Open Access

Original Article

A Comparative Analysis of Role of Magnetic Resonance Imaging and High- Resolution Computed Tomography-Temporal Bone in Preoperative Assessment of Patients for Cochlear Implantation

Junaid Khan, Atiq Ur Rehman Slehria, Rizwan Bilal, Hafsa Aquil, Hassan Khan Jadoon, Zainab Shehzadi

Departments of Radiology, Armed Forces Institute of Radiology & Imaging/National University of Medical Sciences (NUMS) Rawalpindi Pakistan

ABSTRACT

Objective: To compare the roles of MRI and HRCT-Temporal bone as a part of preoperative evaluation of candidates selected for cochlear implant before surgery.

Study Design: Comparative cross-sectional study.

Place and Duration of Study: ENT Departments of the Combined Military Hospital and Pakistan Emirates Military Hospital Rawalpindi, Pakistan from Nov 2022 to May 2023.

Methodology: Patients having bilateral sensorineural hearing loss (SNHL), which ranged in severity from mild to severe, were referred from the ENT departments of the Combined Military Hospital and Pakistan Emirates Military Hospital Rawalpindi. Their Cochlear status was evaluated using HRCT and MRI of the temporal bone before giving the cochlear implant. The anatomical abnormalities of each temporal bone were listed and noted for analysis.

Results: Of the 100 patients, 48% were male, and 52% were female. The most common disorders were abnormalities of the cochlea (45/100) and semicircular canal (20/100). The most frequent cochlear abnormality (10/100) was Mondini's deformity. In 12 cases, MRI was more effective than HRCT at identifying hypoplastic or aplastic vestibulocochlear nerves.

Conclusion: For the diagnosis of membranous labyrinth and nerve abnormalities, MRI of the temporal bone was superior to HRCT. However, neither HRCT nor MRI temporal bone is the only imaging modality of choice for cochlear implant assessment; rather they perform best in combination.

Keywords: Cochlear Implant, Hearing Loss, High-Resolution Computed Tomography (HRCT), Magnetic Resonance Imaging (MRI)

How to Cite This Article: *Khan J, Slehria AUR, Bilal R, Aquil H, Jadoon HK, Shehzadi Z. Comparative Analysis of Role of Magnetic Resonance Imaging and High- Resolution Computed Tomography-Temporal Bone in Preoperative Assessment of Patients for Cochlear Implantation. Pak Armed Forces Med J 2025; 75(2): 328-332. DOI: https://doi.org/10.51253/pafmj.v75i2.10861*

INTRODUCTION

The functional and anatomical segmentation of the auditory apparatus determines two major groups of hearing loss. Sensorineural hearing loss is caused by abnormalities of the inner ear, vestibulocochlear nerve or the central auditory pathway, whereas conductive hearing loss is caused by abnormalities of the external and middle ear.[1] Congenital hearing loss results from a variety of developmental injuries that occur during antenatal period and impair the mechanics of inner ear which is involved in the creation and perception of sound. Any portion of the inner ear has the potential to develop malformations, which serves as the foundation for its pathological classification as malfunction caused either by a solitary anomalous membranous labyrinth or in combination with an anomalous osseous labyrinth. The 20% of congenital hearing loss is caused by osseous malformations, in contrast to the 80% because of membranous abnormalities.[2] Over the period, different treatment modalities have been introduced amongst which cochlear implants have brought revolutionary advancements in the treatment of patients with congenital deafness providing them a better quality of life through enhanced hearing.

A cochlear implant is a surgical device having both internal and external components. Internal components work in close association with the vestibulocochlear nerve.[3] To enable thorough sound analysis, cochlear implants work by stimulating the auditory cortex over a wide frequency range. Within the cochlear lumen, the implant must be correctly positioned.[4] Clinical, speech, and psychological evaluations, as well as imaging of the inner ear structures, are performed on cochlear implant candidates prior to surgery in order to determine the source of hearing loss and to aid in the selection of the affected ear.[5] When assessing and choosing cochlear implant candidates imaging performed prior to surgery is required to determine any potential temporal bone anomalies that could cause the implant surgery to fail.[6] For patients with anomalies of the

Correspondence: Dr Junaid Khan, Departments of Radiology, Armed Forces Institute of Radiology & Imaging Rawalpindi Pakistan
Received: 07 Sep 2023; revision received: 28 Feb 2024; accepted: 06 Mar 2024

temporal bone, magnetic resonance imaging (MRI) and high-resolution computed tomography (HRCT) of the temporal bones are useful diagnostic techniques. Considering the compact yet complex configuration of the temporal bone, radiologists play a significant yet challenging role in the interpretation of various anomalies.[7] HRCT and MRI temporal bone has provided valuable assistance to radiologists in foreseeing successful cochlear implantation.[8] HRCT also plays an important role in post-operative cases in confirming the implant's intracochlear site. Furthermore, it has been evident that HRCT can detect kinking and malpositioning of implants in postoperative patients.[9]

Literature has proven various advantages and disadvantages of each technique, most practitioners in our setting choose to employ both techniques keeping in view the pros and cons. However, there are disparities because of the expensive nature of the studies, the need for sedation, and the "acceptable" level of pathology identification in HRCT and MRI. Radiologists commonly question if dual-mode investigations are genuinely required or which of these imaging modalities would be best to use. Both strategies have so far been tested in clinical settings with an anticipation that they will supplement one another. This study aims to provide important pre-operative imaging components in cochlear implant candidates with respect to HRCT and MRI to support the perceptions of radiologists and surgeons in their day-to-day practice. The study will provide valuable evidence to the concerned clinicians to make better patient-oriented diagnosis and treatment decisions.

METHODOLOGY

The comparative cross-sectional study was carried out on 100 patients from November 2022 to May 2023. Sample size was calculated using the WHO sample size calculator, using a prevalence of 5% as reported by WHO with a confidence interval of 95% and precision of 5%.[10] A Sample size of 100 was taken to acquire generalizable results. Patients were referred by the ENT departments of CMH and PEMH, Rawalpindi, to Armed Forces Institute of Radiology and Imaging (AFIRI) for a diagnosis. Participants of the study were chosen from the referred patients using a convenience sampling technique.

Inclusion Criteria: Patients of either gender with bilateral SNHL who agreed to have cochlear implants as treatment were inlcuded.

Exclusion Criteria: Patients who have congenital aural dysplasia and patients who have an active middle ear illness were excluded.

The Armed Forces Institute of Radiology and Imaging Rawalpindi, Pakistan, reviewed the study with their panel of experts and gave approval to conduct the study. (Vide Letter No. 016). Patients and their parents also provided formal informed consent. The detailed history of patients was acquired. The preoperative evaluation included clinical, psychiatric, social, and speech-language assessment complemented with imaging (HRCT and MRI) of the temporal region. The procedure was thoroughly explained to the patient's parents, and consent was gained after being fully informed of the process for data collection. All the patients received high-field MRI (3T Series) and HRCT (60-slice, spiral, bright-speed) radiological examinations as recommended by their ENT physicians. To generate high-quality coronal reformatted images, a multidetector CT scanner was used to do axial scanning in planes parallel to the infra-orbitomeatal line. Following that, the raw axial imaging data set was reconstructed with a section thickness of 0.3 mm. On a 512x512 matrix, images were evaluated using a high-resolution bone method. For independent recording of the right and left ears, a modest field of view (9 cm) was taken into consideration.

Statistical Package for Social Sciences version 26.0 was used to record, enter, and analyze the data. For ordinal variables, the mean± and standard deviation (SD) were calculated. The frequency and percentage were calculated for categorical variables of the study. The descriptive statistical data were used to compare and assess the anatomical abnormalities of each temporal bone.

RESULTS

The temporal bone in temporal region of 100 participants were bilaterally assessed. Hence, both left and right inner ear were radiologically evaluated. Out of total patients, 48% patients were males and 52% females. Patients were split into two groups based on their symptom (deafness), onset relative to the acquiring of language as Pre-Lingual and Post Lingual. Table-I shows patient distribution based on onset of symptoms in the pre-lingual category and post-lingual category. The pre-lingual group accounts for 58% of instances of deafness and is the most prevalent type. The etiological basis for deafness was congenital in 80% of the respondents making up a significant share, while acquired deafness was in only 20% of the cases as shown in Table-II

Table-I: Distribution of Respondents based on onset of Symptom relative to the Acquisition of Language (n=100)

Deafness	n(%)
Pre Lingual (Before acquiring language)	58 (58%)
Post Lingual (After acquiring language)	42 (42%)
Total	100%

Table-II: Distribution of Respondents based on Etiology of deafness (n=100)

Etiology	n(%)
Congenital	80 (80%)
Acquired	20 (20%)
Total	100%

HRCT Temporal bone was able to detect ossified or sclerotic lesions with aberrant hyper-density which were apparently insignificant on MRI, but focal cochlear fibrosis was detected solely by MRI. Table -III compares the abnormalities detected by each imaging modality in both ears of the participants.

Both MRI and HRCT of the temporal bone were helpful in determining the pathological basis of sensorineural hearing loss. Sclerosis and ossified lesions were well delineated by HRCT as compared to MRI. When it came to locating localized fibrosis and signal loss, MRI outperformed CT imaging. It was inferred from the results of the study that MRI was the sole imaging modality for the detection of abnormalities pertinent to the vestibulocochlear nerve.[12] cases showed no other abnormality except for a hypoplastic or aplastic vestibulocochlear nerve, which was detected on MRI, hence reflecting its superior nature in highlighting the soft tissue lesions.

DISCUSSION

This analytical study involved 100 patients at AFIRI Rawalpindi, compared the imaging outcomes of HRCT and MRI in SNHL patients. Both the MRI and HRCT of the patient's temporal bones were performed. All inner ear anomalies, including abnormal semicircular canals, vestibular malformations, and cochlear dysplasias, were considered for SNHL patients and are reported in the current study. As an authentic treatment approach for this debilitating disease process, the preferred method was cochlear implantation.[11] There is no maximum age for cochlear implants, and they are advised for children as young as 12 months.[12] All Cochlear implants are multichannel intra-cochlear arrays.[13] The findings demonstrated that neither the degree of hearing loss nor the CT scan results were statistically different in both genders. The bulk of our patients were mute, and every single one of them exhibited bilateral severe SNHL with no gender predominance, which was contrary to research done by Bamiou *et al.*, where the male predominance was observed in majority of SNHL patients.[14]

Table-III: Inner Ear Malformations detected with High-Resolution Computed Tomography and Magnetic Resonance Imaging Temporal Bone of 100 patients (200 Ears)

Pathology	High-Resolution Computed Tomography (n=200)	Magnetic Resonance Imaging (n=200)
Normal	110(55%)	108(54%)
Type II (Mondini's deformity)	24(12%)	24(12%)
Loss of internal configuration of cochlea and vestibule (type I incomplete partition)	19(9.5%)	19(9.5%)
Sclerosis and aberrant hyper-density	8(4%)	2(1%)
Loss of structural differentiation between cochlea and vestibule with formation of a cyst (common cavity malformation)	18(9%)	18(9%)
Total lack of inner ear structures (Michel's deformity)	10(5%)	10(5%)
Ossified lesions (late stage labyrinthitis ossificans)	5(2.5%)	0
Focal fibrosis	6(3%)	8(4%)

The study findings did not match with a study conducted in 2023 in Lahore, Pakistan, revealing that 69.9% of cases had normal structure on HRCT of the temporal bone and 2.5% had Mondini deformity, but in the current investigation, 55% of cases had normal structure and 10% had the malformation.[15] Thus highlighting an increase in inner ear deformities. Current research supports Mondini's explanation of this anomaly, with Mondini's and its variants being the most common abnormalities of the cochlea.[16] The small sample size of 21 patients in Johannes P. Westerhof *et al*.'s study, which was able to gather Mondini anomalies and SCC fusion with the vestibule, but couldn't yield the same results as this study. The variety of cases with inner ear and vestibulocochlear nerve abnormalities was included in the study to have generalizable results.[17] In line with a study conducted by D. Morgan *et al.*, the current study demonstrated that SCC and vestibular abnormalities were common among cochlear implant candidates.[18] The findings of this study are that HRCT and MRI are complementary to one another, supporting Indian research that highlights the significance of both HRCT and MRI as being required for preoperative evaluation of cochlear implant candidates.[19] The results of this study also support GN Fraun because, in both studies, MRI was able to detect nerves with greater accuracy than HRCT; however, bony structures were well appreciated with HRCT.[20]

LIMITATIONS OF STUDY

The study design, with a lack of a control group, observational inferences, exclusion of individuals with normal results, and lack of an association with risk variables, were all limitations in the study. The future research can be done in association with above mentioned aspects, and a much higher sample size will give a better understanding of the research objective.

CONCLUSION

The present study indicated that neither HRCT nor MRI temporal bone is the only imaging technique of choice for cochlear implant assessment. Both modalities precisely and comprehensively delineate the inner ear anatomy and its malformations, with the superior nature of MRI in assessment of nerve malformations and of HRCT in osseous malformations, with an added benefit of an overview in highlighting important anatomical variants noteworthy when planning cochlear implantation surgery.

Conflict of Interest: None.

Funding Source: None.

Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

JK & AURS: Conception, study design, drafting the manuscript, approval of the final version to be published.

RB & HA: Data acquisition, data analysis, data interpretation, critical review, approval of the final version to be published.

HKJ & ZS: Conception, data acquisition, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

REFERENCES

1. Tanna RJ, Lin JW, De Jesus O. Sensorineural Hearing Loss. In: StatPearls. Treasure Island (FL): StatPearls Publishing; 2025.
2. Jackler RK, Luxfor WM, House WF. Congenital malformations of the inner ear: a classification based on embryogenesis. Laryngoscope 1987; 97(S40): 2-14. https://doi.org/10.1002/lary.5540971301
3. Deep NL, Dowling EM, Jethanamest D, Carlson ML. Cochlear implantation: an overview. J Neurol Surg B: Skull Base 2019; 80(02): 169-177. https://doi.org/10.1055/s-0038-1669411
4. El-Zayat TM, Elfeshawy MS, Khashaba AH, El-Raouf A, Ezzat M. Role of CT and MRI in Assessment of Temporal Bone Pre and Post Cochlear Implantation. Egypt J Hosp Med 2019; 75(1): 2059-2063. https://dx.doi.org/10.21608/ejhm.2019.29724
5. Gifford RH. Cochlear Implant Candidate Selection. Cochlear Implants Other Implantable Hearing Devices. ed. 2nd, California; 2020: p.47-62.
6. Quirk B, Youssef A, Ganau M, D'Arco F. Radiological diagnosis of inner ear malformations in children with sensorineural hearing loss. BJR Open 2019; 1(1) https://doi.org/10.1259/bjro.20180050
7. Haber K, Burzyńska-Makuch M, Mierzwiński J. The role of preoperative imaging for auditory implants in children. Otolaryngol Pol 2021; 75(1): 23-35. https://doi.org/10.5604/01.3001.0014.2438
8. Agarwal P, Gupta Y, Mundra RK. Role of Imaging in Evaluating Patients for Cochlear Implantation. Indian J Otolaryngol Head Neck Surg 2023 13; 75(4): 2760–2768. https://doi.org/10.1007/s12070-023-03845-8
9. Dubey R, Sen KK, Mohapatra M, Goyal M, Arora R, Mitra S. Role of HRCT as a prime diagnostic modality in evaluation of temporal bone pathologies. Int J Contemp Med Surg Radiol 2020; 5(3): C8-C12. http://dx.doi.org/10.21276/ijcmsr.2020.5.3.4
10. World Health Organization (WHO), Deafness and Hearing Loss [Internet]. Available from: https://www.who.int/news-room/fact-sheets/detail/deafness-and-hearing-loss [Accessed on February 26, 2025]
11. Sharma SD, Cushing SL, Papsin BC, Gordon KA. Hearing and speech benefits of cochlear implantation in children: A review of the literature. Int J Pediatr Otorhinolaryngol 2020 1; 133: 109984. https://doi.org/10.1016/j.ijporl.2020.109984
12. Jachova Z, Ristovska L. Cochlear Implantation in Children With Hearing Impairment. Ann de la Facult de Philos 2022; 75: 483-496. http://hdl.handle.net/20.500.12188/25222
13. Carlyon RP, Goehring T. Cochlear implant research and development in the twenty-first century: a critical update. J Assoc Res Otolaryngol. 2021; 22(5): 481-508. https://doi.org/10.1007/s10162-021-00811-5
14. Bamiou DE, Phelps P, Sirimanna T. Temporal bone computed tomography findings in bilateral sensorineural hearing loss. Arch Dis Child 20001; 82(3): 257-260. https://doi.org/10.1136/adc.82.3.257
15. Akhtar M, Nasir S, Shoaib N, Masood K, Haq MM. Pre-Operative Evaluation of Petrous Temporal Bone Pathologies by CT and MRI in Cochlear Implant Candidates. Pak J Med Health Sci 2023 24; 17(03): 57. https://doi.org/10.53350/pjmhs202317357

16. William W M . What is a 'Mondini' and What Difference Does a Name Make? Am J Neuroradiol 1999; 20(8): 1442–1444.
17. Westerhof JP, Rademaker J, Weber BP, Becker H. Congenital malformations of the inner ear and the vestibulocochlear nerve in children with sensorineural hearing loss: evaluation with CT and MRI. J Comput Assist Tomogr 2001 1; 25(5): 719-726. https://doi.org/10.1097/00004728-200109000-00009
18. Morgan D, Bailey M, Phelps P, Bellman S, Grace A, Wyse R. Ear-nose-throat abnormalities in the CHARGE association. Arch Otolaryngol Head Neck Surg 1993 1; 119(1): 49-54. https://doi.org/10.1001/archotol.1993.01880130051006
19. Hanafi MG, Saki N, Shanehsaz F. Diagnostic value of CT and MRI of Temporal Bone in Cochlear Implantation Candidates. Int J Pediatr 2019; 7(7): 9693-9700. https://doi.org/10.22038/ijp.2019.39126.3339
20. Frau GN, Luxford WM, William WM, Berliner KI, Telischi FF. High-resolution computed tomography in evaluation of cochlear patency in implant candidates: a comparison with surgical findings. J Laryngol Otol 1994; 108(9): 743-748. https://doi.org/10.1017/s0022215100128002

....