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Middle Ear Disease and Cochlear Implant Function: A Case Study

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Abstract

Objectives and Methods—It has been our clinical observation that active middle ear disease (MED) temporally corresponds to a transient decrease in cochlear implant (CI) function, specifically at the apical electrodes. This is non-intuitive as CI function is thought to be independent of middle ear aeration and inflammation. The purpose of this case study is to demonstrate how active MED negatively affects both subjective hearing complaints and objective impedance measures in a CI patient.

Results—Subjective hearing decreased and impedances levels increased significantly when the patient was experiencing active MED. No significant changes in these measures occurred when there was no active MED.

Conclusions—MED may affect CI function in some patients requiring adjustments in programing at times of involvement.

Keywords

Cochlear Implant; Middle Ear Disease; Function; Impedance

Introduction

Since their introduction, cochlear implants (CI) have had a dramatic impact in the improvement of treatment of patients with severe-to-profound sensorineural hearing loss (SNHL) who do not benefit from traditional amplification. As of 2012, approximately 324,000 individuals have received cochlear implants worldwide(1). A CI is a surgically implanted device which functions by way of an electrode array embedded into the scala tympani. The electrodes are located at the distal tip of an array, which traverses through the mastoid cavity and the tympanic space and enters the scala tympani via the round window or a cochleostomy. The electrode fibres within the array are encased in silicone as it traverses the mastoid and middle ear and thereby are protected from middle ear pathology. Typically, the round window opening or the cochleostomy are sealed with muscle or fascia at the time of the surgery to prevent egress of fluid from the cochlea and to protect the cochlea from

middle ear disease. The active contacts of electrodes are sequestered from the middle ear within the cochlea as they directly stimulate spiral ganglion cells.

The benefits of cochlear implants include improved speech understanding and sound awareness, which positively affects communication with friends and family. Cochlear implant outcomes are quite variable and fluctuations in function over time within each subject do occur (2). The mechanisms behind fluctuations in function are poorly understood. CI failures may occur due to surgical complications, such as wound infection, skin flap breakdown, and device extrusion (3). Other failures and performance fluctuations may be due to intrinsic defects within the device circuitry. Loss of hermeticity of the implant and electrode failure are common intrinsic failure mechanisms, which may be detected with device integrity testing (4,5). In contrast, “soft” failures involve device malfunction with decreased perceived clinical benefit without evidence of integrity testing abnormalities (6).

There is some evidence that middle ear disease and inflammation may be associated with cochlear device failures and transient declining implant function (7). The mechanism behind this phenomenon is unclear and there is no clear documentation in the literature supporting the association of active middle ear disease and implant dysfunction. Audiologists at ours and other institutions (per personal communication) have observed changes in both subjective hearing and objective measures of CI performance in patients with active (MED). However, this phenomenon is not well documented in the literature. This is non-intuitive as the middle ear is not thought to participate significantly in CI function. Due to these clinical observations, we seek to demonstrate through a case study an example of this observed phenomenon. This case study clearly demonstrates the evidence of a temporal relationship between active MED and hearing changes (and subsequent recovery) post-treatment.

Case Study

This is the case study of a 77 year old female who underwent cochlear implantation of an HiRes 90K Advanced Bionics device with High Focus 1J electrode (Sonova, Stafa, Switzerland) in her left ear. This patient began to gradually lose her hearing during her early 20s and continued on a progressive course of hearing loss. The aetiology of her hearing loss is unknown. She has no family history of hearing loss and no prior history of ototoxic drug exposure. There was no history of significant occupational or recreational noise exposure and she had no prior history of otological trauma or surgery. She wore bilateral amplification for her entire adulthood until she met CI candidacy criteria. Her hearing loss was severe sloping- to- profound bilateral sensorineural in nature with her left ear being slightly poorer in function. Tympanometry was normal pre-operatively and otoscopic examination was normal prior to implantation. She had no prior history of otitis media prior to implantation. Pre-operative imaging studies were normal.

The surgery and the post-operative period occurred uneventfully and a full insertion of the electrode was obtained during the surgery. This device was documented to perform well both subjectively and objectively post-operatively for a number of years without changes of impedances or stimulation levels. This patient began to experience recurrent otitis media and persistent serous otitis media seven years post-implantation.

During this time of active MED, she reported poor implant function and decreased speech understanding along with left otalgia. Specifically, she first reported a decrease in CI performance at visit 10. In fact, this subjective complaint is what initiated that clinic visit. She described experiencing greater difficulty understanding speech of both male and female voices. During her physical examination at that visit, she was found to have an erythematous tympanic membrane with evidence of a middle ear effusion. She had a type-B pattern tympanogram on the left side with normal volume further supporting middle ear effusion. She was afebrile at the time of presentation and had no constitutional symptoms. She was diagnosed with acute otitis media and was treated with a course of steroids and oral antibiotics. She continued to have evidence of middle ear disease over several weeks (documented at 2 separate visits - #11 and 12) with the persistent symptom of poor speech understanding. Following resolution of the active MED, the patient reported improved CI function and she stated that her speech understanding returned to baseline. An additional similar episode of OM occurred approximately 9 months later (visits 14 and 15) with similar subjective complaints of poor speech understanding of both male and female voices. The physical examination findings were identical and she was treated with the same medical regimen. There was no evidence of abnormal physical findings in the nasal cavity or nasopharynx at the time of the infections and the remainder of the head and neck examination was normal on both occasions. Since the infections were short-lived and resolved with medical management no further diagnostic testing was performed. Again, after the MED resolved, she reported that her speech understanding improved and the otalgia resolved; she felt like she had returned to her baseline level of hearing. To date, the patient has had no further middle ear infections and her implant continues to function well.

As seen in Figure 1, impedance values were mostly stable over the 7 years post-operatively prior to the development of MED, but then shifted to significantly higher levels during active MED. Peak elevations were synchronous with active and resolving middle ear infection, which was confirmed on physical examination and tympanometry. The trend was observed as a rise in impedances and increased stimulation levels the following visit. Interestingly, as noted in Figure 2, the apical-most electrodes (1-9) were observed to have had the most significant impedance changes. During the period of MED, there was an increase in the average comfort levels (M-levels) to achieve sufficient loudness (Figure 3). Following treatment and resolution of the MED, the impedances decreased significantly and the patient reported subjective improvement of speech understanding. When the MED recurred, the patient experienced the same symptoms and increase in impedances and M-levels. Hearing symptoms and impedance increase improved after medical treatment of the second MED episode.

Audiologists were challenged with re-programming this patient's implant to adequately stimulate and provide good speech understanding during these times of active MED. After resolution of the middle ear effusion, hearing was reported to be improved. Impedances decreased but did not return to pre-infection levels and comfort levels remained elevated, but stabilized.

Discussion

Results from this case study demonstrate changes in subjective hearing and objective CI measures synchronous with active MED. In patients without MED, changes in CI impedances, stimulation levels, and dynamic range are expected in the first few weeks or months after implantation, but these parameters stabilize after six to twelve months (8). Even a gradual increase in impedance can occur over time during the life of an implant; however, a sudden dramatic elevation in impedances and stimulation levels is not expected after this time period.

Findings from other studies have suggested changes in CI function related to inflammation. Neuberger et al.(9) described changes in hearing and increased impedance when patients had cold symptoms. Both were improved with steroid and antibiotic administration. These increases were attributed to labyrinthitis and formation of an inflammatory exudate in the cochlea. However they were unable to correlate patients' symptoms with any objective physical examination findings of MED and inflammation(8). Most recently, Vargus and colleagues(10) described a series of four patients who demonstrated increment increases in their impedances which were directly correlated to mucus in the middle ear. They observed moderate to severe alterations in impedances levels requiring remapping. However, this study did not present data on resolution of the clinical findings and the symptoms of implant dysfunction.

The patient in this case study demonstrated a change in subjective hearing and objective implant electrophysiologic parameters at the time of active MED that resolved synchronously. She demonstrated stability in her hearing and speech understanding with a CI for years prior to the onset of active MED with significant alterations observed. Interestingly, CI function did stabilize after resolution of active MED, although at a higher average impedance and comfort levels. While the case presented is an adult, and active MED is not commonplace in the adult population, the observation from the present investigation should be considered in the paediatric population. Given the high incidence of MED in children, careful monitoring of middle ear status and cochlear implant function should be implemented in this population.

The mechanism behind these findings is unknown. We hypothesize that inflammatory processes may affect the local environment around the CI electrode array, resulting in acute deterioration of function. This may involve influx of fluid within the cochlea and/or inflammatory cells influx within the cochlear duct possibly leading to fibrosis. It is also possible that MED leads to transient changes of neural function and transmission of spiral ganglion cells. Further research is warranted to elucidate the mechanism behind MED and deterioration of CI performance.

The authors acknowledge that this is only a single case study, however given evidence from this patient along with other reports of correlations between CI function and active MED, further consideration is warranted by means of a systematic prospective investigation. A prospective cohort study following newly implanted patients with Eustachian tube

dysfunction and MED and comparing them to newly implanted patients without MED would be valuable in better determining the relationship of MED and CI function.

Conclusion

Results from this case study suggest an association between active MED, subjective hearing with a CI, and electrophysiological function of that implant. Care should be taken to document middle ear disease and implant function and integrity. Audiologists should be keenly aware of the potential need to adjust CI maps in cases of active MED. This is particularly important in those patients most susceptible to active MED such as the paediatric population. When counselling patients and parents of patients, it is vital physicians make them aware that they advise their audiologists when MED occurs so that maps can be adjusted if necessary.

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Figure 1. Mean impedance levels over time across all electrodes

Figure 2. Mean impedance levels over time as a function of apical versus basal electrodes

Figure 3. Mean comfort levels over time across all electrodes