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Case Report

Troubleshooting Cochlear Implant Malfunction Using Neural Response Telemetry and Normal Saline

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Cochlear implantation has become a standard of care for a child diagnosed with bilateral profound sensorineural hearing loss with a structured surgical standard operating procedure. A 3-year-old boy with bilateral profound prelingual sensorineural deafness underwent a Med-EL Sonata Ti100 implant. We faced a peculiar situation intraoperatively after inserting the electrodes and closing the wound. The impedance recording indicated high ground path impedance with short-circuiting of few electrodes. As a bionic implant, its electronic components may at times malfunction both intraoperatively and/or postoperatively; therefore, neural response telemetry (NRT) was invented to check it. By using NRT and a few milliliters of normal saline, we were able to diagnose as well as rectify the malfunctioning of the implant.

KEYWORDS: Auditory evoked potentials, cochlear implantation, cochlear implants, sensorineural hearing loss

INTRODUCTION

The intraoperative and/or postoperative functioning of the implant can be tested noninvasively by the use of neural responsive telemetry (NRT), which measures the electrically evoked compound action potential (ECAP).

When a patient's auditory nerve is stimulated by an electrical stimulus after cochlear implantation (CI), its response is measured as ECAP. A detectable response signifies that the implant is firing successfully.[1] This also helps to verify the insertion of electrodes in the cochlea and tests the functioning of electrodes intraoperatively. Therefore, using NRT and normal saline, a malfunctioning CI was brought back to life. We are excited to share this interesting case, which tested not only the technology but a surgeon's presence of mind as well as the experience of a CI engineer.

CASE PRESENTATION

A 3-year-old boy with bilateral profound prelingual sensorineural deafness received a Med-EL Sonata Ti100 implant, which consists of 12 pairs of electrodes. We faced a peculiar situation intraoperatively after inserting the electrodes and closing the wound in layers. The impedance recording indicated a high ground path impedance (GPI) of 9.64 kΩ with electrodes 3, 4, 5, 6, 7, 11, and 12 showing a short circuit symbol opposite to them (Figure 1). The implant failed to record the NRT at 35 and 50 qu, which are the minimum and maximum charges, respectively.

The troubleshooting steps that were followed are:

1. The NRT display suggested a short circuit of the electrodes (Figure 1), which can be attributed to suctioning of the perilymph from the labyrinth and around the electrodes; however, this does not explain the reason for the high impedance. Also, the surgeon was confident that insertion was complete and all the electrodes were in situ; therefore, the decision to reexplore and reinsert the electrodes was deferred.
2. When impedance readings could not be recorded and additional electrodes were short-circuited, the Med-EL engineer was consulted telephonically, and the photographs (Figures 1-3) were shared with her. She suggested 2 possible reasons for the high impedance: (i) tight sutures overlapping the ground electrode in the receiver–stimulator complex [There were no

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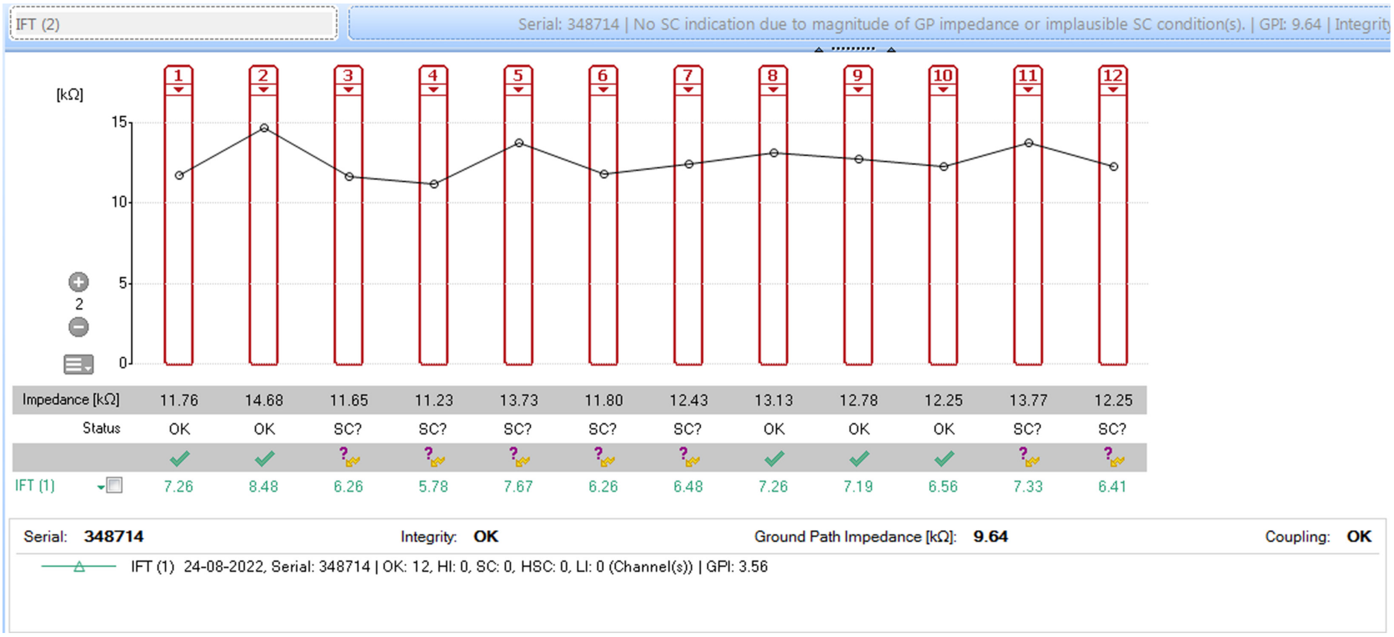

Figure 1. High ground path impedance of 9.64 kΩ at the time of neural responsive telemetry.

overlapping sutures (Figure 4)] or (ii) dryness of the periosteal flap over the ground electrode.

3. On her suggestion few milliliters of normal saline was injected between the flap and the ground electrode to make the circuit complete. Immediately after the injection, the impedance was reduced to 0.98 kΩ. Neural responsive telemetry and ECAP were recordable in all 12 electrodes, as shown in Figures 5 and 6.

The "switch on" of the implant was done after 2 weeks. The normal NRT and GPI recorded during that time is shown in Figure 7. Currently, the child is undergoing speech therapy and responding to sounds. He has started to introduce himself in simple sentences.

An informed and written consent was obtained from the patient's parents for the procedure as well as the use of the intraoperative picture for academic purposes.

DISCUSSION

The NRT was described by Abbas et al as a means to measure the ECAP.[1,2] After the CI, the patient's auditory nerve response to the electrical stimulus, recordable as ECAP, indicates that the implantation is successful. Additionally, the presence of ECAP signifies the insertion of electrodes in the cochlea and not in ectopic sites like the hypotympanum or internal auditory canal. It is also a tool to test the functioning of electrodes of the implant.[1] A computer equipped with a programming interface is used to stimulate specific electrodes in the implanted array. It works by transmitting radiofrequency pulses serially through the skin to the internal receiver/stimulator of the implant, a process known as "forward transmission." This forward transmission powers the electronics and generates an electric stimulus, whereas the internal receiver/stimulator unit does 2 things, it amplifies the signal and converts the analog signal to digital. The voltage thus recorded by the receiver/stimulator unit across a specific pair of electrodes is amplified, sampled, and transmitted back to the external coil. This is known as "telemetry."

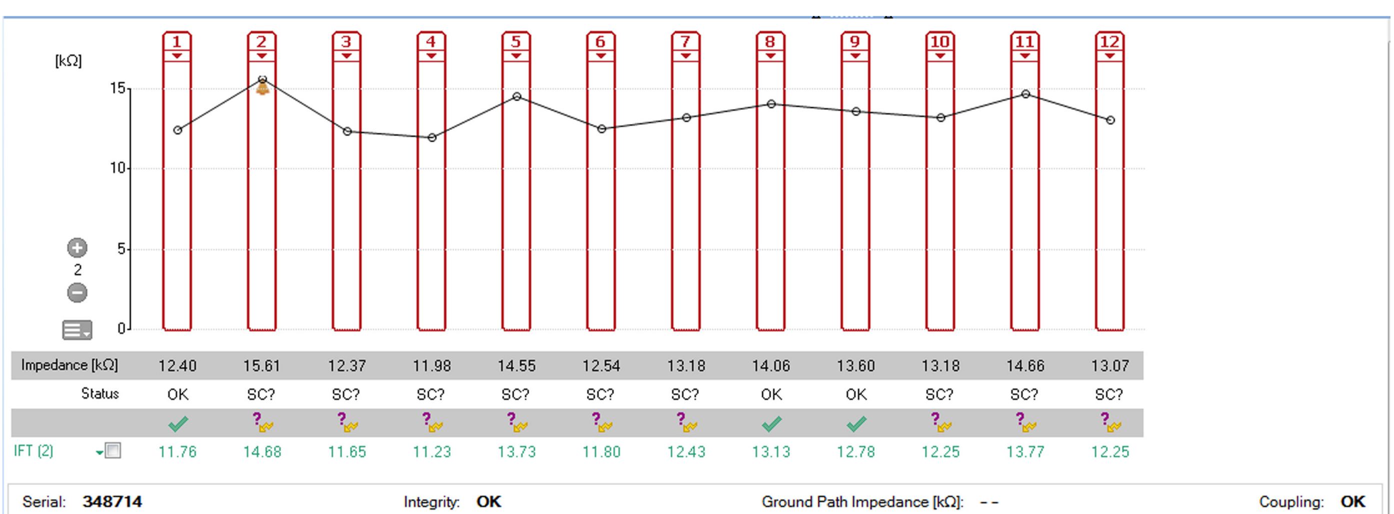

Figure 2. Unrecordable ground path impedance at 0 kΩ after a few minutes and increase in the number of short circuit electrodes.

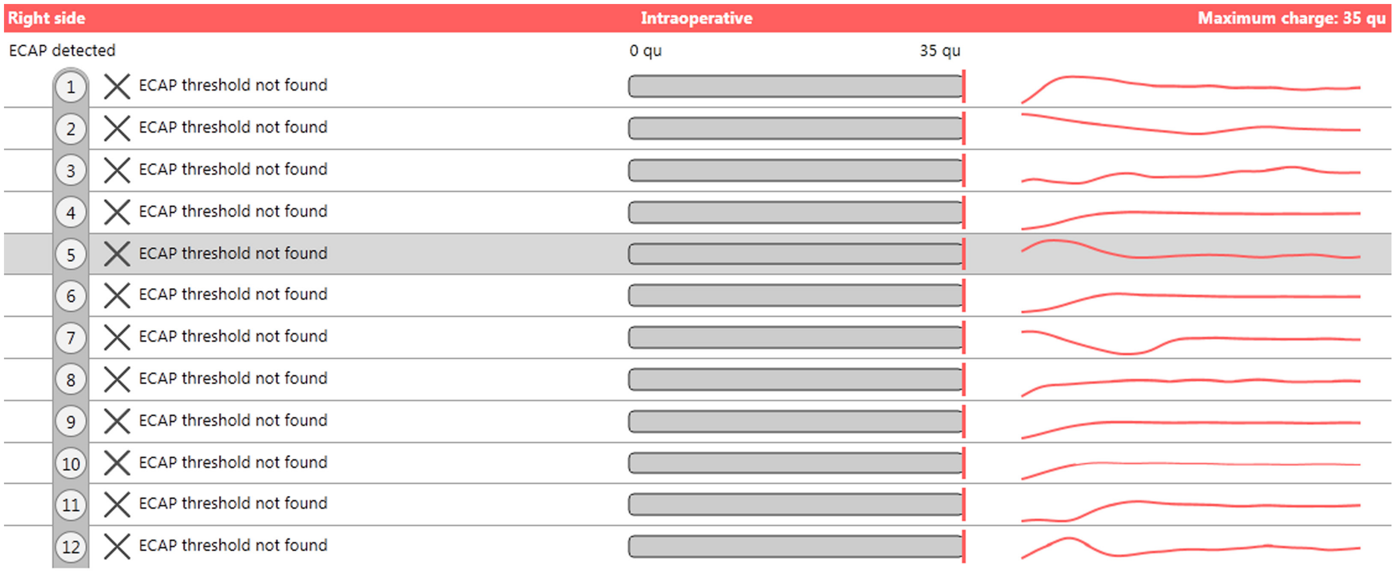

Figure 3. Unrecordable evoked compound action potential at the time of neural responsive telemetry.

The Med-EL Sonata Ti100 is equipped with 12 intracochlear electrodes and 2 extracochlear electrodes. Med-El implants have a built-in ground/neutral electrode instead of a wired ball ground/neutral electrode. This means that if there is air trapped between the implant and the periosteal flap, the circuit will not be complete, the impedance will be high, and NRT will not be recordable. By injecting normal saline between the periosteal flap and the ground electrode, the impedance to the flow of current was reduced and the circuit was completed. This was reflected in the NRT and ECAP recordings, which showed an ideal impedance of less than 1.5 kΩ and the presence of thresholds in all electrodes (Figures 5 and 6).

Figure 4. Injecting saline between the periosteal flap and the ground electrode of the cochlear implant.

Emphatically, a checklist sequence can be followed, which can reduce the chances of unwarranted surgical reexploration and fiddling with the implant. The checklist includes:

1. Before opening the implant, its functional integrity must be checked to ensure that it is not faulty.
2. If the perilymph has been suctioned inadvertently during electrode insertion, it can lead to high impedance in NRT. However, it returns to normal in the postoperative period.
3. If the electrode insertion has taken place in a site other than the round window or cochlea, then the NRT will be unrecordable. In such cases, the position of the electrodes can be ascertained by intraoperative radiology.
4. Ensuring moist overlying periosteal flap is a simple, yet vital step.
5. Tying sutures must not be too tight around the receiver–stimulator complex, which may lead to recording of high GPI values.

CONCLUSION

There is a dearth of literature where the surgeons have reported and shared their experiences with the intraoperative cochlear implant device failure attributable to hardware or software errors. Moura et al[3] in their case series followed up children with absent intraoperative NRT and concluded that 45% of such children responded positively to continued electrical stimulation after an average of 4.9 months, which they explained by hypothesizing that synaptic activity can be altered by continuous electric stimuli by providing sustained neurotrophic support to the auditory nerve. Thus, the absence of intraoperative NRT in the series was not due to hardware or software malfunction.

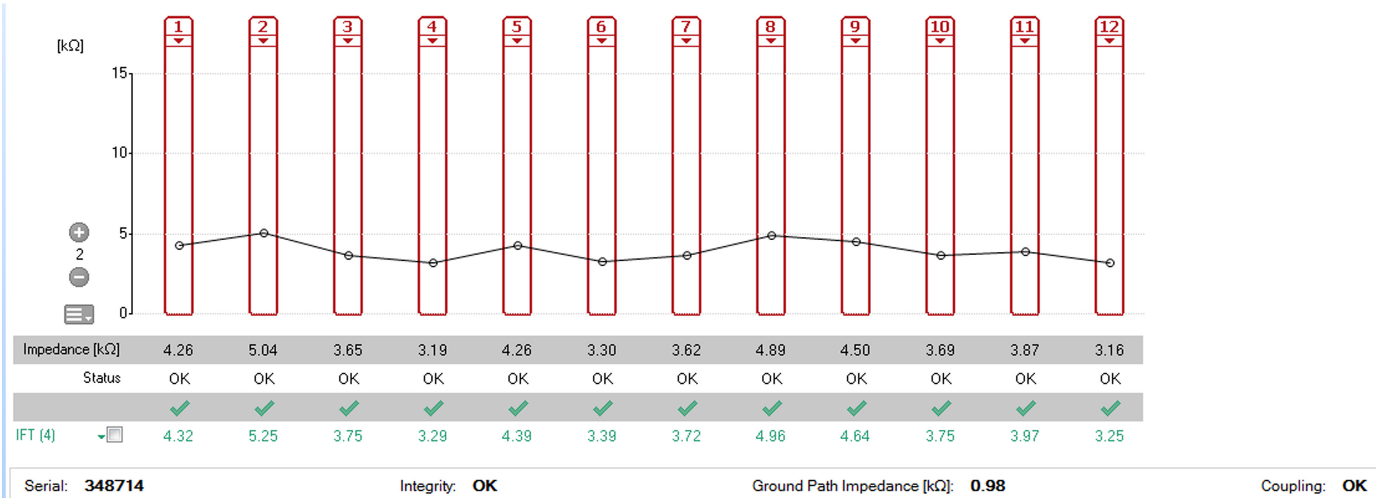

Figure 5. Ideal ground path impedance (less than 1.5 kΩ) and neural responsive telemetry following saline instillation.

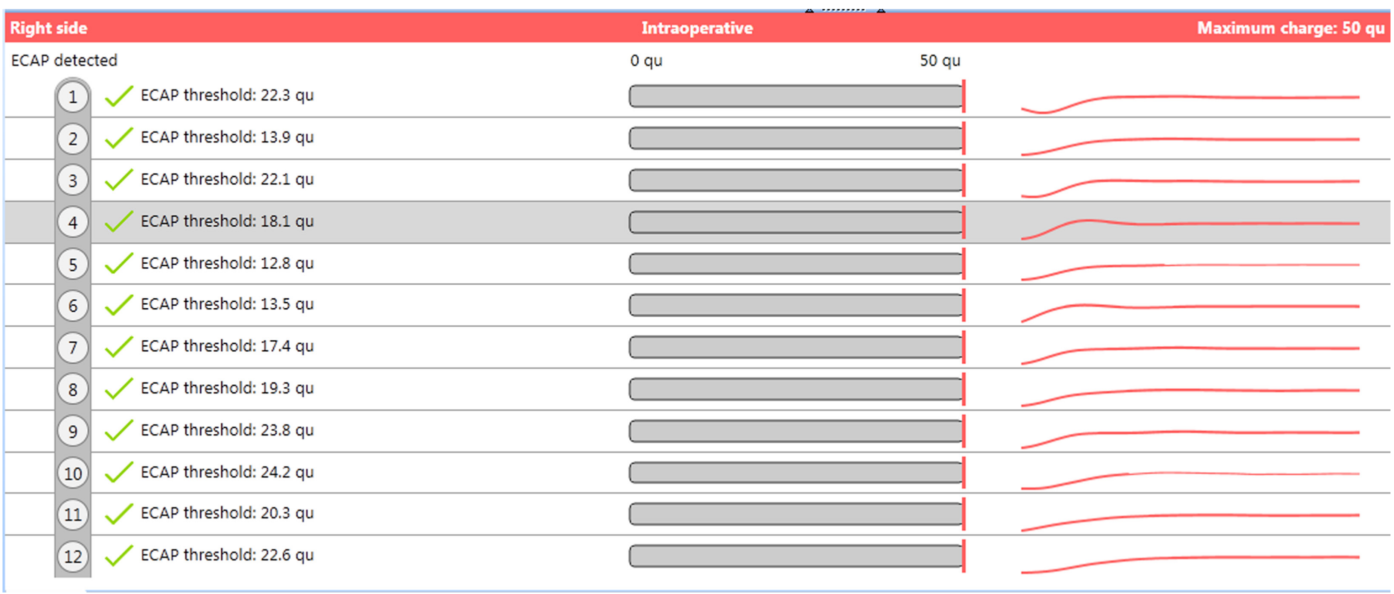

Figure 6. Recordable evoked compound action potential following saline instillation.

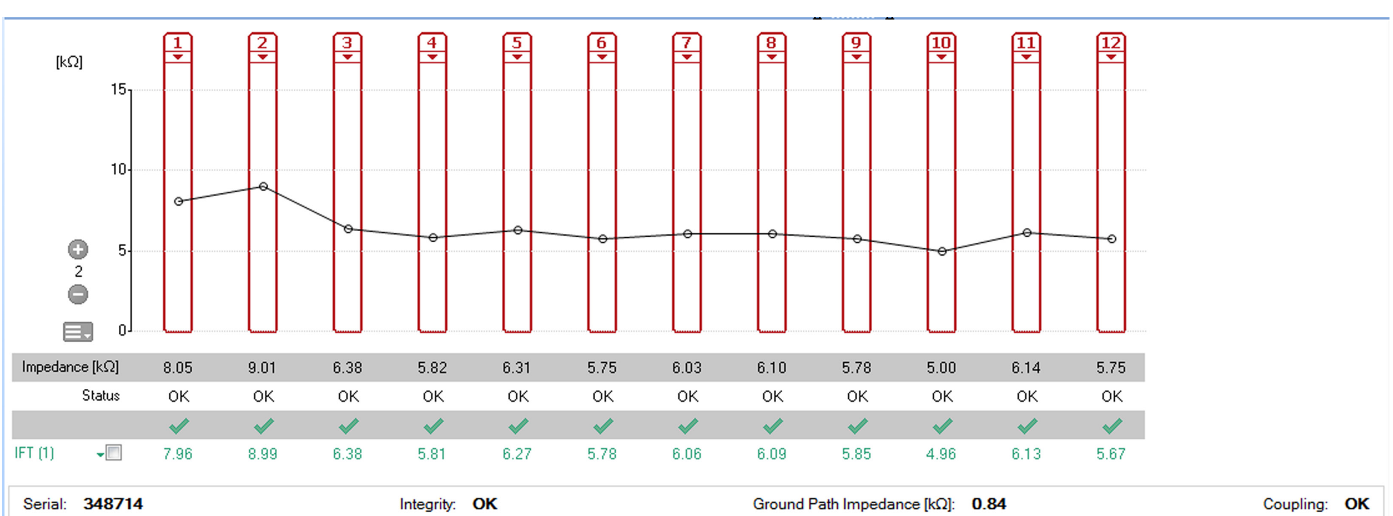

Figure 7. Normal neural responsive telemetry in the postoperative period during "switch on" of the implant.

This interesting case points out that strong clinical suspicion, clinical acumen, coupled with the usage of technology, can troubleshoot a malfunctioning cochlear implant. It also emphasizes that a checklist sequence can be followed before undertaking a surgical re-exploration and unwarranted fiddling with the implant, which must be the last step.

Informed Consent: Informed consent for publication of their clinical details and/or clinical images was obtained from parents of the patient.

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