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ORIGINAL ARTICLE

Pre-Operative Evaluation of Petrous Temporal Bone Pathologies by CT and MRI in Cochlear Implant Candidates

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ABSTRACT

Aim: To evaluate pathologies of the petrous temporal bone in cochlear implant candidates on CT and MRI preoperatively.
Methods: A cross-sectional study was conducted at Combined Military Hospital Lahore from Jan 2014 to April 2016. 163 candidates were evaluated on CT and 149 were evaluated on MRI. All patients belonged to pediatric age group. Pathologies were grouped using classification of Sennaroglu & Saatci and every pathology was sought in all the cases ensuring that the pathologiesare not missed.
Results: High-resolution CT scan temporal bone revealed 69.9% normal studies. Chronic otitis media with mastoiditis was major abnormality observed in 16.6% of cases. Unilateral mastoiditis was seen in 6.1% of patients. Bilateral CSOM without mastoiditis was seen bilaterally in 1.8% of cases. While unilateral CSOM was observed 0.6 % of patients. Among inner ear malformations, Mondini malformation was seen in 4 cases (2.5%). A high jugular bulb was seen in 2 cases (1.2%).93.3% of cases were labeled as normal study on MRI. Four cases showed Mondini malformation. Infective process of middle ear showed a cumulative frequency of 2.7%. Inner ear aplasia was found in one patient. Sclerosing labyrinthitis was also found in one case.
Conclusion: Both CT and MRI have substantial role in pre-operative evaluation of petrous temporal bone in cochlear implant candidates. Preoperative evaluation of petrous temporal bone by CT scan and MRI successfully identifies pathologies which can be absolute or relative contraindications of the cochlear implant as well as conditions in which surgical procedure needs to be modified.
Keywords: Cochlear implants, HRCT temporal bone, MRI cochlea, Mastoiditis, Mondini malformation

INTRODUCTION

Cochlear implants have emerged as miraculous treatment options for different types of deafness (congenital or acquired). Cochlear implant is a prosthetic device, implanted in the inner ear of completely or nearly deaf individuals[1]. It was first introduced in 1985 for adults and in 1990 for pediatric population and has greatly reduced disability caused by hearing impairment.A study conducted in Pakistan in 1998 showed 7.9% prevalence of hearing impairment among 607 children with different risk and associated factors[2].There has been a steady rise over the past years in the use of cochlear implants in Pakistan[3]. Multiple tests are required for establishing candidacy for cochlear implant which includes HRCT and MRI of temporal bone ear amongst others[4]. CT and MRI are effective at predicting normal inner ear anatomy, and thus at predicting candidacy of patients suitable for implantation[5].

Cochlear implant candidates undergo extensive and thorough preoperative assessment comprising of clinical, psychological, speech therapeutic and CT/MRI imaging of the cochlear region to characterize the etiology causing hearing loss and associated findings which may contraindicate surgery. Cochlear implants integrate complex sound analysis by adopting mechanism to stimulate auditory cortex over various frequency settings and in order to achieve this goal, the implant must be placed well within the cochlear lumen[6].

Normal imaging findings of the temporal bone are identified in a large number of candidates however, anatomic variations and abnormalities along with vestibulocochlear anomalies can be seen in about 40% of the candidates. Patients presenting with severe cochlear aplasia, deformed vestibule, deformed semicircular canals, absent cochlea and those with missing or insufficient cochlear nerve do not qualify for cochlear implantation on the affected side[7].

The aim of this study is to document the frequencies of CT and MRI findings for different pathologies which were encountered in candidates of cochlear implants in an attempt to provide much-needed data of Pakistan-based population. It can also facilitate provision of data to further guide about hearing impairment, its prevention, and cure.

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MATERIALS AND METHODS

This descriptive cross-sectional study evaluated a total of 312 (163 in CT and 149 in MRI) patients aged up to10 years, selected through nonprobability consecutive sampling from January 2014 to April 2016.HRCT temporalbone scans were performed on “Toshiba Acquilion 64 (Japan)” with 64 slices machine, In axial plane using 120 kV and 50 mA, 512 x 512 matrix and slice thickness of 0.5 mm. Reformatted images in sagittal and coronal planes were also obtained. MRI was performed on “Philips Achieva” of 1.5T using Head coil for temporal bone at a slice thickness of 1.5mm, protocols with T1, T2, FLAIR, DWI & BFE sequences.

All the pathologies were classified into different groups using classification of Sennaroglu & Saatci and then evaluated accordingly ensuringcareful assessment for each disease entity.

RESULTS

A total of 163patients were evaluated with HRCT temporal bone and 149 patients with MRI.For MRI55% male and 45%, female candidates were presented while the ratio was 51 to 49 for a male to female in CT candidates, respectively.
CT findings: Among all the patients scanned with HRCT, 69.9% demonstrated no abnormality. Chronic otitis media with mastoiditis was the major abnormality observed in 16.6% of cases. Unilateral mastoiditis was seen in 6.1% of patients. Bilateral chronic suppurative otitis media (CSOM) without mastoiditis was seen bilaterally in 1.8% of cases. While unilateral CSOM was observed in 0.6 % of patients. Among inner ear malformations, Mondini malformation was seen in 4 cases (2.5%). High jugular bulb was seen in 2 cases (1.2%).
MRI Findings: Out of 149 cases examined,139 cases revealed no abnormality. Four cases showed Mondini malformation. Infective

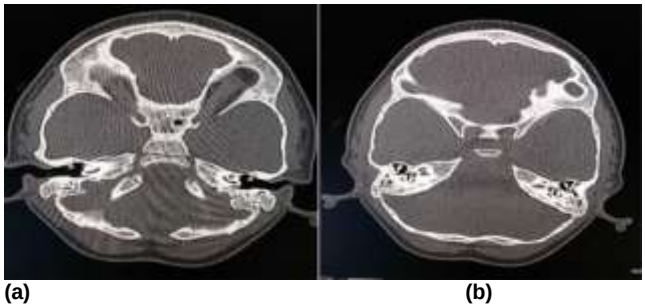
process of middle ear showed a cumulative frequency of 2.7%. A single case of inner ear aplasia was found and single case of sclerosinglabrynthitis was found.

Table 1: Frequencies of petrous temporal bone pathologies by CT

CT scan findings			
FINDINGS	**Frequency**	**Percentage**	
Normal	114	69.9 %	
Bilateral CSOM with Mastoiditis	27	16.6%	
Unilateral Mastoiditis	10	6.1%	
Mondini malformation		4	2.5%
Bilateral Chronic Otitis media		3	1.8 %
High jugular bulb		2	1.2%
Bilateral Mastoidits		1	0.6%
Unilateral CSOM		1	0.6%

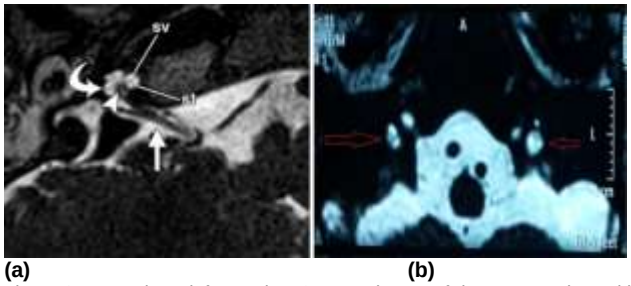
Table 2: Frequencies of petrous temporal bone pathologies by MRI

MRI Findings		
Findings	**Frequency**	**Percentage**
Normal study	139	93.3%
Mondini Malformation	4	2.7%
Bilateral Mastoiditis	2	1.3%
Bilateral CSOM	1	0.7%
Unilateral Mastoiditis	1	0.7%
Inner ear aplasia	1	0.7%
Sclerosinglabrynthitis	1	0.7%



(a) **(b)**

Figure 1: Images on right: CT scan axial image in bone window settings demonstrate normal 2.5 cochlear turns on the left (red arrow) and the basal turn on the right with the modiolus.



(a) **(b)**

Figure 2: Image b on left: Another CT scan image of the same patient with normal bilateral ear ossicles giving characteristic cone appearance but with bilateral otomastoiditis.

Image a on right for comparison showing T2WI axial image demonstrating middle and apical turns with the modiolus (arrowhead) and the spiral lamina (curved arrow) dividing the cochlea into the scalavestibuli (sv) and the scala tympani (st). The nerves are seen in the cerebellopontine angle and IAC (straight arrow)

Image b on left: MRI T2WI demonstrates common cavity on left showing complete aplasia and a 1.5 turns on right demonstrating Mondini deformity; red arrows.

DISCUSSION

There has been a prevalence of hearing loss of about 1.1 to 1.3 per 1000 live births and prevalence of childhood and adolescent hearing loss based on studies conducted in USA and UK[8,9]. A sharp contrast was observed in data demonstrated by a Pakistan-based study conducted in 1998 which showed the prevalence of 7.9% in general population[2]. Another Pakistan based study conducted in 2002 showed a steep rise to 33.2% in a different Pakistani population where siblings of deaf children were screened for hearing loss[10]. Congenital causes attribute to 50% of deafness which is further divided into syndromic (30%) and non-syndromic (70%) cause[9]. Most forms of non-syndromic autosomal recessive deafness are due to cochlear defects[11].A number of therapies and implants which include hearing aids, bone implants, and cochlear implants have been devised to address the impact of disease considering the magnitude of hearing loss and socio-economic outcomes on individuals. Cochlear implants have been accepted as a treatment method for severe to profound hearing loss in patients who drive little benefit from other methods[12].

Cochlear implants are prosthetic devices consisting of external and internal components. The external component works as a receiver that intercepts sound waves and further transmits these to the transmitter which functions as a mini processor. Different processors are used by different manufacturers but mostly behind the ear (BTE) processor is used. Internal components include an implanted transmitter which functions to communicate with external transmitter through a magnet installed in it. It is surgically placed within the bone behind the ear. It communicates with internal ear via electrodes which are surgically installed along with transmitter and directly stimulate the hair cells[12].

Cochlear implants have been reserved for persons with severe bilateral prelingual deafness, however, with passage of time,there has been leniency in the criteria for candidacy[1]. Criteria for pediatric patients are slightlydifferent as compared to theadult population. Audiological tests, medical examination speech tests, and radiological studies including high-resolution CT of the temporal bone (HRCT temporal bone) and MRI of internal acoustic canal (IAC) are all part of the series of conducted tests. Pre-operative evaluation of temporal bone allows identification of inner ear abnormalities, especially in children in which there are higher chances of finding a malformation. A study conducted at the University Clinic in Freiburg showed malformations in up to 15% of childhood cochlear implant candidates[13]. Accurate labyrinth anatomy can be demonstrated by using CT scan which may further guide about surgical approach and type of implant with its precise variety to be used, while MRI is superior at imaging cranial nerves and membranous labyrinth[14].

A surgical procedure is employed for implantation of cochlear implants which is performed on an outdoor basis. A postauricular incision line approach is made extending deep and raising periosteal flaps, followed by mastoidectomy to create room for BTE processor and implant using a high power drill.To reach the cochlear turns a posterior approach via facial recess is implied. Chocleostomy is done just anterior and inferior to round window and electrodes are introduced into scala tympani[1].

The importance of preoperative imaging in candidates of cochlear implant can easily be assessed by having a brief look at the steps of the procedure. CT and MRI may be used to study a number of inner earpathologies. Pre-operative evaluation has shown to change management in up to 20% of cases as shown in a study conducted in 2015[15]. We divided these abnormalities using classification of Sennaroglu & Saatci with modifications to include middle ear and petrous bone abnormalities in our study[16].

In our study 74.2% and 94.6% cases revealed no ear deformity or abnormality on CT and MRI respectively. These figures correspond to a study conducted in 2015 in whichinner ear abnormalities were demonstrated to be 20%[17]. Cochlear aplasia or absence of the eighth nerve are absolute contraindicationsto cochlear implantation and puts a halt to the further process of cochlear implant if any of two is demonstrated[12]. Our study found a

single case of cochlear aplasia on MRI which is deemed better investigation at finding the abnormality. A cumulative percentage of 25.7% cases on CT and 2.7% cases on MRI were found to havean infective process of the middle ear, which is a relative contraindication to a cochlear implant and requires treatment prior to implant as it can lead to meningitis or labyrinthitis and high rate of implant failure. Labyrinthitis and meningitis can lead to fibrosis and cochlear ossification. Cochleostomy becomes more difficult in patients with cochlear ossificationand requires electrodes with short array[12]**.** Our study showed a single case of ossific labyrinthitis. A sharp contrast was however noted with a study conducted in the US which showed only 3.3% cases with the infective process[15]. Four cases of Mondini malformation were revealed on MRI and CT which results from growth arrest during the 7th gestational week resulting in 1.5 turns of cochlea instead of normal 2.5–2.75[14]. This condition is again not a contra-indication as successful implantshave been achieved inpatient, with Mondini malformation[3]. This condition requires slight change of procedure as either short array electrodes are used or incomplete insertion of electrodes is done is dysplastic cochlea.1.2 %of patientsshowed high jugular bulb which is included in vascular anomalies. Tomura et al showed percentage of 2.4% in a study conducted in 1995[18] and 3.5% in another study conducted in 2015[17].

Our study provides a preview of magnitude of problems a radiologist can encounter in Pakistan which are essential to report. There was a large percentage of normal studies which gives the surgeon confidence to proceed freely with implant. But true importance of radiological studies in cochlear implant candidates lies in abnormal findings. Abnormal findings not only decide about contra indication but also guides the surgeon to a great extent about the course and type of equipment to be used. This study provides much needed data on frequencies of different pathologies in our population.

CONCLUSION

Our study concludes that radiological investigations (HRCT temporal bone and MRI) are essential to evaluate cochlear implant candidates. These investigations not only help in classification of abnormalities but their main importance liesin guidingthe surgeons about the strategy of procedure and selection of type of implant to be used, which can have an impact on success rate of the procedure. It will also help in reduction of operative& post-operative complications of surgery.

Conflict of interest: Nothing to declare

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