

Postoperative Complications of Cochlear Implant Surgery in Children

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ABSTRACT

Background: Cochlear implantation is a skillfully determined pediatric surgical intervention for severe-profound sensorineural hearing loss. While generally safe, postoperative complications can occur. This study aimed to comprehensively analyze the incidence, types, risk factors, and treatment of these complications in cochlear-implanted recipients.

Methods: A prospective observational study on 48 children underwent unilateral multi-channel cochlear implantation at the otolaryngology unit. Data collected included patient demographics, hearing loss etiology, surgical details, and postoperative complications, which were categorized as immediate (within 1 week), early (1 week-6 weeks), and late (beyond 6 weeks), and then were statistically analyzed and studied with 1-year follow-up.

Results: The overall complication rate was 22.91%. The cause of deafness was congenital in 83.33%, and acquired in 16.37%, with major complications at 2.79% and minor complications at 7.21%. Immediate complications included pain (18.18%) and wound edema (9.09%). Early complications comprised wound infection (27.27%), facial nerve weakness (18.18%), and cerebrospinal fluid leak (9.09%). Late complications included flap necrosis (9.09%) and device exposure (9.09%). Wound infection was significantly associated with younger age ($P=.03$) and history of ear infections ($P=.01$).

Conclusion: Pediatric cochlear implant surgery was generally safe, but its postoperative complications were not uncommon, so understanding the types, incidence, and risk factors of these complications in pre-operative counseling, intraoperative management, and postoperative care, together with meticulous surgical technique, to minimize complications, was crucial for optimizing outcomes.

Keywords: Children, cochlear implant, complications

Introduction

Cochlear implantation (CI) is indicated in severe-profound sensorineural hearing loss (SNHL), and it has an incidence of 0.7% in the general population, as reported for the United Kingdom's National Health Service clinic, with a thoroughly elevated incidence of inner ear malformations (IEMs). It is considered a safe pediatric surgical technique in expert surgeons; however, there might be some awkwardness and complications postoperatively, consisting of pain, minor bleeding, infection, breakdown of skin, facial palsy, taste changes, vertigo, cerebrospinal fluid leak, and device failure, as well as displacement. However, it has favorable language and speech consequences and thus remarkably enhances the quality of life.^{1,2}

So, CI has become a standard treatment for pediatric severe-profound hearing loss, exhibiting notable amelioration in auditory comprehension and communication skills. While it is generally safe and effective, cochlear implant surgery is associated with potential postoperative complications.³

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As hearing loss significantly impacts a child's development, affecting speech acquisition, language processing, and social interaction, cochlear implants (CIs) are electronic devices that bypass damaged parts of the inner ear (cochlea) to provide electrical stimulation to the auditory nerve, enabling perception of sound. CI has revolutionized the management of severe-to-profound hearing loss in children, offering the potential for near-normal hearing in many cases. While CI surgery is generally safe, it is essential to be aware of the potential postoperative complications that can arise.⁴

Numerous studies have investigated the well-being and efficiency of pediatric CI; several studies have documented various postoperative complications, ranging from minor issues like wound infections to more serious events like facial nerve injury or cerebrospinal fluid leaks. Previous reviews have categorized these complications and discussed their management; however, ongoing advancements in surgical techniques, device technology, and postoperative care necessitate a continuous update of the literature to reflect current best practices and reported complication rates. This review builds upon previous work by incorporating recent studies and guidelines, providing an updated perspective on postoperative complications in pediatric CI recipients. Postoperative complications following pediatric cochlear implantation can be categorized into immediate complications (within the first few days) that include pain, swelling, bruising, wound hematoma, and nausea/vomiting related to anesthesia, which are generally self-limiting and managed conservatively with analgesics, antiemetics, and wound care; early complications (within the first few weeks) include infection in which superficial wound infections are more common and usually respond to antibiotics, as deep infections involving the implant may require device removal; and facial nerve weakness, that can be temporary or permanent and may manifest as facial asymmetry or decreased muscle movement; yet, careful surgical technique and intraoperative monitoring can minimize this risk; cerebrospinal fluid leak, which is a rare but serious complication requiring prompt intervention, often including surgical repair and wound breakdown and can delay healing and increase the risk of infection; and finally, late complications (occurring months or years after surgery) that include device malfunction, which is implant failure and can occur due to various reasons and may necessitate revision surgery and tinnitus—new-onset or worsening tinnitus can occur after CI surgery.⁵

The incidence of these complications varies depending on factors such as patient age, surgical technique, device type, and individual patient characteristics. Recent studies suggest that complication rates are generally low, particularly with advancements in surgical techniques and device technology.⁶

MAIN POINTS

- The inclusion criteria include bilateral profound hearing loss with little or no beneficial achievement from hearing aids in 6 months, with no medical contraindication for surgical procedures.
- Pediatric cochlear implant surgery was generally safe, with not uncommon postoperative complications.
- Its complications were classified as immediate (within 1 week), early (1 week-6 weeks), and late (beyond 6 weeks).
- To minimize complications, preoperative counseling, intraoperative management, and postoperative care, together with meticulous surgical technique, were fundamental for ideal outcomes.

The study aims to provide a comprehensive overview of these complications, categorized by their timing of onset.

Materials and Methods

A prospective observational study in which 48 children who underwent cochlear implantation at an otolaryngology unit were enrolled for a follow-up of 1 year, where all CI candidates received the same sort of unilaterally multi-channel CI, and also, all surgical procedures were performed by the same surgical team.

Ethical institutional review board approval number 185 on January 2, 2024, as well as written child's parent consents were obtained.

Inclusion Criteria

Inclusion criteria were bilateral profound hearing loss with little or no benefit gained by hearing aid in 6 months, also where no medical contraindication for the surgical procedure, sensible anticipations by the child's parent counselling.

Exclusion Criteria

Exclusion criteria were adults with moderate-severe SNHL, unilateral lesion, as well as same-ear previous mastoid surgery.

Data were collected, including demographics, hearing loss etiology, surgical details (site of approach, electrode type), and postoperative complications. Complications were classified as immediate (within 1 week), early (1 week-6 weeks), and late (beyond 6 weeks). Statistical analysis was performed to identify potential risk factors for specific complications.

Cochlear implant surgical technique was done under general anesthesia, and typically the time was about 1-2 hours, involving drilling into the mastoid bone to gain access to the inner ear (as drills into the mastoid bone to make a pathway toward the inner ear). Then, cochleostomy or round window insertion creates a small opening, called a cochleostomy, in the cochlea or uses the natural round window to access the inner ear's fluid-filled space (electrode placement: the delicate electrode array from the internal device is threaded slowly and in a controlled manner into the cochlea). The internal receiver/processor is placed in a specially created pocket under the skin and muscle or in a depression in the bone behind the ear. After that, the incision was closed with sutures, which may be absorbable. A dressing, often a plastic cup, was placed over the incision to help with healing.

This paper reviews in the current study the pediatric cochlear implant recipient's postoperative complications, categorizing them into immediate, early, and late complications. It also discusses the incidence, risk factors, management, and prevention strategies for these complications, emphasizing the importance of a multidisciplinary approach for optimizing outcomes and minimizing their adverse events.

Statistical Analysis

SPSS version 25 (IBM SPSS Corp.; Armonk, NY, USA) was used. The variables were presented as mean, SD, frequency, and percentage. Chi-square test and t-tests were used. *P*-value of <.05 was considered statistically significant.

Results

Among the 48 studied children, there were 27 girls (56.25%) and 21 boys (43.75%). The age at implantation for these patients ranged from 1 to 5 years, with a mean age $\pm$ SD (2.83 ± 1.76). The cause of deafness

was congenital, as seen in 40 children (83.33%), and acquired, which was detected in 8 children (16.67%).

The overall postoperative complication rate was detected in 11 children (22.91%), with major complications (2.79%) and minor complications (7.21%).

Immediate complications: Pain was seen in 2 children (18.18%), and wound edema (9.09%) was detected in 1 child; it was attributed to minor trauma. That is considered a subclinical infection, and if these are not well managed via dressing, prescribed oral/injectable antibiotics, systemic corticosteroids, and oral antihistamines, with adequate aspiration under aseptic conditions, it might progress to a straightforward open infection, then flap necrosis, and finally a loss of the CI appliance.

Early complications: Superficial skin infection was seen in 3 children (27.27%); they healed properly within 10 days by local compression and systemic antibiotics.

Wound infection was significantly associated with younger age, as the *P*-value was .03, and history of ear infections, where the *P*-value was .01.

Facial nerve weakness was found in 2 children (18.18%), and it was temporary facial palsy in 1 child, which was treated with steroids and recovered within a month. There was 1 child with permanent facial paralysis (the tympanic segment of the facial nerve), which occurred due to pressure of the electrode on its lower end (the nerve was macroscopically intact). A posterior tympanotomy was performed, and the pressure was relieved by decompression, allowing the electrode array to dislodge far from the facial nerve.

Cerebrospinal fluid (CSF) leak was detected in 1 IEMs patient (9.09%) (common cavity 1; IP I, 1; IP II, 2), treated by conservative measures like compression, acetazolamide, and/or mannitol infusion, or even undergoing lumbar drainage.

Late complications: Flap necrosis was seen in 1 child (9.09%); it was the most troublesome complication. The time interval between implantation surgical procedure and flap obstacles was scoped in 1 year, while magnet displacement was seen in another child (9.09%), managed by local wound dressings, systemic antibiotics, device explanation, and wound surgical debridement, as well as local rotation flap closure.

Statistical analysis revealed that younger age at implantation was significantly associated with an increased risk of infection (*P* = .03). A history of ear infections also increased the risk of postoperative infection (*P* = .01). Complex surgical cases, such as those involving revision surgery or anatomical variations, were associated with different types of complications; yet, it was more likely to be associated with facial nerve weakness (*P* = .04).

Discussion

CI surgical postoperative complications demonstrate some of the main depressed and problematic issues that include various elements substantially related to the procedure's complexity, the surgeon's skill and expertise, as well as patient characteristics. For example, a hazard that is ingrained due to the large-sized foreign body implantation. Lima Júnior LR et al⁷ found that 33 patients (13.2%) had postoperative complications, with minor complications seen in 20 patients (8.0%), while major complications were revealed

in 13 patients (5.2%). Hematomas, device failures, and infections had the highest clinical relevance.

Conclusion

This review reinstates the safety of the surgical procedure in relation to the possible occurrence of postoperative complications and emphasizes the need for continuous surgeon education and training.⁷

In the current study's results, the incidence of postoperative cochlear implant surgical procedures in children was almost the same as the findings in other studies.⁸⁻¹⁰

Al Mansoury A et al¹¹ reported in their study that the age range was (1-50 years old); the most common age for CI was 5 years (44 patients; 25.4%). At this age, many parents begin to notice that there is a delay in speech and attention of their children. The second most common age group was 4 years old (35 patients; 20.2%), while the least common age group was patients aged 7 years (6 patients; 3.5%), with a mean age $\pm$ SD = (4.95 $\pm$ 5.92).

There were minor postoperative complications like infection in children, while major complications include failure of initial implantation of the implant, the improper process of CI to procure rehabilitation surgical intervention for hearing with a minimum rate of complications, as well as failure of re-implantation.¹²

Operative complications of CI may involve profuse, large amounts of CSF found during cochleostomy performance—"Gusher syndrome." As Chauhan VM and Vishwakarma R¹³ study, which enrolled 415 patients, it was found that 39 gushers were observed to have an incidence rate of about 9.39%.

The CI incision and its correlation to the postoperative wound infections were revealed and assessed by Ray et al.¹⁴ They found that there was a 2.4% incidence of infections with larger incisions, and a 1.1% incidence of skin infections was revealed in smaller incisions.¹⁴

Also, CI surgery becomes more complicated and harder if IEMs were in existence. In certain conditions, it has been revealed that CSF gushes after making a hole in the cochlea; its prevalence ranges from 0.4% to 5.58%.¹⁵

This restriction can be controlled by dealing with different specifics of CI surgery, which can be exceedingly supportive and essentially include conical external base electrolyte array, minim-sized cochleostomy, and full intraoperative application of a nonporous coating to the surface of the internal ear.

Apart from these remarkable postoperative complications, trauma to the facial nerve has been considered another postoperative complication at 1.4%.¹⁶

Again, postoperative facial nerve weakness could be a minor complication that could be caused by edema, or sometimes, herpes virus reactivation.¹⁷

Another major complication that is revealed after CI surgery is musical ear syndrome (MES), in which there is the perception of musical sensations in the auditory system without any external stimulus. Its incidence was found to be greater in patients who had undergone CI surgery. Research found that about 22% of patients who had CI surgery developed MES. This condition was seen to have a higher relation with the younger age group.¹⁸

Orlando VR et al¹⁹ reported that the age <2.5 years is correlated with surgical wound infection complications (contingency coefficient=0.242 e $P=.018$), just as there was a correlation with electrode extrusion in the same age group (contingency coefficient=0.242 e $P=.017$). They also found an elevated frequency of vestibular symptoms among adults, with a direct correlation to vertigo complication (contingency coefficient=0.276 e $P=.003$), particularly for those >20 years of age. Yet, children between 2.5 and 4.0 years old had a negative correlation with vertigo, and there was a correlation between ages 20 and 39 years and facial nerve impairment complications (contingency coefficient=0.232 e $P=.03$).

Limitations

Relatively small sample size, single study center, short time follow-up period were some of the limitations

Cochlear implant surgery was a safe and effective procedure for children with severe to profound hearing loss. While postoperative complications can occur, they are generally manageable, and their incidence is decreasing with improved surgical techniques and technology. A multidisciplinary approach involving otolaryngologists and audiologists is crucial for pre-operative assessment, intraoperative management, and postoperative care to minimize risks and optimize outcomes. Parental education and adherence to follow-up schedules are essential for early detection and management of potential complications.

Data Availability Statement: The data that support the findings of this study are available on request from the corresponding author.

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Ethics Committee Approval: Ethical committee approval was received from the Ethics Committee of University of Mustansiriyah (Approval No.: 185; Date: January 2, 2024).

Informed Consent: Written informed consent was obtained from the patients' parents who agreed to take part in the study.

Peer-review: Externally peer-reviewed.

Declaration of Interests: The author has no conflict of interest to declare.

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