Journal of Medicine in Scientific Research

Volume 4 | Issue 4 Article 16

Subject Area: Otolaryngology

The role of postoperative imaging in cochlear implants

Essam F. Mohammed
Ear Nose and Throat in the Hearing and Speech Institute, Essament2014@gmail.com

Recommended Citation

Mohammed, Essam F. (2021) "The role of postoperative imaging in cochlear implants," *Journal of Medicine in Scientific Research*: Vol. 4: Iss. 4, Article 16.
DOI: https://doi.org/10.4103/jmisr.jmisr_25_21

The role of postoperative imaging in cochlear implants

Essam F. Mohammed
Ear Nose and Throat in the Hearing and Speech Institute, Imbaba, Giza, Egypt

Abstract

Objective
The aim was to evaluate the role and efficacy of high-resolution computed tomography (CT) scan after cochlear implantation in evaluating the integrity and insertion of the electrode, whether complete or incomplete, whether intracochlear or extracochlear, and whether to change the decision for revision or not.

Sitting
The study was conducted at the Hearing and Speech Institute.

Patients and methods
All the patients 300 cases undergo CT scan radiology within one week postoeratively and reevaluated for electrode insertion. Complete, incomplete, or over insertion. intracochlear or extracchlear.

Results
This study was carried out on 312 cases from January 2019 to December 2020. Age ranged from 1.2 to 64 years, with a median age of 9.7 years. The number of children under the age of 18 was 254 cases, with a median age of 4.3, and the number of cases above 18 years was 58 cases, with a median age of 33.6 years. The right ear was implanted in 280 cases. Male patients represented 152 cases, and female patients represented 148 cases. Postoperatively CT scan showed two cases with major complication (extracochlear insertion) that required revision surgery. A total of 290 cases had standard insertion, five cases showed one electrode extracochlear, and three cases showed overinsertion, with no intervention performed.

Conclusion
The radiograph only affects the decision making and patient management. CT high-resolution is mandatory after cochlear implants.

Keywords: Cochlear implant, computed tomography, temporal bone

Background

Individuals who experience severe hearing impairment and do not benefit from wearing a hearing aid should be treated using a cochlear implant. Cochlear implantation has become the first line in the treatment of cases of severe to profound sensory hearing loss due to the interest of countries moreover, the growth of training and rehabilitation programs. The electrodes inserted classically into the scala tympani stimulate the spiral ganglion by bypassing the nonfunctional hair cells [1,2]. To obtain good results, it is necessary to check the preoperative procedures and to provide good conditions during the surgery and to ensure that the electrode is in place, straight, and adjacent even to the lateral wall or premodiolar [3,4]. We speak about postoperative evaluation to check the electrode insertion, whether cochlear or extracochlear, complete or partial, and any migration of the electrode postoperatively. Insertion of electrode may be associated with difficulty, leading to improper insertion, ranging from minor complications, such as incomplete insertion, kinking, tip rollover, and scalar transition, to extracochlear placement, which is considered a terrible complication owing to its effect on the postoperative

Access this article online

Quick Response Code:

Website: www.jmsr.eg.net

DOI: 10.4103/jmisr.jmisr_25_21

Correspondence to: Essam F. Mohammed, MD, Department of otolaryngology, Hearing and Speech Institute, Imbaba, Giza, Egypt. Tel: 01227743007; E-mail: essament2014@gmail.com

Submitted: 26-Mar-2021 **Revised:** 25-Apr-2021 **Accepted:**20-May-2021 **Published:** 11-Dec-2021

How to cite this article: Mohammed EF. The role of postoperative imaging in cochlear implants. J Med Sci Res 2021;4:375-9.

hearing and speech results because of its failure to provide a benefit and cause hazards to adjacent neurovascular structures. Revision surgery is mandatory and urgent. Extracochlear placement is very rare (0.37%) [5]. So, very careful and meticulous electrode insertion is one of the vital factors affecting the results postoperatively. To gain more information for confirmation a perfect insertion of electrodes, an ideal way of imaging postoperatively is essential. Postoperative imaging to evaluate the patients after multichannel cochlear implantation has been described in the otolaryngologic literature [6–9]. There is no standard accepted protocol for postoperative imaging in cochlear implantation. Practically, imaging ranges from routine intraoperative or postoperative imaging, to imaging in selected patients in whom there is an operative difficulty in electrode insertion. Three-dimensional rotational radiography, and computed tomography (CT) may also be performed intraoperatively or postoperatively for more detailed array localization [10]. In our institute, cochlear implants are now being done as day-case procedures [11]. We perform postoperative CT scan within 1 week from discharge of the patients, but in difficult cases of insertion, we do it on the second day. The target of this project is to evaluate the postoperative imaging of the multichannel cochlear implant and to suggest the role of imaging evaluation of patients after implant insertion.

Patients and methods

The Ethics Committee of the Research Center approved the thesis. The study adhered to the tenets of the Declaration of Helsinki. All participants signed an informed consent form. This retrospective study was carried out from January 2019 to December 2020. The study included children and adult patients. All the patients underwent complete physical and psychological assessment. Preoperative full radiological data were extracted to exclude contraindicated cases. Cochlear implant surgery team in the hearing and speech institute performed the surgery. The procedure was done as the standard approach for CI, including postauricular incision, cortical mastoidectomy, posterior tympanotomy, and round window or extended round window approach to the cochlea. We prepared a bed for the receiver. The dura is most probably exposed in children but less in adult. After fixation of the receiver, we inserted the electrode. This step is reviewed by the team, especially in suspected difficult cases, and then the electrode is secured by muscles within the posterior tympanotomy. Another way to ensure that the electrode is inside the cochlear duct and is working properly is intraoperative tests such as electrical impedance telemetry and electrically evoked compound action potentials by noting the number of intracochlear electrodes. Moreover, in difficult cases, we check the stapedial reflex. Then, we close the wound. The patient is discharged on the second day under regimen of medical treatment and reviewed after 1 week with postoperative CT to evaluate the electrode position, integrity, and straightness. The team of CI surgery and consultant of radiology reevaluated all radiological data, especially in cases with serious complication; serious complication includes extracochlear placement of the electrode.

Results

The study was carried out on 312 cases, with 313 electrodes used, from January 2019 to December 2020. Age ranged from 1.2 to 64 years, with a median age of 9.7. The number of children under the age of 18 years was 254 cases, with median age of 4.3, and the number of cases above 18 years was 58 cases, with a median age of 33.6 years. Only one case was implanted bilaterally simultaneously. Three cases of revision one in the same ear, two in the contralateral ear, and revision cases due to hard failure from years ago. Six cases with cochlear anomalies as common cavity that have incomplete insertion that known intraoperative by surgeon and by electrical tests. Three cases known to have meningitis and have difficult and incomplete insertion. Revision cases, cases of cochlear anomalies, and meningitis cases (12 cases) are excluded from the study. Right ear was implanted in 280 cases and the left ear in 21 cases. Male patients were 152 cases (50.6%) and female patients were 148 cases (49.4%). We implanted the devices of Med-el in 60.2%, AB in 5.7%, Cochlear in 32%, and Oticon in 1.9%. All cases were done by the team of CI in our institute with no complications recorded intraoperatively or postoperatively. The electrode insertion was evaluated by telemetry; evoked action potential and evoked stapedial reflex showed complete insertion in 281 patients; two cases showed no response at all. A total of 18 cases showed no response in one or two electrodes only. All the patients (300 cases) underwent CT scan radiology within one week, except for the two cases with no response at all. They underwent CT on the second day. In the first patient who was complaining of vertigo, we found the electrode in the lateral semicircular canal (Fig. 1). This patient underwent urgent revision surgery. The round window was widened, especially at the crista fenestra, and the electrode was reinserted. In the second case, the electrode was found in the middle ear and also underwent revision surgery two days later (Fig. 2). In the two cases, all electrical tests intraoperatively showed positive results. A total of 290 cases showed complete insertion (Fig. 3), five cases showed only one electrode outside the cochlea (Fig. 4a), and three cases show overinsertion (Fig. 4b and 4c). All cases show no underlying fluid collection and the receiver/stimulayor is well fit figure (Fig. 4d). The digital x ray demonstrates normal configuration of the distal cochlear implant wire spiraling within the cochlear (Fig. 5). Electrical tests done postoperatively showed positive results in all cases, except five cases with no response in one electrode only. Only two cases showed major complications that necessitated urgent surgery. Minor complications were recorded only in eight cases. Nothing was done for these cases, with satisfactory results.

Discussion

Cochlear implantation become the standard management of sever to profound SNHL with no response to the hearing

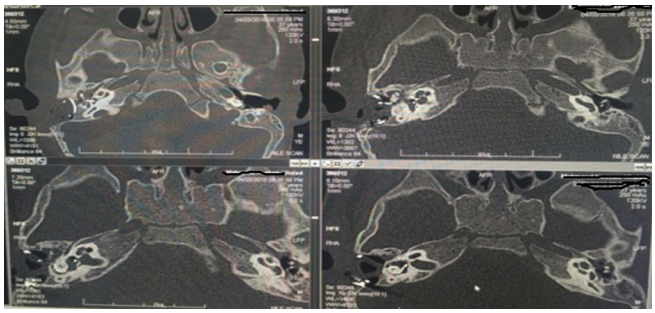

Figure 1: HRCT scan imaging of the temporal bone, post cochlear implant. Right ear show the electrode in the lateral semicircular canal, major complication.

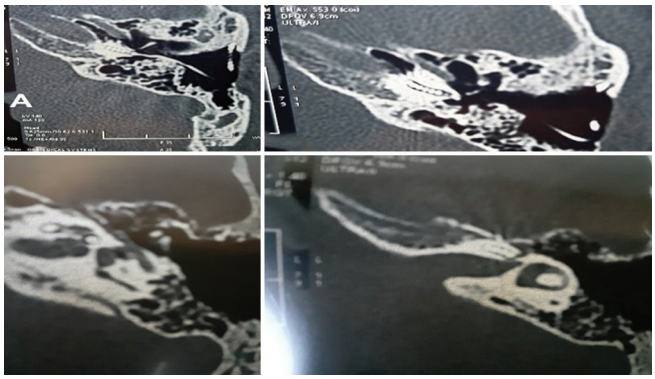

Figure 3: HRCT scan imaging of the temporal bone, post cochlear implant. Right ear, axial view show stander insertion of the electrode, basal turn, middle turn and apex of the cochlea.

aid [12,13]. It is associated with very minor complication, wound dehiscence, or infection, ranging from 0.26% to 2.09% of cases, and complications related to electrode insertion are estimated in the literature at 0.17% to 12.2%. A reason for these rare complications is that all patients undergoing CI surgery are evaluated carefully by full examination preoperatively to detect any anatomical abnormalities or even any pathological conditions [14]. Our study was done to evaluate the use of postoperative imaging and whether it will affect the decision making. We consider that radiology performed postoperatively carries the same importance as preoperative radiology to obtain high successful results, as children cases usually have no time to be lost, and they require high results to obtain useful language skills. We found two cases (0.6%) with extracochlear implantation that necessitated a revision surgery. These results are in harmony with the results of a recent literature study estimating a rate of 0.37% [5]. We found one electrode in the lateral semicircular canal (0.3%) and the other electrode in the middle ear (0.3%). We found that the incidence of the common site in the recent literature greatly varies as follows: superior semicircular canal is the common in the study of Ramalingam, Sorrentino, and Cosetti [10,15,16]; the vestibule [17]; the lateral semicircular canal [18]; may be hypotympanic air cells [19]; and may also found the electrode in the Eustachian tube, internal auditory meatus, and internal carotid artery, according to the recent literature studies by

Figure 2: HRCT scan imaging of the temporal bone, post cochlear implant. Right ear (a), axial view; (b) coronal view, show no electrode in the cochlea, the electrode in the hypotympanum.

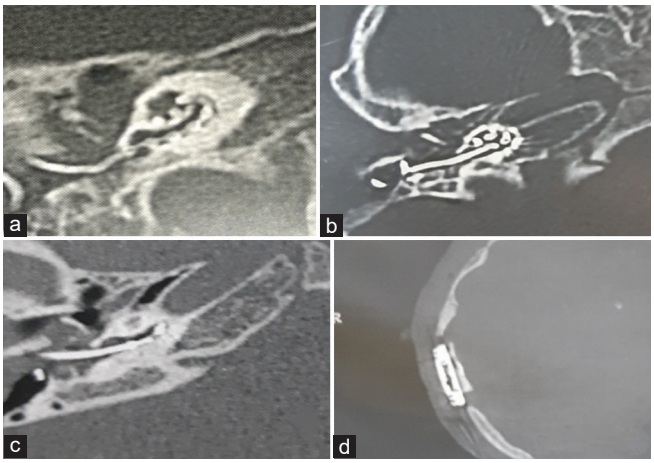

Figure 4: HRCT scan imaging of the temporal bone, post cochlear implant. (a), axial view show one electrode outside of the cochlea. (b and c), axial view show overinsertion of the electrode. (d) Axial CT scan of the skull at the level of implant bed with no underlying fluid collection and the receiver / stimulator is well fit.

Ying, Todt, and Nevoux, respectively [5,20,21]. The site of extracochlear electrode does not change the decision of revision surgery for two causes: the first to avoid damage to any neurovascular structure, and the second cause to gain benefit from the implant. We find also the compatibility between the electrical tests and the radiological finding in extracochlear insertion. Our explanation of the possible causes of extracochlear insertion of the implants by the shape and size of cochlea may have a dynamic effect on the insertion of the electrode. Moreover, a contributing factor was malposition of the head of the patients and surgical difficulties such as small mastoid and narrow posterior tympanotomy; all these factors cause poor visualization, limited access, and abnormal angle of insertion of electrode. Most cases (>50%) had no adverse factors predisposing to IEI. Moreover, Lee *et al*.[22] found in a histopathological analysis of 27 temporal bones analyzed for IEI no remarkable soft tissue or bony intrascalar obstruction in most of the cases. Minor complication such as incomplete insertion in our review was seen in only 3 cases (1%),

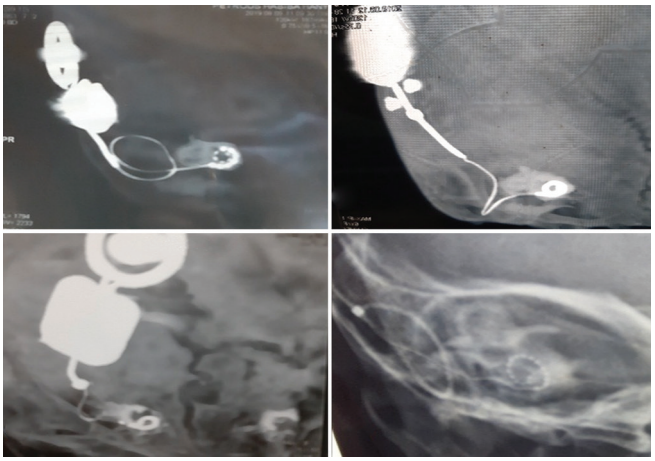

Figure 5: Postoperative imaging. a Modified Stenvers view of the right temporal bone .The digital X-ray demonstrates normal configuration of the distal cochlear implant wire spiraling within the cochlea.

confirmed by radiology and electrical tests, which are one of the best results in the literature, owing to the exclusion of cases of meningitis and cochlear anomalies. Shpizner *et al*.[23] and Coombs *et al*.[24] reported a 9.2% rate of incomplete insertion on imaging. The electrical tests intraoperatively may be affected by air bubbles, blood, and deficient perilymph in the cochlear duct, so there could be discrepancy between intraoperative electrical tests and postoperative electrical tests and radiology. Our protocol is postoperative radiology. However, some centers prefer intraoperative radiology to manage accordingly at the same anesthesia, but this requires certain equipment, is time consuming, and has some limitations, as it is usually done with plain radiography. We prefer CT radiology, whereas others prefer three-dimensional rotational radiography [25]. In our study, we reviewed that the intraoperative electrical impedance and electrically evoked compound action potentials cannot affect the decision, and high-resolution CT only affects the decision making and patient management. Imaging considered by our institute is mandatory postoperatively for providing a feedback, future development data, and for medicolegal in cases of future extrusion.

Conclusion

Postoperative plain radiology is routinely done as a part of cochlear implant surgery to be sure that the position of the electrode array intracochlear, complete or incomplete insertion. Plain radiographs act as a reference in case of future electrode migration and provide the surgeon with feedback on array position. Postoperative radiology continues be an essential step of cochlear implants. CT scan is preferred than plain radiography. Radiology has no role in minor complication of array insertion.

Recommendation

We recommend searching for how to evaluate radiologically the quality of electrode insertion rather than complete or incomplete insertion and provide rapid technique with lower radiation. We must pay attention toward the electrode intracochlearly, in relation to the lateral wall or perforation of basilar membrane (Fig. 6).

Figure 6: (a) Paracoronal reconstruction at the level of the basal turn of the right cochlea we can count the number of the electrode in the cochlea and assess the relation of the electrode to the lateral wall. (b), paraxial view, right ear, show artifact but can evaluate the electrode intracochlear. (c), axial view of the left temporal bone show the relation of the electrode to the lateral wall.

Conflicts of interest

None.

References

1. Lenarz T, Laszig R. Cochlea-Implantat Versorgung und zentral-auditorische Implantate. Leitlinie der Deutschen Gesellschaft für Hals-Nasen- Ohren-Heilkunde, Kopf- und Hals-Chirurgiee.V., Bonn. Register number 017-071. Autorisiert für elektronische Publikation: AWMF. 2012. Available at:. http://www.awmf.org/leitlinien/detail/ll/017-*071.html* [accessed April 18, 2014].
2. Witte RJ, Lane JI, Driscoll CLW, Lundy LB, Bernstein MA, Kotsenas AL, Kocharian A. Pediatric and adult cochlear implantation. Radiographics 2003; 23:1185–1200.
3. Aschendorff A. Imaging in cochlear implant patients. Laryngorhinootologie 2011; 90:S16–S21.
4. Trimble K, Blaser S, James AL, Papsin BC. Computed tomography and/or magnetic resonance imaging before pediatric cochlear implantation? Developing an investigative strategy. Otol Neurotol 2007; 28:317–324.
5. Ying YL, Lin JW, Oghalai JS, Williamson RA. Cochlear implant electrode misplacement: incidence, evaluation, and management. Laryngoscope 2013; 123:757–766.
6. Rosenberg RA, Cohen N, Reede DL. Radiographic imaging for the cochlear implant. Ann Otol Rhinol Laryngol 1987; 96:300–304.
7. Ball JB, Miller GW, Hepfner ST. Computed tomography of single channel cochlear implants. Am J Neuroradiol 1986;7:41–47.
8. Gray RF, Evans RA, Freer CE, Szutowicz HE, Maskell GF. Radiology for cochlear implants. J Laryngol Otol 1991; 105:85–88.
9. Marsh MA, Xu J, Blamey PJ, Whitford LA, Xu SA, Silverman JM, Clark GM. Radiologic evaluation of multichannel intracochlear implant insertion depth. Am J Otol 1993; 14:386–91.
10. Cosetti MK, Troob SH, Latzman JM, Shapiro WH, Roland JT, Waltzman SB. An evidence-based algorithm for intraoperative monitoring during cochlear implantation. Otol Neurotol 2012; 33:169–176.
11. Powell HR, Rowlands RG, Lavy JA, Wright A. Day-case pediatric middle ear surgery: from myringoplasty to bilateral cochlear implantation. Int J Pediatr Otorhinolaryngol 2010; 74:803–806.
12. Isaacson B, Lee K, Kutz Jr, Roland PS, Sargent EW. Cochlearimplants,

indications. Emedicine. 2008. Available at: http://www.emedicine.com/ent/topic424.*htm.* [Last accessed on 2008].
13. Whiting BR, Bae KT, Skinner MW. Cochlear implants: threedimensional localization by means of coregistration of CT and conventional radiographs. Radiology2001; 221:543–549.
14. Roland JT. Complications of cochlear implant surgery. In: Waltzman SB, Cohen N, editors. *Cochlear Implants*. New York, NY: Thieme; 2000. 170–177.
15. Ramalingam R, Ramalingam KK, Padmaja HS. An unusual occurrence in cochlear implantation surgery: misplaced electrode. J Laryngol Otol 2009; 123:e4.
16. Sorrentino T, Cote M, Eter E, Laborde ML, Cochard N, Deguine O, *et al*. Cochlear reimplantations: technical and surgical failures. Acta Otolaryngol 2009; 129:380–384.
17. Muzzi E, Boscolo-Rizzo P, Santarelli R, Beltrame MA. Cochlear implant electrode array misplacement: a cautionary case report. J Laryngol Otol 2012; 126:414–417.
18. Rotteveel LJ, Beynon AJ, Mens LH, Snik AF, Mulder JJ, Mylanus EA. Cochlear implantation in 3 patients with osteogenesis imperfecta: imaging, surgery and programming issues. Audiol Neurootol 2008; 13:73–85.
19. Windmill IM, Martinez SA, Nolph MB, Eisenmenger BA. Surgical and nonsurgical complications associated with cochlear prosthesis implantation. Am J Otol 1990; 11:415–420.
20. Todt I, Rademacher G, Ernst A. Identification and revision of a displaced cochlear implant electrode in the internal auditory canal. Cochlear Implants Int 2013; 14:236–239.
21. Nevoux J, Loundon N, Leboulanger N, Roger G, Ducou Le Pointe H, Garabedian EN. Cochlear implant in the carotid canal. Case report and literature review. Int J Pediatr Otorhinolaryngol 2010; 74:701–703.
22. Lee J, Nadol JB, Eddington DK. Factors associated with incomplete insertion of electrodes in cochlear implant surgery: a histopathologic study. Audiol Neurotol 2011; 16:69–81.
23. Shpizner BA, Holliday RA, Roland JT, Cohen NL, Waltzman SB, Shapiro WH. Postoperative imaging of the multichannel cochlear implant. Am J Neuroradiol 1995; 16:1517–1524.
24. Coombs A, Clamp PJ, Armstrong S, Robinson PJ, Hajioff D. The role of post-operative imaging in cochlear implant surgery: a review of 220 adult cases. Cochlear Implants Int 2014; 15:264–271.
25. Cosetti MK, Waltzman SB. Outcomes in cochlear implantation: variables affecting performance in adults and children. Otolaryngol Clin North Am 2012; 45:155–171.