrospectively who presented between march 2018 to march 2020 and 10 patients were studied prospectively between April 2020 to September 2021, who presented in the department of Radiodiagnosis for imaging evaluation of sensorineural hearing loss. Exclusion criteria include general contraindication to MRI and unwilling to participate in the study. Both HRCT and MRI were done simultaneously, and comparative study of these modalities done in the evaluation of cause of SNHL and for selection of patient for cochlear implantation. The Classification and Current Management of Inner Ear Malformations proposed by Sennaroglu(4) was used for this investigation.

Imaging Protocol

All the patient received HRCT and MRI examination. A 128 slice and dual source layer 256 spiral CT scanner was used for HRCT scan. No contrast was used. The scan was obtained in

the supine position with the chin tucked and orbit line kept parallel with the scan baseline without gantry tilt to facilitate free reconstruction of the images. The volume data were collected to reconstruct cross sectional, coronal and sagittal plane images. The scan parameter used during study were: 120 kV, 200 mAs, beam collimation 0.3mm, Pitch 1 and FOV 90mm.

Magnetic resonance scans were performed using 3.0 T MR system. The following sequences will be performed as a part of MR evaluation- T1, T2, FLAIR, FIESTA. The inner ear and auditory nerve scans were performed twice using FIESTA sequence on axial views and the parameter were TR 15ms, TE 7ms, flip angle 80, effective slice thickness 0.8 mm, matrix 384*320, FOV 210-230 mm, was used to analyze vestibulocochlear nerve and inner ear membranous labyrinth. MRP was performed perpendicular to the long axis of the internal auditory canal.

Statistical Analysis:

IBM SPSS Statistics for Windows, Version 26.0. Armonk, NY: IBM Corp. was used to analyse the data. Pearson chi square and specific test applied whenever required in the study.

RESULTS

Eighty ears of fourty patients with congenital SNHL were evaluated with HRCT and MRI scan. The mean age of the patients was 3.30 ± 1.49 years (range: 4 months to 6.00 years). Sample included 23 (57.5%) males and 17 (42.5%) females, showing a male predominance. HRCT detected abnormalities in 19 (23.75%) ears whereas MRI detected abnormality in 22 (27.5%) ears (table 1). So total 22 ears had abnormality out of 80 diseased ears.

Cochlear, vestibular, SSC and internal auditory canal shows similar number of abnormalities on both imaging modalities. Cochlear nerve abnormality in 7 diseased ear was only detected on MRI, and enlarged endolymphatic duct system detected in 12 ears on MRI as compared enlarged vestibular aqueduct in 10 ears on HRCT.

Table 1: Comparative Study Of Cases Of Inner Ear Abnormality On Hrct And Mri

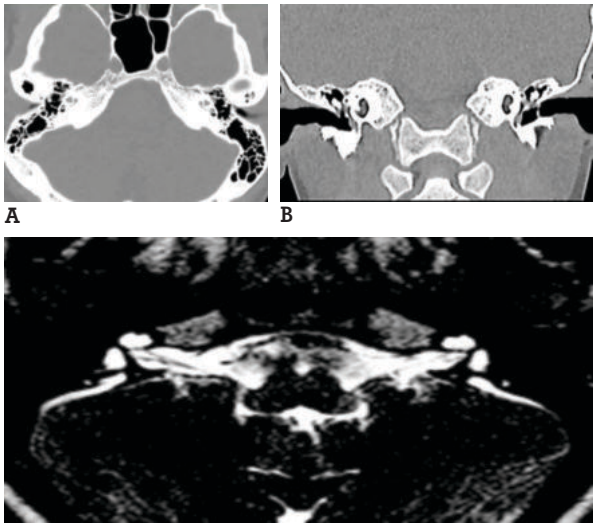
	HRCT		MRI	
	NO.	Percentage (%)	NO.	Percentage (%)
Normal	61	76.25%	58	72.50%
Abnormal	19	23.75%	22	27.50%
TOTAL	80	100%	80	100%

Vestibular aqueduct and cochlea were the most common abnormality (10 each) diagnosed by HRCT. Enlarged endolymphatic duct system (12) was the most common followed by cochlear (10) abnormality detected on MRI.

Table 2: Comparative Study Of Inner Ear Abnormality On Hrct And Mri (80 Ears)

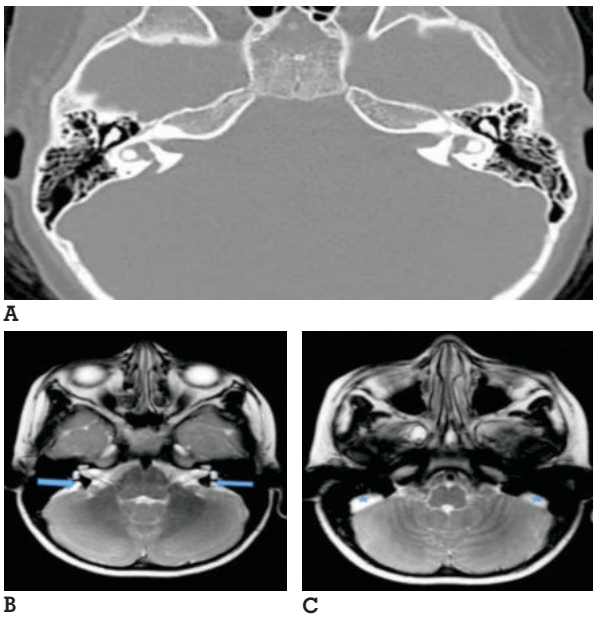
S.No.	Variable	Abnormality	HRCT		MRI	
			Number	%	Number	%
1.	Cochlea	Normal Aplasia C.H.-I C.H.-II I.P-II Ossificans	70 2 2 1 3 2	87.5 2.5 2.5 1.25 3.75 2.5	70 2 2 1 3 2	87.5 2.5 2.5 1.25 3.75 2.5
2.	Vestibule	Normal Dilated Dysplastic Dilated and fused with SCC	72 5 2 1	90 6.25 2.5 1.25	72 5 2 1	90 6.25 2.5 1.25
3.	SCC	Normal Dysplastic Ossificans Dilated and fused with Vestibule	5 2 1	6.25 2.5 1.25	5 2 1	6.25 2.5 1.25
4.	Vestibular Aqueduct/ EDS	Normal Dilated	10	12.5	12	15
5.	Internal Auditory Canal	Normal Narrow	75 5	93.75 6.25	75 5	93.75 6.25
6.	Cochlear nerve	Normal Hypoplastic Absent	- -	- -	73 4 3	91.25 5 3.75

Of the 22 abnormal ears, in 55 % enlarged endolymphatic duct system, in 45 % cochlear abnormalities, in 36 % vestibular and SCC, in 32 % cochlear nerve, in 23 % cases internal auditory canal abnormality were present.



A B C

Fig. 1: Bilateral incomplete partition type-II. A-Axial & B-coronal) HRCT section through cochlea shows absent modiolus in middle and apical turn to form cystic apex. C) Axial FIESTA image shows cystic apical part of cochlea with absence of inter-scalar septum and associated with B/L dilated Endolymphatic duct system.



A B C

Fig.2: B/L Enlarged Vestibular Aqueduct and Endolymphatic duct and sac. A) Axial HRCT image shows bilateral enlarged vestibular aqueduct. B) T2 weighted MR image at the level of vestibular Aqueduct demonstrate bilaterally dilated Endolymphatic duct (arrow) C) MRI section slightly below the above section shows B/L enlarged endolymphatic sac (star mark).

DISCUSSION:

In the present study we found abnormality in 22 ears out of 80 scanned ears with HRCT and MRI. HRCT detected abnormality in 19 ears as compared to 22 abnormal ears detected by MRI. This study shows that HRCT and MRI detect similar malformed inner ears except for Endolymphatic duct system and cochlear nerve abnormality.

Among 22 abnormal ears, 10 (45%) ears had cochlear abnormalities. Similar percentage of cochlear abnormalities we noted in studies conducted by H. Park et al.(5) (42%), Westerhof et al.(6) (48%). Incomplete partition was the most common cochlear abnormality noted in three ears followed by cochlear hypoplasia, cochlear aplasia and cochlear ossificans seen in two patients each. S. K. Agrawal et al.(7), Dagikiran et al.(8) and Jacklar et al.'(9) also detected I.P. type II as most common cochlear findings in patients with SNHL.

Eight ears (10%) showed vestibular abnormalities, dilatation was seen in six ears, one ear with dilated vestibule had associated fused semi-circular canal. Vestibular dysplasia was seen in remaining two ears. Lin et al (10) also found vestibular malformation in 10% of the examined ears.

Semicircular canals were structurally abnormal in 10% of the ears. Dysplasia of SCC was the most abnormality (five out of eight ears) followed by SCC duct ossificans and dilatation.

The pathologies detected by HRCT in the assessment of bony labyrinth were in concordance with the pathologies detected by MR by assessment of membranous labyrinth. However, cochlear ossification is preceded by cochlear fibrosis which is difficult to diagnose by HRCT. We did not find any such cases with cochlear fibrosis on MRI which were labelled normal on HRCT. Seidman et al found up to 57% of misdiagnosis rate for early ossification with cochlear fibrosis on HRCT. Therefore, in suspected cases with SNHL, an additional MR evaluation should be considered before deciding the treatment protocol.

Endolymphatic duct system (EDS) abnormalities were seen in 12 (55%) out of 22 abnormal ears. Out of 12 abnormal ears in our study, 10 ears had dilatation of endolymphatic duct and sac, which corresponded to dilated vestibular aqueduct seen on HRCT. Enlarge vestibular aqueduct is consider when the midpoint between posterior labyrinth and operculum is larger than 1.5 mm. Two ears which had dilatation of endolymphatic sac alone had normal vestibular aqueduct on CT scan. HRCT cannot evaluate the endolymphatic sac (ELS) except for a small portion which lies within temporal bone. Therefore, in cases with SNHL having suspicion of structurally abnormal ELS with normal ELD, MR imaging is crucial. Most patients enlarged endolymphatic duct system suffer from progressive or fluctuating SNHL that may trigger by minor head trauma (11) that's why it is advised that contact sports are avoided in these patients.

In present study, the internal auditory canal (IAC) was narrowed in five out of 80 ears. Number of ears with narrowed IAC were same on HRCT and MRI. HRCT can demonstrate the diameter of IAC but cannot provide details of the contents present within it. All five ears with decreased diameter showed associated abnormality of cochlear nerve on MR imaging. Two had absence of cochlear nerve while rest three had hypoplasia of cochlear nerve. There was significant association between narrowed IAC and cochlear nerve abnormality ($P < 0.001$) in our study.

Two out of 75 ears with normal IAC luminal diameter also showed cochlear nerve abnormality. Absent cochlear nerve was seen in one ear with normal IAC while other had nerve hypoplasia. Therefore, the diameter of the IAC is not always consistent with the auditory neurodevelopmental situation. All applicants for cochlear implantation should undergo MRI evaluation irrespective of the status of IAC diameter to ensure the efficacy of hearing rehabilitation after surgery.

We assessed the co-existent malformation in association with abnormality of cochlea in our study. Five out of ten ears (50%) with abnormal cochlea showed abnormality of semi-circular canal (dysplasia in three and duct ossificans in two). There was significant association between cochlear abnormality and abnormality of SCC (p value 0.001). Similarly, six (60%) ears with abnormal cochlea had malformation of endolymphatic duct system, two (20%) had narrowed IAC and three (30%) had absent/hypoplastic cochlear nerve. The association between cochlear malformation and above stated anomalies of EDS, IAC and cochlear nerve was found to be significant (p value <0.05). Westerhof et al.(6) also found associated malformations of SCC, vestibular aqueduct/ EDS and IAC in cases with structurally abnormal cochlea.

Absent cochlear nerve is absolute contraindication for cochlear implant surgery. One of the most important findings is that MRI scan allows full appreciation of normal anatomy and abnormality of vestibulocochlear nerve in children with SNHL.

HRCT better depict the any bony labyrinth abnormality as well as any pathology of middle and external ear and associated anatomical variants like narrowed facial recess, anteriorly placed sigmoid sinus and high riding jugular were other abnormalities of middle ear seen in 20%, 3.75% and 2.5% ears respectively in our study. Therefore, the associated abnormalities of middle ear should be assessed in order to select the appropriate surgical approach for cochlear implantation surgery, to reduce intraoperative complications and for better treatment outcome.

CONCLUSION:

MRI better depicts the fluid-filled structures of the inner ear and provides assessment of cochlear nerve, retro-cochlear and cerebral pathology that leads to determination and feasibility of candidacy for cochlear implantation. Whereas, HRCT provides visualization of any co-existing bony abnormalities of the inner ear, middle and external ear and rule out any bony anatomical variation and facial nerve course to determine side of implant and minimize intraoperative complication. Therefore, we suggest use of both MRI and HRCT in cochlear implant candidates.

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