Magnet migration in a cochlear implantee – a serendipitous diagnosis

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Abstract The successful outcome of a cochlear implant habilitation program depends upon a multitude of vital factors, including the avid cooperation of the cochlear implantee, committed participation of the parents/family members and total dedication of the habilitation team of implant audiologists and auditory verbal therapists. In a rare situation, where the implantee's performance is suboptimal or poor inspite of successful implantation, anxious moments engulf the parents and the implant team, with the morbid fear of a device failure lingering at the back of their minds. We report such an incident in a 13-year-old cochlear implantee, who was an excellent cochlear implant performer for 8 years, following which she had rapid deterioration of her auditory verbal skills within the next few weeks. The hidden etiology, was the inconspicuous migration of the internal magnet of the Receiver-Stimulator Coil placed in the mastoid temporal bone of her skull, due to unexplained reasons. We share our experience with the diagnosis and management of this condition and review the existing world literature on this rarely reported entity.

Keywords Cochlear implantation · Receiver-stimulator coil magnet · Neural response and impedance telemetry (NRT/IT) · Cochlear mapping · Category of auditory performance (CAP) · Speech intelligibility rating (SIR) · Auditory verbal habilitation

Introduction

The journey of a successful cochlear implantee commences from a deaf world, often as a dramatic event at 'Switch On', meanders through an intense course of auditory verbal habilitation and completes with his or her successful integration into the society as a normal individual. Outcomes of cochlear implantation are monitored throughout the habilitation period, based upon the CAP and SIR scores as postulated by O'donoghue et al.[1, 2]. Immense joy is felt by the entire implant team on achieving the anticipated results at the completion of a successful habilitation program.

In certain difficult to map individuals, it may be an intriguing challenge for an experienced implant team, to elicit the optimal thresholds for auditory stimulation via the cochlear implant, in order to induce ideal behavioral responses in the implantee. A situation may arise, where the implantee's performance is suboptimal or poor inspite of successful implantation, inducing anxiety in the minds of the parents and the implant team. Electrophysiological correlations with psychophysical behavioral thresholds become paramount in such difficult mapping situations. Recent advances in electrophysiology and mapping technology, have paved a way to explore such challenges and find ideal solutions.

We report one such diagnostic challenge experienced by our implant team, due to the inconspicuous migration of an internal magnet of the Receiver-Stimulator Coil in a cochlear implantee, which lead to rapid deterioration in her auditory skills. This article highlights the inclusion of this rare entity, in the etiology of a cochlear implantee's poor auditory verbal performance.

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The MERF experience

A 13-year-old intelligent girl of non-consanguineous parentage, with normal perinatal history, normal growth and developmental milestones was diagnosed with congenital bilateral severe to profound cochlear hearing loss. She

Fig. 1 X-ray skull AP and lateral views displaying the magnet which has migrated from its socket in the Receiver-Stimulator Coil of the cochlear implant

underwent cochlear implantation in her right ear, at 3 years of age. She had completed successful auditory verbal habilitation for 1 year at our institution, under the intense scrutiny of her well trained parents and an experienced implant team. She joined a normal school and has been a brilliant student since then for the past 8 years, being an excellent performer with her cochlear implant until recent times. Her cognition was age appropriate, speech was intelligible to all listeners and language development was remarkable. She could participate in abstract or general conversations using appropriate prepositions, conjunctions, adjectives and verbs fluently and could also chat over a telephone with known and unknown listeners.

She presented to our cochlear implant clinic, with complaints of insidious, recent onset of rapid deterioration in her auditory verbal skills, since the past few weeks. She was presently unhappy and irritable, having realized that she was unable to use her cochlear implant optimally and was progressively losing her hearing capabilities. She perceived acoustic distortions to loud sounds, when the implant was switched on and could not comprehend conversations in a crowded atmosphere like her classroom. She had to concentrate and strain her ears to pick up conversations, which she could easily comprehend previously at home and in school. As a result, she frequently preferred to switch off her implant at school and attempted to lip read.

At the first hint of deterioration in her hearing skills, her mother took her to our implant audiologist, who rechecked her map. He had also performed electrophysiological tests to objectively correlate her present poor auditory verbal scores and found that her neural response thresholds were varied

from her previous maps, due to high impedance levels. With a strong suspicion of a possible device failure, he referred her to the implant surgeon for further assessment.

A meticulous clinical examination did not reveal any source of infection or electrode extrusion in the operated ear. The tympanic membrane appeared normal and there was no evidence of middle ear or mastoid disease. The only subtle sign noticed was a small boggy swelling in her mastoid region over the internal Receiver-Stimulator Coil site, which had become more prominent in the previous week. Plain radiographs of her skull were done in order to check the integrity of the intra-cochlear electrode array and to rule out any masked mastoiditis.

The skull X-rays unraveled the hidden diagnosis of migration of the internal magnet of the Receiver-Stimulator Coil placed in the mastoid temporal bone of her skull (Fig. 1). The radiogram also confirmed that the electrode array was in normal position within the cochlea and there was no evidence of middle ear or mastoid infection. The magnet migration had occurred due to unexplained reasons, since the girl did not have a history of trauma to her skull and had no history of an inadvertent exposure to a strong magnetic field, which could have possibly attracted the well-seated internal magnet out of its socket in the Receiver-Stimulator Coil of her implant.

Once the diagnosis was arrived at, she was prepared for surgical exploration of the implanted ear for repositioning the migrated magnet back into its socket in the Receiver-Stimulator Coil of the implant. Under general anesthesia, with all aseptic precautions as followed for cochlear implantation, the implanted mastoid temporal bone was

Fig. 2 Radiological image and the intraoperative picture revealing the displaced position of the migrated magnet in relation to the Receiver-Stimulator Coil

explored by an extended postaural incision. Underneath the Palvas' musculo-periosteal flap, the Receiver-Stimulator Coil was found to be in normal position within its osseous bed, whilst the magnet alone had migrated from its socket in the coil, in the infero-lateral direction by 3 cm (Fig. 2). The displaced magnet was densely surrounded by a separate fibrous capsule with serous fluid within it, which had actually presented as the boggy swelling at clinical examination. This fluid was aspirated and the fibrous capsule was excised to deliver the magnet out. As the magnet strength was maintained, special non-metallic surgical instruments were needed for recovering and re-implanting the magnet in its position in the Receiver-Stimulator Coil socket. The magnet was found to be snugly fitting into the socket and it was reinforced with a temporalis musculo-fascial flap cover to prevent a recurrent displacement in the future (Fig. 3).

After wound closure, intraoperative electrophysiological tests including impedance Telemetry, Neural Response Telemetry and Electrically Evoked Auditory Brainstem Responses were performed to objectively assess the implant function. Her intraoperative Impedance levels returned back to normal, NRT and EABR correlates were good. Postoperatively, her recovery was uneventful. After complete wound healing, the implant was re-mapped and the threshold and comfort levels of her cochlear map were restored to previously mapped levels.

She was gratified to use her implant optimally once again with remarkable recovery in her auditory verbal skills. At further follow up, her auditory performance has improved and equaled her previous CAP and SIR scores. She has presently returned to her school and is performing satisfactorily, much to the relief and satisfaction of her parents.

Fig. 3 Repositioning of the magnet into its socket in the Receiver-Stimulator Coil

Discussion

Recent world literature has reported a few cases of magnet migration in cochlear implantees, most of which had occurred subsequent to a minor head trauma or in a few cases due to inadvertent exposure to a strong magnetic field like MRI scanners. Most magnets have either migrated in the immediate postoperative period, possibly due to the innate loose fitting of the Receiver-Stimulator Coil socket or within a few months, during the auditory verbal habilitation period wherein the internal magnet is exposed to periodic tractional forces while being coupled with an external

magnet of varied strengths, by the implant team in order to achieve the best approximation for arriving at the ideal threshold parameters for auditory stimulation.

Wilkinson et al. in 2004 [3], reported the first known published case of cochlear implant magnet migration in a 2-year-old child who had sustained a head injury 10 months after implantation and had lost auditory perception after the fall. The device was replaced soon after which the child's auditory verbal performance was restored back to previous levels.

In order to overcome recurrent magnet displacement, device migration and extrusion, Davis et al. in 2004 [4], proposed the fixation of cochlear implant Receiver-Stimulator Coils, using a prosthetic mesh, which proved technically superior to the traditional fixation methods.

Yun et al. in 2005 [5], performed a retrospective analysis of their cochlear implantees and concluded that 14% of young male children of their implant group had developed magnet migration subsequent to minor head trauma. All these children received cochlear implant with removable magnets (for MRI purposes) and these magnets had migrated within 14 months of implantation. All magnets were replaced within their implant coils and the scalp over mastoid region, was bolstered with a dermal allograft. In spite of this reinforcement, 6 months later recurrent magnet dislodgement was encountered in one patient.

Goycoolea et al. [6], in a Latin American cochlear implant study done in 2005, reported an incidence 0.35% magnet migration (13 cases among 3,773 devices implanted, $p = 0.016$) and all such cases involved ceramic implants.

Migirov et al. in 2005 [7], reported two children with magnet migration between 20 and 28 months after cochlear implantation. They highlighted the possibility of magnet migration in cases of device malfunction during habilitation and proposed a simple technique for re-insertion of the magnet into its socket in the Receiver-Stimulator Coil of the implant.

Stokroos et al. in 2007 [8], reported a postlingual adult cochlear implantee with magnet migration secondary to mild head trauma, leading to device failure. Surgical exploration was performed with non-magnetic instruments and the magnet was re-fixed *in situ*. Postoperatively, implant function was restored to previous levels after complete wound healing.

Tange et al. in 2007 [9], performed a retrospective analysis of postoperative computed tomographic scans in 39 cochlear implantees. These scans showed that, in a large number of cochlear implantations, the external ball electrode of the cochlear implant migrated from the insertion place toward the magnet of the Receiver-Stimulator unit of the implant and this migration of the external ball electrode does not influence the function of the cochlear implant or affect

the results of hearing habilitation in the short-term. They concluded that, extra-cochlear ball electrode can migrate in the space between the temporal bone and the temporalis muscle during the postoperative healing phase.

Lokman [10], from University of Kebangsaan, Malaysia reported four cases of inconspicuous magnet migration without head trauma or magnetic field exposure, at the APSCI conference held at Sydney in November, 2007. All magnet migrations had occurred within 24 months of implantation. He repositioned the magnets into their sockets and reinforced the Receiver-Stimulator Coil with a "Silastic Scalp Bolster", to prevent recurrent migration. All his patients reverted back to normal auditory performance and had no further migration.

Our experience was unique, since our implantees' magnet has migrated as a much later sequelae, 8 years after implantation due to no obvious reasons. The girl could reliably say that she had no recent head trauma, nor did she get exposed to any magnetic field in the recent past, apart from the external magnet of her transmitter coil. Retrospectively, a rare possibility of being exposed to a hidden magnetic field, like in a public security scanning system in her surroundings could not be ruled out.

Conclusion

The rare and unusual occurrence of an inadvertent migration of the internal magnet, from its socket in the Receiver-Stimulator Coil of a cochlear implant, can lead to rapid deterioration of the implantees' auditory verbal skills. It may make even a sagacious implant team to ponder over a diagnostic dilemma, with no obvious reason being sited for an implantees' poor performance. Future research potential lies in finding a potent way of bypassing this magnetic interface in cochlear implant technology. The horizon for such an invention seems to be near, with the introduction of cochlear implants with magnet protective shields, totally implantable cochlear implants (TIKI) and cochlear implants with bluetooth technology.

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