ORIGINAL RESEARCH PAPER
VOLUME-6 | ISSUE-5 | MAY - 2017 | ISSN No 2277 - 8179 | IF : 4.176 | IC Value : 78.46
INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

Imaging guided Decision making in Cochlear Implantation.

Radiology

Dr Roma Gandhi B J Medical college, Ahmedabad

Dr Rajesh Vishwakarma B J Medical college, Ahmedabad

ABSTRACT

Background: Imaging procedures are a mainstream tool in the daily ENT workflow. Cochlear Implant patients are representing a special population with specific demands for imaging. There are different imaging techniques available for pre-operative evaluation.

Objective: High-resolution computed tomography (HRCT) is the standard imaging technique used in cochlear implantation. However, cochlear and retrocochlear soft-tissue abnormalities may not be detected with HRCT alone. To determine whether magnetic resonance imaging (MRI) and HRCT provides clinically significant information in the evaluation of candidates for cochlear implants, we performed this study.

Study type: Prospective nonrandomized observational study

Setting: Otorhinolaryngology department at civil hospital ahmedabad.

Materials and method: 207 patients with profound hearing loss underwent HRCT and MRI scans using 1.5 tesla scanner with 16 channel head coil. MRI was performed and axial, coronal and sagittal reformatted images and were analyzed systematically.

Result: Various anamolies were found during HRCT and MRI and these findings were significant for clinical decisions regarding candidacy for surgery, side selection for surgery, and surgical technique in cochlear implantation.

Conclusion: Study concludes that HRCT and MR provides accurate anatomical delineation of complex soft tissue of inner ear and 3D reconstruction improves preimplant evaluation.

KEYWORDS:

INTRODUCTION

The cochlear implant is an electronic auditory prosthesis with a component that is surgically inserted in the ear and coupled with a detachable component that is worn externally like a hearing aid. It is designed to stimulate the spiral ganglion cells in patients whose hair cells have been lost or not developed.

The device give the sensation of sound to otherwise deaf patients. Imaging plays key role in the preoperative and postoperative evaluation of the device.

This study will highlight the fundamental principles, technology, and anatomy of cochlear implantation as well as the important aspects of imaging in cochlear implantation.

MATERIALS AND METHOD

207 patients who were admitted in ENT ward of department of Otorhinolaryngology and head and neck surgery of civil hospital, Asarwa, Ahmedabad between January 2014 to October 2015 with clinical and other evidences of bilateral profound sensorineural hearing loss and who were planned for cochlear implant surgery were included in this study. These patients after detailed evaluation, routine investigations and hearing assesement were admitted for Radiological evaluation prior to the surgery.

All the patients underwent

- HRCT temporal bone with bony cochlea, which was performed with contiguous native sections of 0.5-1-mm thickness in axial plane, with bone windows setting, using the smallest pixel size. Edge bone enhancement increases the delineation of Inner ear structures. Orientation of axial sections in a plane +30° allows to avoid the orbital lenses and to obtain good delineation of round window. No contrast injection was needed.

The following cochlear structures can be seen, from below: firstly, the sausage-shape of the basal turn with its parallel side walls and the osseous lamina; secondly, the air-filled round window niche under the subiculum; and then, the apical and the medial cochlear turns communicating with the IAM by the modiolus.

HRCT evaluates the status of mastoid pneumatisation, thickness of the cortical bone, middle ear aeration, the round window niche. It may display anatomic middle ear variations of surgical importance such as: dehiscent facial nerve, low lying roof, high jugular bulb and aberrant carotid artery. Furthermore, CT may demonstrate anomalies of the bony labyrinth such as Paget, otosclerosis, post meningitis stenosis of the round window niche.

- MRI brain with 3D reconstruction of bony cochlea, which was performed with 1.5 or 3 Tesla MRI. Sedation was used in most children 3D volumetric CISS in axial plane with coronal and sagittal reformation and MIP reconstruction Slice thickness of 0.4 – 0.7 mm Oblique sagittal reformatted images in plane perpendicular to 7th and 8th nerve in IAC Routine axial T2WI of brain to exclude CNS causes of sensorineural hearing loss

Three dimensional (3D) constructive interference in steady state (CISS) is a heavily T2 weighted fully refocused gradient echo MR sequence.

Being heavily T2 weighted it is better suited for imaging of structures surrounded by fluid like 7th – 8th nerve complex and membranous labyrinth.

3D sequence, so reconstruction in any plane possible.

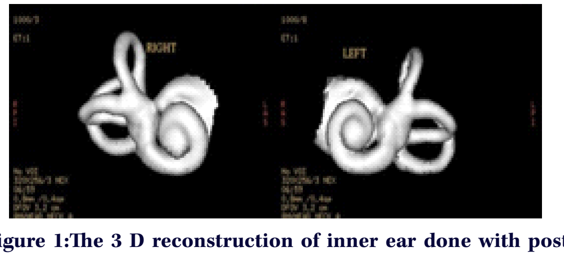

Figure 1:The 3 D reconstruction of inner ear done with post-processing by maximum intensity projection (MIP) and multi-

planar reconstruction (MPR) by using 3D-CISS sequence
1.Preoperative CT examination for cochlear implantation

Mastoid process
Size:
- Normal
- Hypoplastic
- Deep sigmoid

Pneumatization: limited
- Throughout
- Beyond
- Effusion:
- No
- Yes

Middle ear
- Normal
- Exposed jugular bulb
- Aberrant carotid artery
- Aberrant facial nerve
- Other: specify

Cochlear morphology
- Normal
- Incomplete partition
- Hypoplasia
- Common cavity
- Aplasia

Cochlear ossification
- Yes
- None

Round window
Vestibular aqueduct
- Normal
- Large

Internal auditory canal
Other

2. Preoperative MRI Evaluation:
Cochlea
IAC
Cochlear nerve
7and 8 nerve complex in IAC
CP angle
Vestibule
Semicircular canals
Vestibular aqueducts
MRI Brain

OBSERVATIONS AND DISCUSSION

1. The age distrubtion of the study was as follows:

AGE	PTS	%
0-5	129	62.32
6-10	54	26.09
11-15	20	9.66
16-20	2	0.97
21-25	2	0.97
>25	0	0.00
TOTAL	207	100
Males	109	52.65
Females	98	47.34

TABLE 1: AGE AND SEX DISTRIBUTION

Majority of the patients in this study belonged to the age group of 0 to 5 years (129,62.32%). No patients were found to be more than 25 years of age.

2. Pre-Operative HRCT Temporal bone findings:

HRCT TEMPORAL BONE FINDINGS	ABNORMAL	NORMAL	TOTAL
NO OF PATIENTS	35	172	207
PERCENTAGE	16.9	83.09	100

TABLE 2: Pre-operative HRCT Findings

The above table shows that 16.9% of patients with bilateral profound sensorineural hearing loss were having abnormal HRCT during their pre operative evaluation which was useful for various decision making.

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- The various abnormalities found on HRCT were congenital cochlear malformation, cochlear ossification, otitis media, jugular bulb dehiscence, arcuate eminence thining and others.

SRNO	ABNORMAL HRCT FINDINGS	NO OF PATIENTS
1	CONGENITAL COCHLEAR MALFORMATIONS	
	MICHELS DEFORMITY	2
	COMMON CAVITY	1
	COCHLEAR APLASIA	2
	MONDINIS DYPLASIA	8
2	COCHLEAR OSSIFICATION	2
3	OTITIS MEDIA	16
4	OTHERS	
	JUGULAR BULB DEHISCENCE	1
	ARCUATE EMINENCE THINING	1
	NARROW IAC	1
	COMMUNICATING HYDROCEPHALUS	1
	TOTAL	35

TABLE 3: ABNORMAL HRCT FINDINGS

- Two patients were rejected for cochlear implantation on the basis of following imaging findings: Congenital cochlear malformations. One case had bilateral cochlear aplasia. The second patient had bilateral Michels deformity.

- Special electrode arrays were used for patients having malformations like Mondini's dyplasia and also for post meningitic cochlear ossification..

- There were chances of CSF gusher in patients having common cavity which was known pre operatively by the HRCT.

- In three patients, HRCT findings determined the side selected for implantation as follows:

a) One patient was operated for OMAYA shunt for communicating hydrocephalus on right side and thus left side was preffered for implantation.

b) One patient had complete cochlear aplasia on right side and Mondinis dysplasia on left side and thus left side was preffered.

c) Another patient had right normal cochlear anatomy and left was hypoplastic cochlea and thus right side was preffered.

- Special considerations were taken intraoperatively and surgical technique was accordingly modified for patients having abnormal HRCT findings like Dehiscent jugular bulb, Thinning of arcuate eminence, otitis media and others.

5. MRI -Preoperative Findings

MRI brain with 3D reconstruction of membranous labyrinth was done, the findings of which are reviewed in table 4.

MRI FINDINGS	ABNORMAL	NORMAL	TOTAL
NO OF PATIENTS	68	139	207
PERCENTAGE	32.85	67.14	100

TABLE 4: Pre-operative MRI Findings

- The above table shows that 32.85% of patients with bilateral profound sensorineural hearing loss were having abnormal MRI during their pre operative evaluation which was useful for various decision making.

SR NO	ABNORMAL MRI FINDINGS	NO OF PATIENTS
1	DEMYELINATION IN BRAIN	23
2	CONGENITAL COCHLEAR MALFORMATIONS	10
3	ABNORMAL VESTIBULAR SYSTEM WITH DILATED ENDOLYMPHATIC SAC	10
4	COCHLEAR NERVE HYPOPLASIA/ APLASIA	6
5	COCHLEAR OSSIFICATION	3
6	OTITIS MEDIA	16
	TOTAL	68

TABLE 5: ABNORMAL MRI FINDINGS

- The various demyelinating abnormalities found on MRI brain can explain the wide variation of performance across individual cochlear implant users and therefore proper counselling about implant results and agressive post implant therapy could be explained beforehand to the patients. They may be caused by Congenital, post-traumatic or post-ischemic effects on brain.

- The various congenital cochlear malformations which were already picked up by the HRCT were better visualised by the 3D Reconstruction images. In one patient HRCT was normal but MRI picked up the membranous cochlear dyplasia.

- Three patients were found to have cochlear ossifications two of which were picked up by HRCT. One patient had subtle and early ossification and was better picked up by MRI.

- 10 patients were found to have dilated vestibular system with dilated Endolymphatic sac in whom chances were more for CSF gusher and accordingly preparations were made preoperatively.

- One patient was refused for cochlear implantation and was advised for auditory brain stem implant as MRI showed bilateral cochlear nerve aplasia.

- MRI also picked up minor degrees of mastoiditis earlier than HRCT. 16 patients were found to have otitis media with mastoiditis on MRI.

- One patient had absent cohlear division of eighth nerve on right side and thus left side was preffered for implantation.

- In one patient MRI showed CHOROID PLEXUS CYST on right side and thus left side was preffered for implantation.

3. Types of Electrode Arrays used for implantation.

- Compressed and medium electrode arrays were used for cochlear malformations like Mondinis dysplasia and were decided after the ITD testing.

- The FORM series of electrodes are specifically designed for use in cases of cochlear malformations in whom the chances of CSF gusher are high.

- MED-EL's FLEX Soft is the softest and most flexible electrode array designed for the majority of patients and optimised for Structure Preservation and the preservation of residual hearing.

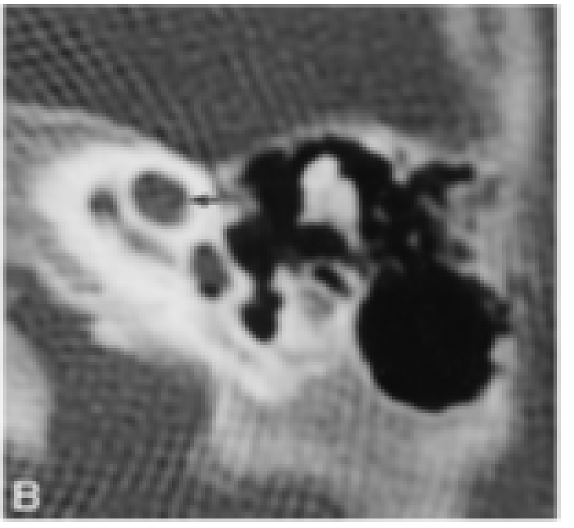

Fig 1: HRCT temporal bone showing MONDINIS Deformity

Fig 2: MRI showing MONDINIS Dysplasia

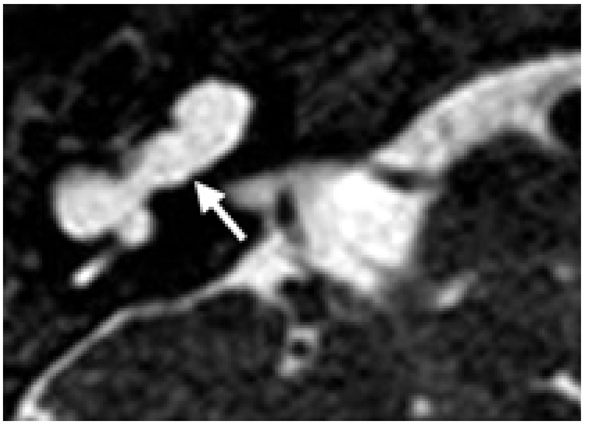

Fig 3: MRI showing COMMON CAVITY

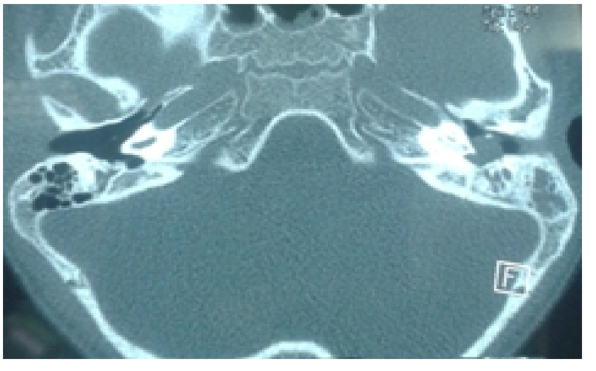

FIG 4: HRCT Temporal bone showing left COCHLEAR SCLEROSIS (post meningitic)

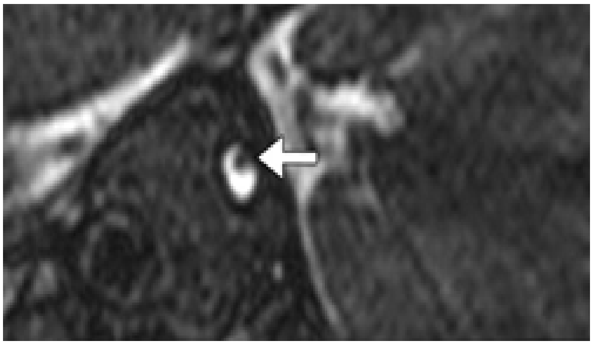

Fig 5: Sagittal MRI : single nerve within the IAC, suggesting absent 8th nerve

CONCLUSIONS

Review of literature and our experience has led us to the following conclusions:

1. HRCT temporal bone continues to be the mainstay for detection of inner ear abnormalities due to its reliability and easy availability. CT is superior to MRI for detection of a high riding jugular bulb. Another important advantage of CT over MRI is in tracing the course of the facial nerve. In cases of complex congenital malformations, the facial nerve may have an aberrant course and thus liable to injury during implantation.

2. MRI has gained popularity in recent times primarily due to its superiority over HRCT in detecting labyrinthine ossification. Early fibrotic obstruction may be missed on CT even by experienced radiologists and will require MRI for early detection. Another potential advantage of MRI is in identification of the cochlear nerve. An absent cochlear nerve is an absolute contraindication for an implant. MRI is superior to CT in detecting the large vestibular aqueduct syndrome.

3. A realistic and practical imaging protocol should comprise of a preoperative HRCT temporal bone and MRI brain with 3D reconstruction of membranous labyrinth in all patients.

5. Imaging of the complex ear is time consuming and involves subtle findings that can influence major and often very expensive decisions. Therefore, we emphasize strongly the requirement of trained and dedicated radiologists who are an inherent part of the cochlear implant program.

6. An organized report in cochlear implant patients should provide the surgeon with clear and concise information for thorough preoperative evaluation, selection of type of device and surgical approach.

Common goal of all imaging procedures in cochlear implant patients is the improvement of surgical planning and results, the control of surgical quality, and the reduction of complications.

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