International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Dislocation of Internal Magnet of a Cochlear Implant: A Case Study

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Abstract:

Introduction: A cochlear implant is a surgically implanted electronic device that provides a sense of sound to a person who has severe to profound sensorineural hearing loss. It consists of two parts- external and internal. These parts may suffer complications due to several reasons. One of the complications is the dislocation of internal magnet of the implant due to minor head traumas.

Aim: The aim of this study was to highlight the role of audiological findings in a case of magnet displacement of cochlear implant and to recommend appropriate management strategy.

Methodology: A case aged 6 years, male with right ear being implanted came to the department with a complaint of coil being attached behind the pinna instead of its previous location and inability to hear through the implant. The intra-operative and post-operative audiological tests such as impedance and NRTs were measured to assess the functional integrity of the cochlear implant. In addition to this, for assessing structural integrity of cochlear implant, radiological evaluation was done and which was subjected to comparison with the radiological findings immediately after the surgery.

Result and discussion: The intra-operative impedance values were within normal limits across all the 22 electrodes. However, at present impedance values were normal for electrodes 4 to 22 except electrode 1 to 3. The impedance values for electrodes 1 to 3 has increased gradually. Hence, ruling out it to be the effect of accidental internal magnet displacement. The intra and post Auto-NRT showed presence of ECAPs at all the electrodes except 1 to 3. The absence of ECAPs at electrodes 1 to 3 was not related to electrode migration post-accident but was existing prior to the complaint. The comparison of radiological evaluation done immediately after the surgery with that of the post-complaint, confirmed the dislocation of internal magnet of implant alone.

Conclusion: The present study confirmed internal magnet dislocation through comparison of intra-operative and post-operative impedance and NRT findings along with radiological evaluation. Thus, as a healthcare professional, an audiologist should counsel the parents to be cautious about the child's activities in daily living and safety from any physical trauma.

Keywords: Cochlear Implant, ECAP, NRT, Impedance

Introduction:

Cochlear implants (CI) are surgically implanted electronic devices that provide sense of hearing to a person with permanent hearing impairment. The essential components in a cochlear prosthesis system include a microphone for sensing sound in the environment, a speech processor to transform the microphone input into a set of stimuli for the implanted array of electrode, transcutaneous link for the transmission of power and stimulus information across the skin, an implanted receiver/ stimulator to decode the information received from the radiofrequency signal produced by an external transmitting coil, a cable to connect the outputs of the receiver/ stimulator to the electrodes; and, the array of electrodes (Moller, 2006). Adding further, the cochlear implant's functionality is assessed through objective measures at the time of surgery (intra-operative) and on regular intervals after the surgery is completed (post-operative). Few among the many measurements are: Impedance telemetry, Neural Response Telemetry (NRT) or electrically evoked compound action potentials (ECAP) etc. Impedance measures provide information about the properties of the tissue in contact with the electrode's surface. It is not uncommon to see changes in electrode impedance over time. Once the implant is stimulated, impedance typically decreases gradually and is stabilized within the first few months of device use. Abnormal increase or decrease in impedance values of the electrodes after stabilization help in determining various conditions (Hall, 2015).

ECAP is a synchronous physiological response from an aggregate population of auditory nerve fibres in response to electrical stimulation. It is characterized by a negative deflection, N1, followed by a positive peak or plateau, P2. The ECAP is elicited by stimulation through the cochlear implant. A measurable ECAP response can be used to verify electrode function. ECAPs are measured at the time of surgery and periodically on regular intervals after stimulation (Michelle, 2016).

Nonetheless, surgery for cochlear prosthesis insertion exposes the patient to several potential risks. An important non-surgical complication in the paediatric population is trauma to the head, which may either damage the parts of the implant or dislocate it from its original place. Such physical traumas could build up structural changes which need medical intervention whereas functional change requires intervention at the level of device mapping. One such problem occurs due to internal magnet displacement. There are various reasons for propensity of magnet displacement due to trauma. It could be due to thinness or higher curvature of child's skull. Due to this curvature, the magnet gets placed at a greater angle relative to the receiver-stimulator making it more susceptible to dislocation (Yun, Colburn & Antonelli, 2005). The removable internal magnet has been deliberately designed so that it could be extracted in case of an operation involving magnetic field interaction such as MRI (Bumgartener, Youssefzadeh & Hamzavi, 2001). Thus, detection and management of such a complication should be dealt by cochlear implant team members mainly audiologist and cochlear implant surgeon as an emergency.

Methods:

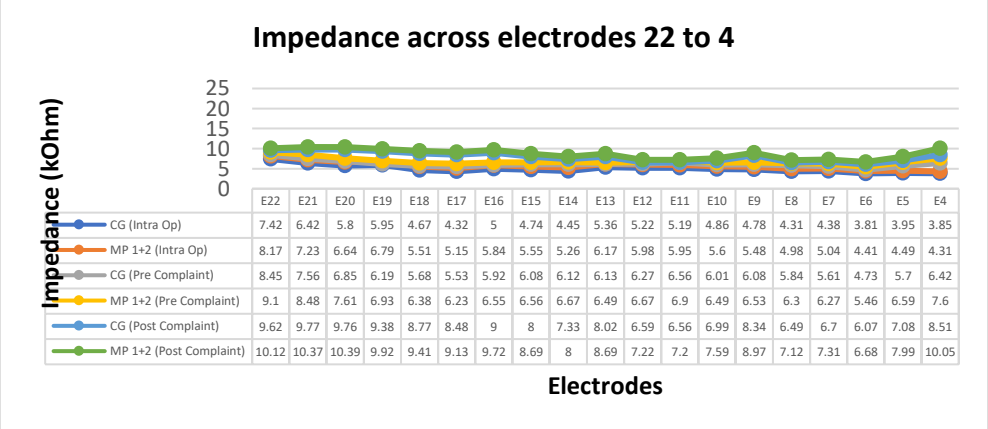
A child of age 3 years 6 months came to SAIMS, Indore (M.P.) under RBSK scheme and was fulfilling all the needed criteria for candidacy of cochlear implant surgery with respect to the scheme. CI surgery was done on 29th January, 2018 using CI24RE straight electrode array (internal implant), and N5 CP802 (external processor). Thereafter, the child attended the scheduled mapping and speech language therapy sessions though inconsistently. Later, the child came to the department at the age of 6 years, with the complaint that the coil was not attaching on the head where it was attaching previously, but behind the pinna and inability to hear through the implant. When the cause was probed, it was found that the child

used to play with magnetic toys and with no history of physical trauma. In addition to this, during visual inspection there were no signs of swelling and extrusion on the site of the magnet alignment. Henceforth, impedance telemetry, NRT, ENT evaluation and radiological evaluation (plain X-ray) were performed. Impedance and NRT measurements were performed to assess the functional integrity of cochlear implant whereas the radiological evaluation helped in assessing the structural integrity of cochlear implant. For impedance and NRT measurements, Custom Sound 5.1 software by Cochlear manufacturer was used. Alongside, the hardware constituents were speech processor (N5 CP802), implant CI24RE straight, a coil cable, coil with magnet and wireless programming pod (WPP).

Results and Discussion:

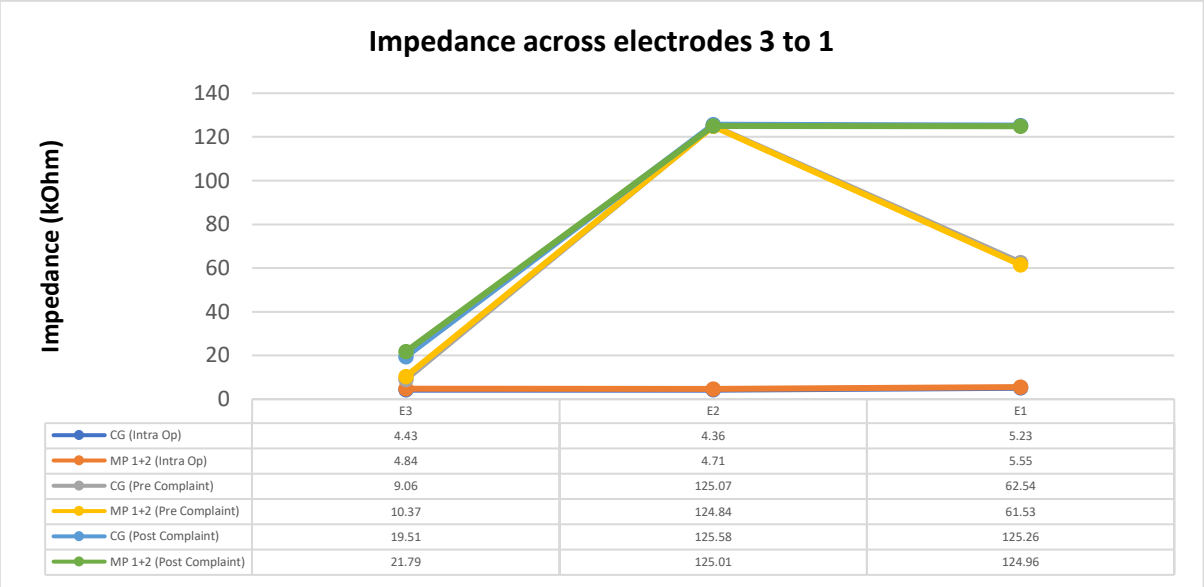
The functional changes and integrity of cochlear implant can be evaluated using impedance measurements and NRT. The intra-operative record of neural responses (ECAP) is the baseline for future monitoring of the device function. Hence, comparison between intra-operative and post-complaint findings of impedance, NRT and radiological evaluation serves to measure functionality of internal cochlear implant. In present case, audiological and radiological evaluation was performed. The audiological evaluation consisted of impedance telemetry and NRT. To begin with telemetry, Cochlear implant's processor was connected with Custom Sound 5.1 software via WPP and it was found that software could not detect the internal implant when the external coil was being placed where it was attaching through magnetic attraction. Later, when the external coil was placed manually (holding it close to the receiver stimulator) at its original position, i.e. prior to the trauma. In this position of the transmitter, the software detected the implant suggesting displacement of the internal magnet only and not the implant itself. Impedance values for 22 to 4 and 3 to 1 electrodes on Common Ground (CG) and Monopolar 1+2 (MP1+2) stimulation modes, were compared at three different timelines (at the time of surgery, pre-complaint and post-complaint) as shown in Graph 1 and Graph 2 respectively. Intra-operative impedance values were within normative limits for all the 22 electrodes suggestive of normal conductance of electrical stimulations across the electrodes. However, post complaint impedance values revealed open circuit at electrodes 1, 2 and 3 which were at basal end of the cochlea. Pre-complaint impedance values were then subjected to comparison with that of post-complaint and it was noted that impedance values of electrodes 1, 2, and 3 increased gradually thus, ruling out it to be the effect of any trauma.

Graph 1: Impedance changes of the electrodes 22 to 4 at CG and MP1+2 stimulation modes across three timelines (at the time of surgery, pre-complaint & post-complaint)



	E22	E21	E20	E19	E18	E17	E16	E15	E14	E13	E12	E11	E10	E9	E8	E7	E6	E5	E4
CG (Intra Op)	7.42	6.42	5.8	5.95	4.67	4.32	5	4.74	4.45	5.36	5.22	5.19	4.86	4.78	4.31	4.38	3.81	3.95	3.85
MP 1+2 (Intra Op)	8.17	7.23	6.64	6.79	5.51	5.15	5.84	5.55	5.26	6.17	5.98	5.95	5.6	5.48	4.98	5.04	4.41	4.49	4.31
CG (Pre Complaint)	8.45	7.56	6.85	6.19	5.68	5.53	5.92	6.08	6.12	6.13	6.27	6.56	6.01	6.08	5.84	5.61	4.73	5.7	6.42
MP 1+2 (Pre Complaint)	9.1	8.48	7.61	6.93	6.38	6.23	6.55	6.56	6.67	6.49	6.67	6.9	6.49	6.53	6.3	6.27	5.46	6.59	7.6
CG (Post Complaint)	9.62	9.77	9.76	9.38	8.77	8.48	9	8	7.33	8.02	6.59	6.56	6.99	8.34	6.49	6.7	6.07	7.08	8.51
MP 1+2 (Post Complaint)	10.12	10.37	10.39	9.92	9.41	9.13	9.72	8.69	8	8.69	7.22	7.2	7.59	8.97	7.12	7.31	6.68	7.99	10.05

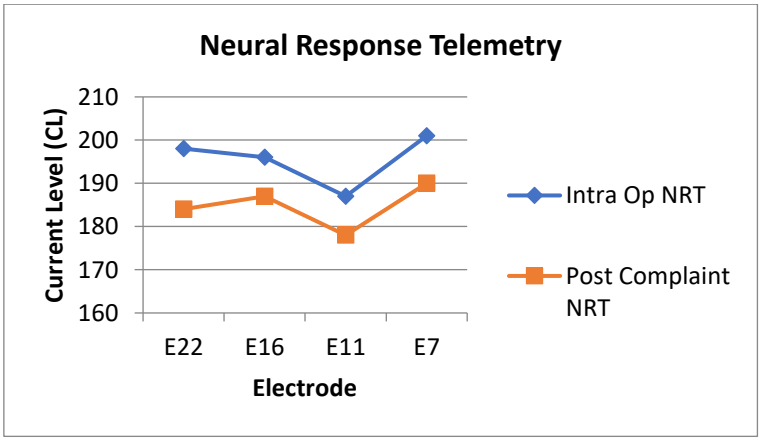
Graph 2: Impedance changes of the electrodes 3 to 1 at CG and MP1+2 stimulation modes across three timelines (at the time of surgery, pre-complaint, post-complaint)



	E3	E2	E1
CG (Intra Op)	4.43	4.36	5.23
MP 1+2 (Intra Op)	4.84	4.71	5.55
CG (Pre Complaint)	9.06	125.07	62.54
MP 1+2 (Pre Complaint)	10.37	124.84	61.53
CG (Post Complaint)	19.51	125.58	125.26
MP 1+2 (Post Complaint)	21.79	125.01	124.96

The findings of intra-operative and post-complaint NRT revealed similar results. ECAP were present at electrodes 22, 17, 12, and 7 and absent at electrodes 1, 2 and 3 as observed in Graph 3. The absence of ECAP at these electrodes can be due to electrodes lying outside the cochlea at the time of surgery. To conclude from the above findings, absence of ECAP was not related to electrode migration post-complaint but was existing since the time of surgery.

Graph 3: Comparison of intra-operative and post-complaint NRT



Furthermore, as a part of radiological evaluation, the child was sent for Plain X-ray scan post-complaint. Plain X-ray scan which was taken immediately after the surgery (Figure 1) and the second one taken post-complaint (Figure 2) were compared which revealed that the internal magnet has been displaced. However, no displacement of internal implant and electrode array was noted by comparing the loop of electrode array between the two X- rays. Thus, the audiological evaluation findings helped to detect the problem of internal magnet dislocation with no electrode migration. These findings were confirmed with the radiological evaluation. Hence, the child was recommended for revision surgery in order to replace the internal magnet of CI.

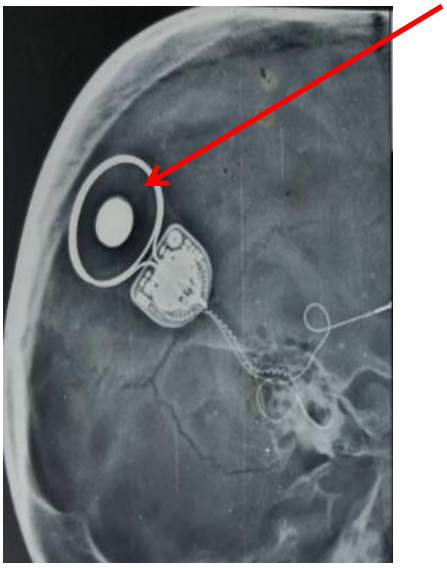


Figure 1: X-ray (Trans-oblique view) scan of temporal bone after Cochlear Implant surgery but before discharge.

Figure 2: X-ray (Trans-oblique view) scan of temporal bone post complaint.

Conclusion:

The current study validates the displacement of the internal magnet within the implant by analysing intra-operative and post-complaint impedance and NRT data alongside radiological assessments. It was advised that the child should undergo revision surgery to replace the internal magnet. Consequently, as a healthcare provider specializing in cochlear implants, it's crucial for audiologists to educate parents on safeguarding their child from potential accidents and minimizing the risk of trauma in daily living activities.

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