Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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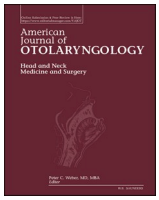

Cochlear implant failure following COVID 19: Report of two cases

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ABSTRACT

Background: Hearing loss is a relatively newly reported symptom of novel strain of coronavirus (COVID-19). Cochlear implant is an effective therapeutic method for patients with severe to profound hearing loss.
Case report: We describe two cochlear implanted children with the sole presenting symptom of a sudden speech perception problem. They not suspected to have COVID-19 until they showed respiratory symptoms on the first week of admission.
Conclusion: The current report indicates the importance of COVID-19 screening in hearing impaired patients (including cochlear implanted recipients) presented with sudden or gradual deterioration of speech intelligibility during the pandemic.

1. Introduction

The clinical spectrum of the novel coronavirus disease 2019 (COVID-19) ranges from asymptomatic infection to severe acute respiratory distress syndrome, leading to intensive care unit (ICU) admission. The clinical spectrum of the COVID-19 ranges from asymptomatic infection to severe acute respiratory distress syndrome, leading to intensive care unit (ICU) admission. In symptomatic patients, pneumonia is the most common clinical feature, primarily characterized by fever, sore throat, dry cough, myalgia, and breathlessness. The uncommon symptoms include headache, gastrointestinal problems, anosmia, and hearing loss [1,2].

Hearing loss is a relatively newly reported symptom of COVID-19 infection. Recent evidence indicates that the COVID-19 virus, similar to SARS-CoV viruses, exploits the angiotensin-converting enzyme 2 (ACE2) receptor to enter into the cells. The interaction between the ACE2 and SARS viruses has been suggested as a potential factor in their contagion. Therefore, the virus can infect many organs, including the peripheral and central nervous systems. In addition, the virus may lead to cytokine release increase, endothelial damage, and systemic micro-circulatory dysfunction. The virus is also capable of invading the cochlea-vestibular nerve and soft tissues of the cochlea [3–5].

Cochlear implant (CI) is a standard treatment for bilateral severe to profound sensorineural hearing loss (SNHL) with no benefit with hearing aids. The CI device presents a sequence of current pulses, similar to those produced by the biological hearing system, via a platinum multi-electrode array located in the cochlea. It has been demonstrated that CI recipients typically experience improved speech comprehension and speech production ability [6].

We report two cochlear implanted children with confirmed COVID-19 pneumonia who were admitted to our outpatient clinic with the sole presenting symptom of speech perception deterioration in quiet and noisy situations. They were not suspected of having COVID-19 until they developed respiratory symptoms (interstitial pneumonia) on the first week of admission. To the best of our knowledge, it is the first study that reports the CI malfunction following COVID-19 infection.

2. Case-report

2.1. Participants

The local Ethical Review Board approved all procedures of the study and written informed consent was obtained from the children's parents. Both implanted children had received a Nucleus 24® CI system (see Table 1), and had regular follow-up sessions. The only complaint of these children on presentation to our CI center, in August 2020, was abruptly reduced speech comprehension during the everyday listening environment. They denied cough, fever, shortness of breath, sore throat,

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Table 1
Demographic and clinical characteristics of cochlear implanted patients.

Parameter		Case 1 (S. Hashemi)	Case 2 (E. Abdolkhani)
Gender		Male	Female
Implantation age		26 months	75 months
Length of cochlear implant use		6 years	5.5 years
Etiology of deafness		Congenital SNHL	Progressive SNHL
Side of implantation		Right	Right
Cochlear implant prosthesis		Cochlear freedom (CI24RE)	Cochlear freedom (CI24RE)
Cochlear implant processor		CP910	CP810
SIR score	Before COVID infection	5	6
	After COVID infection	2	3
CAP score	Before COVID infection	5	6
	After COVID infection	2	2
Number of deactivated electrodes		12	11

SNHL: sensorineural hearing loss; SIR: speech intelligibility rating; CAP: categories of auditory performance.

anosmia, or headache.

2.2. Procedures

In the exam session, play audiometry evaluation in CI-on condition revealed an abrupt decrement in hearing thresholds (at least 20 dB HL) across 500 to 4000 Hz frequency range. During the electrode impedance (EI) measurement, we found open circuit or short-circuited electrodes in half of the channels (see Fig. 1). Furthermore, we did not record any reliable neural response telemetry (NRT) responses in both patients. Using the NRT measurement, it is possible to record the electrically evoked compound action potential of the 8th nerve without the use of surface electrodes. That is, the electrical action potential response is obtained directly from the internal device by recording the response from the different electrode bands which has been utilized to stimulate the spiral ganglion fibers. The auditory performance and speech intelligibility of implanted children indicated that a noticeable reduction after coronavirus infection compared to the pre-infection time-point (see Table 1).

The studied children did not suspect to have COVID-19 until they reported respiratory symptoms on the 5th or 6th day of admission. The diagnosis of COVID-19 was performed according to a *positive* result from a Real-Time Reverse Transcriptase Polymerase Chain Reaction (rRT-PCR) analysis of nasopharyngeal swab specimens. Furthermore, viral

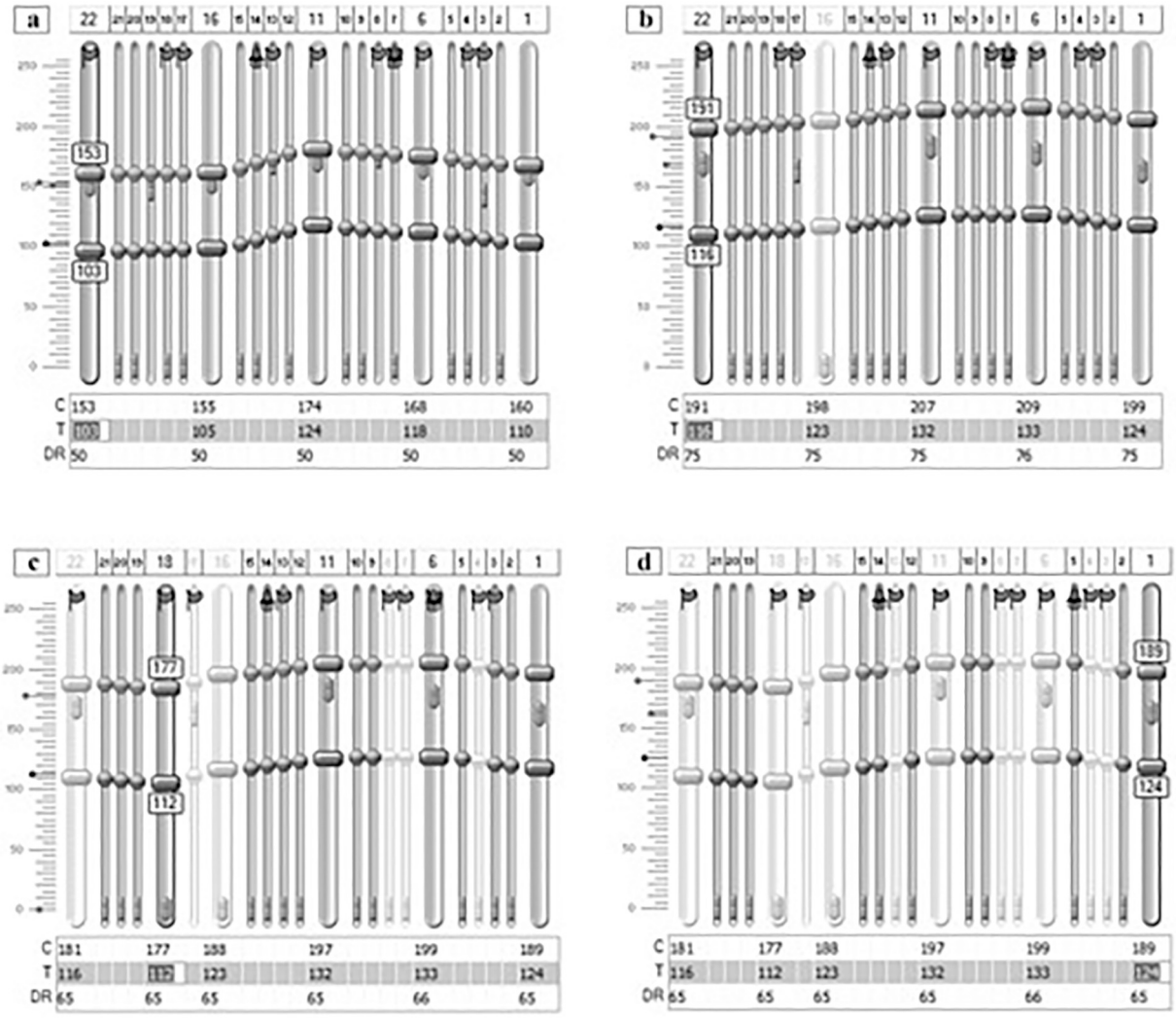

Fig. 1. Cochlear implant electrode's map at different time points.
a) Map at four-month before COVID-19; b) map at one-month before COVID-19; c) first map after COVID-19; d) map at two-month after COVID-19.

serology markers for HIV, cytomegalovirus, hepatitis C, hepatitis B, and syphilis serology were negative. The autoimmune screening result was also negative for antinuclear antibodies.

3. Discussion

We presented two cochlear implanted patients with novel coronavirus pneumonia who first presented to our otology clinic. Our patients do not tend to present with typical COVID-19 symptoms, possibly because they were in the early stages of the infection.

Different theories have been proposed to explain the mechanism of hearing loss following COVID-19 infection. The human brain has been reported to express ACE2 receptors observed over glial cells and neurons, which makes them a potential target of COVID-19. As ACE2 density is rather high in the brain, the temporal lobe may be involved. In addition, COVID-19 may lead to cytokine release once it binds to the ACE2. Therefore, the hearing centers may be influenced by the inflammatory mediators released upon binding to the surface receptors in the central auditory nuclei [7–9]. Another plausible hypothesis of SNHL is ensuing decreased perfusion to the auditory structures due to ischemia. It seems that the virus may infect ACE2 receptors found in the vascular smooth muscle and clot formation diminishes blood supply, thus resulting ischemic problems, which may contribute to the hearing impairment [3].

Harenberg et al. [4] reported that serotonin is a sensitive marker for sudden SNHL (SSNHL) diagnosis, and plausibly activates platelets in the microcirculation. The novel COVID-19 infection appears to cause endotheliitis in the hearing center of the temporal lobe, the auditory nerve, and cochlear tissues. Serotonin release and COVID-19 infection intertwine to stimulates platelets and cause SSNHL.

The rapid technological developments of cochlear implant systems have resulted in better hearing outcomes and lower device failure rates. CI failures may be due to device (hard) failure, soft failure, or surgical complications. Soft failure is a condition in which the implant device passes the integrity test but patients experience declining speech comprehension or non-auditory aversive symptoms [6,10]. In the present study, the “short circuits” condition was observed in half of the electrodes in both cases. Short circuits occur when the circuits of two electrodes on the array become electrically connected, leading to a substantial reduction of EI values. It has been shown that novel coronavirus could have an inflammatory effect on inner ear structures, including sensory hair cells and the fluid surrounding the electrodes array [8]. EI indicates the resistance to charge transfer between the electrode and the solution surrounding it, and also provides a measure device functionality. Therefore, it is plausible that the inflammatory process in the inner ear fluids following COVID-19 has a detrimental impact on CI performance, leading to a short-circuit or switch-off condition.

It has been shown that reducing the number of active electrodes has an adverse effect on spectral resolution ability. This limitation will result in reduced performance on consonant- and vowel-recognition tasks for CI listeners.

The current report is the first to bring awareness to practitioners to look for COVID-19 positivity in patients with sudden hearing loss. It is hoped that this report will contribute to the practice of otolaryngology and audiology by enabling early identification of these patients, their isolation, prevention of their infectiousness in the early stage of the disease, and early and targeted medical treatment.

4. Conclusion

The current report highlights the importance of COVID-19 screening in CI patients presented with a sudden or gradual decrement of speech intelligibility nowadays, particularly if neurologic symptoms are present. However, understanding the pathogenesis and auditory complications of this challenging disorder needed much workup. Furthermore, identification of patients presenting with non-specific COVID-19 symptoms (e.g., hearing loss) during the pandemic period may play a key role in breaking the infection chain and decreasing transmission.

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Declaration of competing interest

The authors declare that they have no conflicts of interest.

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