Review

Cochlear Implant and its Complications: A Literature Review

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Review

Cochlear Implant and its Complications: A Literature Review

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Abstract: *Introduction:* Cochlear implants are a modern approach for the treatment of multiple cases of profound sensorineural hearing loss. Factors such as the ethiology of hearing loss and the potential for achieving good postoperative outcomes are considered in cochlear implantation. Additionally, surgical strategies, protocols, the experience of the surgeon and audiologist, and the presence of postoperative issues and risks that may require revision surgery should also be taken into account. The surgeon specialized in cochlear implantation must inform the patient and his relatives not only about the surgical technique but also about possible complications. The literature shows different rates of complications evaluated both in adults and in children. An evaluation of adverse events in order to prevent complications can be made if the definition of medical complications and mistakes is strictly approached based on the CLAVIEN-DINDO classification system. The rate of complications can be compared with existing literature. Studies demonstrate the need for preoperative vaccination for pneumococcus, which can prevent complications, especially in patients with inner ear malformations who present an increased postoperative risk. *Relevant Sections:* This review is structured around the collection of specialized literature from PubMed, organized into subchapters related to intraoperative complications such as Gusher syndrome, foreign body reaction, endocochlear inflammation phenomena, issues related to electrode positioning and associated complications, vestibular phenomena related to cochlear implantation, as well as late complications related to the surgical wound and cochlear implant extrusion. The important sections in this review are: Inner Ear Malformations and Gusher Syndrome: Intraoperative Complication Risks, Electrode Insertion and Positioning Issues, Intracochlear Inflammation, Foreign Body Reaction, and Intracochlear Fibrosis: Phenomena That Can Occur with Cochlear Implantation, Vestibular Disorders, Tardive Postoperative Complications: Wound Injuries and Cochlear Implant Extrusion and Otitis Media and Cholesteatoma as Complications of Cochlear Implantation. *Conclusions:* Postoperative complications, although considered quite rare. The surgical limits and long-term evolution of cochlear implants cannot be concretely established, despite the fact that this intervention is considered safe in the medium and long term. *Future directions:* Given that cochlear implants represent the most modern surgical technique for auditory rehabilitation in adults and children, with massive implications for quality of life, there is a tendency to extend surgical indications in the future, and especially to inform doctors in related specialties about the benefits of this medical device. Surgeons must be knowledgeable about cochlear implantation methods, as well as the methods for managing complications that can arise immediately postoperatively, as well as in the medium and long term.

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Introduction

Cochlear implants provide auditory rehabilitation for patients with severe to profound sensorineural hearing loss. Technological advances and different surgical approaches have increased the number of patients who benefit from this surgical method. Patients with residual hearing at low frequencies also qualify for cochlear implantation [1].

Cochlear implants are a modern approach for the treatment of multiple cases of profound sensorineural hearing loss [2]. Factors such as the ethiology of hearing loss and the potential for achieving good postoperative outcomes are considered in cochlear implantation. Additionally, surgical strategies, protocols, the experience of the surgeon and audiologist, and the presence of postoperative issues and risks that may require revision surgery should also be taken into account. Preoperative information for families of children undergoing cochlear implantation and adult patients must be treated with maximum consideration by the surgeon [3]. The surgeon specialized in cochlear implantation must inform the patient and his relatives not only about the surgical technique but also about possible complications. The literature shows different rates of complications evaluated both in adults and in children [4].

An evaluation of adverse events in order to prevent complications can be made if the definition of medical complications and mistakes is strictly approached based on the CLAVIEN-DINDO classification system. The rate of complications can be compared with existing literature. Studies demonstrate the need for preoperative vaccination for pneumococcus, which can prevent complications, especially in patients with inner ear malformations who present an increased postoperative risk [5].

Systemic autoimmune conditions can cause congenital hearing loss. The physician must be familiar with these aspects taking into account that early diagnosis and management of this type of hearing loss are directly responsible for postoperative outcomes and cochlear implantation issues. A multidisciplinary approach is the optimal management approach for these conditions that require cochlear implantation. Postoperative outcomes are usually excellent, with only minor complications related to intraoperative fibrosis and fluctuations in audiological performance [6]. In cochlear implant patients, regardless of the type of implant used, an inflammatory process happens, leading to fibrosis. This tissue reaction can long-term affect cochlear function, impacting residual hearing. The inflammatory and fibrotic response affects clinical outcomes, influencing therapeutic strategies. These aspects relate to the electrode's design, material, and other factors [1]. Approaches to reduce surgical trauma and fibrosis are dependent on the biomaterials surrounding the electrode. A better understanding of cellular, anatomical, and molecular aspects underlying inflammatory phenomena and cochlear fibrosis explains how the cochlear response to implantation occurs and influences postoperative outcomes, which will determine the development of new generations of neural prostheses [1].

Modifying surgical techniques, such as closing the posterior tympanotomy with muscle or sealing the cochlea with muscle after cochleostomy and using round window and original anatomy for cochlear implantation, can significantly reduce the risk of post-implantation complications [7].

Even though cochlear implantation is considered a safe surgical method associated with a low frequency of complications, surgeons must be familiar with these issues. Minor complications such as otitis media in children or tinnitus and vertigo in adults are common, with a higher incidence in adults. Major complications resulting from revision surgery or system failure often require reimplantation [8,9].

Postoperative complications are also related to revision surgery, involving particular aspects such as internal device failure [10]. Older and adult patients have a higher complication rate compared to younger patients, especially regarding the occurrence of implant displacement and the appearance of dizziness. However, the literature shows a comparable complication rate between the two patient groups. The age of implantation as an isolated risk factor remains under discussion must be taken into account in the statistical analyses [11].

Cochlear implants represent an ideal treatment method for sensorineural hearing loss; however, their complications must be considered and discussed. Based on their occurrence, complications can

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be classified into: intraoperative complications, immediate postoperative complications, or late postoperative complications, which can occur more than three months after surgery. In this context, cochlear implant surgery is a modern technology with a low complication rate. If complications are diagnosed early and receive appropriate treatment, the prognosis is good. The importance of preoperative patient preparation and preoperative education on complications and their management is mandatory before the surgical intervention [12].

Materials and Method

This review is structured around the collection of specialized literature from PubMed, organized into subchapters related to intraoperative complications such as Gusher syndrome, foreign body reaction, endocochlear inflammation phenomena, issues related to electrode positioning and associated complications, vestibular phenomena related to cochlear implantation, as well as late complications related to the surgical wound and cochlear implant extrusion. Additionally, it includes complications associated with anatomical malformations of the cochlea, as well as those related to inflammatory phenomena of the middle ear—such as otitis media and cholesteatoma. Data from the literature were gathered through a systematic analysis of results obtained from clinical studies.

This review examines the results in the field of cochlear implants, focusing on the previously mentioned subdomains. It reflects the most common aspects of complications occurring during and after cochlear implantation, focusing on both surgical and non-surgical therapeutic outcomes.

The review analyses the relationship between surgical techniques, the type of electrode used, the implantation method, the presence of associated conditions, inner ear malformations, and the occurrence of intraoperative complications. It analysis also the immediate and late postoperative complications, occurring more than three months after cochlear implantation.

Discussions

1. Inner Ear Malformations and Gusher Syndrome: Intraoperative Complication Risks

In 1 out of 100 cochlear implant operations, extravasation of cerebrospinal fluid can be observed at the opening of the cochlea both through the round window and through the cochleostomy, a phenomenon known as GUSHER syndrome. CSF leakage is more frequently observed in cases with cochlear malformations, with an incidence rate of 40-50%, due to communication between the internal auditory canal and the perilymph of the inner ear. Preoperative evaluation using computed tomography (CT) and magnetic resonance imaging (MRI) can reveal cochlear anomalies associated with intraoperative Gusher syndrome. However, in 1.5-2.5% of cases, Gusher syndrome can occur even when imaging shows a normal cochlea. This is because imaging techniques may fail to detect minor communications between the cochlea and the internal auditory canal.

Preoperative imaging evaluation of a normal cochlea, in terms of size and the width of the vestibular aqueduct, without defects in the modiolus, especially when cochlear implantation is performed via the round window approach, can still detect a Gusher during cochlea opening [13]. If inner ear malformations are present, a defect in the floor of the internal auditory canal is a major cause of Gusher syndrome [15]. In such cases, the use of intravenous mannitol and propofol, stopping the CSF leakage. and rapid electrode insertion is indicated. There is a risk of electrode extrusion, necessitating fixation of the electrode with periosteum or muscle [13].

Literature suggests specific procedures to manage intraoperative Gusher syndrome such as the Trendelenburg position, controlled hyperventilation to reduce venous return to the heart and decrease cerebral perfusion, with hypercapnia and vasoconstriction of cerebral vessels. Additionally, administration of propofol, electrode insertion after Gusher cessation, and rapid closure of the opening are recommended. In some situations, complete blockage of the middle ear and Eustachian tube by performing subtotal petrosectomy may be required. It is crucial to note that Gusher syndrome is an intraoperative complication associated with detectable or non-detectable inner ear malformations but it can also occur in cases of apparently normal ears. [13]. Although cochlear implantation is considered a safe procedure, the complication rate can reach 12.5%, particularly in

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children. Structural cochlear anomalies increase the risk of Gusher syndrome. Among these, the unique cavity or Mondini dysplasia is associated with a higher rate of Gusher, emphasizing the importance of accurate preoperative imaging interpretation [15]. The evaluation of surgical outcomes in Gusher syndrome cases takes into account demographic, radiological, neurophysiological, and surgical aspects, discussing medical management techniques that recommend a conservative approach for managing these patients in the immediate postoperative period [16].

The presence of Gusher syndrome associated with inner ear malformations occurs in approximately 30% of cases, primarily due to the bony defect of the internal auditory canal floor, which is responsible for Gusher syndrome. Therefore, much discussion revolves around cochlear implantation in cases of inner ear malformations and associated risks [17].

Regarding postoperative outcomes after intraoperative Gusher syndrome, it can be noted the fact that Gusher syndrome may occur with postlingual hearing loss ? in children with normal imaging. Therefore, the surgeon must be prepared to manage these situations by ensuring perfect closure of the electrode insertion site, followed by surgical or non-surgical techniques to stop CSF leakage [18].

Cochlear implant surgery presents serious issues in the context of inner ear malformations, raising questions about management strategies. Cochlear implantation in ears with inner ear malformations can be performed safely, especially when preoperative imaging anticipates potential intraoperative risks associated with inner ear anomalies. Each surgical intervention is planned with a safe approach, correlated with the type of electrode used, and considering the surgical experience of the surgeon, who must be capable of modifying the operative technique based on intraoperative findings [19].

Inner ear malformations, accounting for approximately 20% of congenital hearing losses, can be summarized as incomplete partition and congenital hypoplasia. This raises two major intraoperative problems: Gusher syndrome and facial nerve anomalies, which should be identified and discussed before surgery. [20] In such situations, an alternative surgical approach may be necessary, along with postoperative prevention of meningitis. Incomplete partition type I malformation, often associated with a fistula in one of the windows, can cause severe Gusher syndrome, representing an urgent intraoperative situation with a risk of meningitis [21].

It is considered that the surgical approach to abnormal ears for cochlear implantation requires surgical experience and clinical centers with expertise in this field [22]. The postoperative outcomes of cochlear implants in cases with cochleo-vestibular anomalies are generally unsatisfactory, with patients demonstrating a reduced ability to utilize the auditory information received through the cochlear implant [23].

2. Electrode Insertion and Positioning Issues

The literature highlights various complications related to electrode positioning in the cochlea and the management of incorrect electrode placement. It is noted that incomplete electrode insertion and electrode twisting are more frequently observed with the straight electrode, although the frequency is no higher than 2% in cases of cochlear implantation in a normal cochlea. The incidence of electrode tip curvature is higher with perimodiolar electrodes compared to straight electrodes, but it is still below 5%. Electrode migration is more common with straight electrodes, with a rate of 46%. Scalar translocation has been described in both types of electrodes, with a higher rate of 56% reported for perimodiolar electrodes inserted through cochleostomy, with reduced contact of the electrode with the cochlear lateral wall.

Electrode positioning complications account for a significant proportion of perioperative complications, impacting the benefits of post-implantation outcomes. These complications can be minimized through proper surgical planning, careful preoperative evaluation, and intraoperative imaging, which can help reduce the impact of faulty electrode positioning. It is crucial for the surgeon to anticipate the risks of incorrect electrode placement and adhere to proper intraoperative steps and timings.

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Electrode positioning is influenced by the type of electrode. Studies have shown that longer, flexible, straight electrodes, such as those measuring 31.5 mm with direct contact with the cochlear lateral wall, provide good placement regardless of the brand. The rate of electrode tip curvature is 5.3% for perimodiolar electrodes and 1% for straight electrodes [24].

Scalar translocation causes cochlear trauma due to the electrode penetrating from the scala tympani into the scala vestibuli or the middle scala, negatively affecting postoperative audiological performance. Studies indicate that scalar translocation and concomitant electrode tip curvature with negative effects on postoperative results are more frequent with perimodiolar electrodes compared to straight ones. This may explain why straight electrodes, with intimate contact with the cochlear wall, are preferred to prevent intracochlear trauma [25].

Regarding surgical approaches through the round window or cochleostomy and electrode insertion, it is challenging to specify which method is ideal for electrode placement. Studies suggest that insertion through the round window is associated with a perimodiolar electrode position, positioning the electrode closer to the cochlea's neural substrate and shortening the electrical circuit. This results in increased potential for electrical transmission due to the reduced distance from the electrode to the modiolus. Intraoperative and postoperative measurements indicate that insertion through the round window offers several advantages over cochleostomy and is demonstrated to be much safer [26].

In summary, the discussion of the two insertion techniques, their utility, and their respective advantages or disadvantages indicates that both approaches can achieve correct insertion into the scala tympani, if the cochlear structures are well-visualized through computed tomography [27].

3. Intracochlear Inflammation, Foreign Body Reaction, and Intracochlear Fibrosis: Phenomena That Can Occur with Cochlear Implantation

Although cochlear implantation is considered a procedure with a low complication rate, these rates vary between 6-20%. Major complications require surgical interventions, while minor ones can be treated with medication. There are also rarer complications involving the cochlea, such as cochleitis or labyrinthitis with fibrosis or ossification, which necessitate explantation. Performing thorough investigations, including medical history, immunological and autoimmune tests, electrophysiological measurements for the cochlear implant, and associated imaging, is important to accurately identify and describe intracochlear complications [28].

Intracochlear fibrosis is a rare condition producing hearing loss. The ethiology of fibrosis is diverse, including infections, inflammations, and possible procedures following cochlear implantation. Causes of ossification and scarring tissue growth in the cochlea can produce progressive cochlear obstruction. Imaging is crucial and sensitive for identifying fibrosis and cochlear ossification, and postoperative follow-up is also important for monitoring audiological outcomes.

The foreign body response to the material electrode material manifests in altering the functionality of the medical device. For the cochlear implant, this response can reduce the device's performance, battery viability, and preservation of residual hearing.

The administration of dexamethasone significantly reduces hearing loss caused by trauma during electrode insertion, as demonstrated by animal studies [29]. Since the cochlear implant is a prosthesis, its biocompatibility is important, possibly causing electrode extrusion, chronic inflammation, and tissue damage.

In some cases, a granulomatous reaction to the electrode, an allergic reaction characterized by increased eosinophils, and an accentuated inflammatory response at the base of the cochlea, closer to the cochleostomy than distal to it, has been observed, with a statistically significant difference ($p<0.05$) [30].

Intracochlear fibrosis is a rare condition in hearing pathology that affects the cochlea, causing hearing loss and presenting a challenge for cochlear implantation. It can also occur postoperatively after cochlear implantation due to inflammatory phenomena occurring in the cochlea. The causes of cochlear ossification and scarring tissue growth will determine the progressive obstruction of the

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cochlea. These can be identified by high-resolution computed tomography and magnetic resonance imaging. The literature, however, presents only a few and selected cases of cochlear fibrosis.

In the preoperative preparation of patients, the degree of cochlear ossification and fibrosis should be considered, but it can sometimes go unnoticed in audiometric tests. When opening the cochlea through the round window, the surgeon can identify the presence of an ossified structure, the tympanic ramp through which the cochlear implant is inserted. Postoperative audiometric evaluation is important to establish audiological results.

When discussing cochlear implants and their complications, the foreign body reaction to implanted materials must be considered. For cochlear implants, the presence of such a reaction can significantly reduce the device's performance, battery life, and preservation of residual hearing [31]. The foreign body reaction is considered one of the most frequent and severe complications, which can lead to skin infections and subsequently implant extrusion [32].

4. Vestibular Disorders and Cochlear Implants

The prevalence of vestibular dysfunction and its impact on hearing is notably higher in patients with an enlarged vestibular aqueduct and those with incomplete partition type II, where intraoperative Gusher syndrome and postoperative balance disturbances (vertigo) can also occur. Anatomical abnormalities in the vestibule or semicircular canals are frequently associated with the onset of postoperative balance disorders. It is believed that other factors such as surgical approach, electrode type, intraoperative Gusher syndrome, or postoperative complications, do not significantly alter the prevalence of balance loss [33].

Postoperative balance loss can occur in 23-100% of cases, highlighting the importance of preoperative vestibular function evaluation. However, studies indicate that there is no direct correlation between postoperative vestibular symptoms and preoperative investigations. Additionally, vestibular assessment in children is challenging and often it can only be performed partially. Nevertheless, vestibular testing aids in identifying the implanted ear and localizing any vestibular lesions that might be induced [34].

After cochlear implantation, damage to the horizontal semicircular canal can occur, affecting its function as well as saccular function. This may manifest as reduced audiological performance post-implantation [35]. There is a real risk that cochlear implantation may lead to damage of the semicircular canals and otolithic function. The posterior semicircular canal typically being more affected than the lateral one. It is crucial to perform vestibular tests designed to evaluate each of the three semicircular canals. Vestibular tests should assess vestibular function pre- and postoperatively, to anticipate postoperative outcomes. These tests can be used as well in the ear surgery [36] .

Vestibular evaluation is important for both adults and children, as postoperative complications are seen in both groups. Children with cochlear implants often exhibit peripheral vestibular syndrome. In children, vestibular complications with otolitic function impairment occurs differently in those with normal anatomy compared to those with an enlarged vestibular aqueduct. These changes are analyzed using vestibular tests such as the caloric test, cervical and ocular vestibular-evoked myogenic potentials, and video head impulse test, conducted before implantation and at 9 months post-implantation [37].

For adults with bilateral vestibulopathy, the evaluation criteria for cochlear implantation include postural tests that reveal instability, lack of balance, with reduced or absent vestibular function in both ears. These signs include abnormal results from caloric and rotational tests [38].

Specialized literature shows that clinical vertigo after cochlear implantation ranges from 0.33% to 75%, with vestibular function loss occurring in 20-75% of cases. The risk of vestibular loss and postoperative vertigo is relatively low ?. Postoperative vertigo does not occur more frequently in patients with preoperative vestibular lesions compared to those with normal vestibular function. Therefore, preoperative vestibular function tests may not be indicative of the frequency of vertigo after cochlear implantation. If a vestibular organ is tested as abnormal during preoperative evaluation, cochlear implantation on the opposite, normal side is not recommended [39].

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In cases of simultaneous bilateral implantation, utricular vestibular function is usually preserved. Cochlear implantation tends to affect saccular function more frequently. Persistent dizziness as a symptom post-implantation impacts patients' quality of life. Clinical studies focus on assessing dizziness after cochlear implant surgery and patient quality of life by using questionnaires. Results indicate that these questionnaires are a valid tool for documenting and evaluating dizziness that can affect quality of life. They can be used complementarily to assess peripheral vestibular dysfunctions [40].

5. Tardive Postoperative Complications: Wound Injuries and Cochlear Implant Extrusion

Extrusion of the Cochlear Implant

Extrusion of the cochlear implant is a rare but significant late postoperative complication with multiple underlying causes [41]. Effective management of cochlear implant extrusion demands the surgeon's expertise and persistence, with a focus on optimizing implant functionality and ensuring patient safety [42].

One of the most common causes of cochlear implant extrusion is related to the external auditory canal, which may be damaged during the surgical procedure. Specifically, the external auditory canal can become very thin during surgery, thus increasing the risk of rupture. Additionally, if the electrode is curved within the mastoid, it can exert additional pressure on the posterior-superior wall of the external auditory canal. In pediatric cases, mastoid growth also plays a crucial role in the evolution of cochlear implantation outcomes [43].

Although electrode exposure is not a frequent complication, it requires meticulous management, including careful monitoring and assessment of the implant's functionality [44]. The exposure of the electrode post-cochlear implantation is a rare late complication, potentially resulting from implant migration or damage to the tympanic membrane. Both the surgeon and audiologist need to be aware of this issue, and surgical intervention to close the external auditory canal may be necessary [45].

Cochlear implantation surgery is generally considered safe with relatively few complications. However, in cases where electrode extrusion or exposure occurs, explantation might be required, although it is not always necessary if no associated infection is present [46]. The need for explantation should be assessed based on the presence of infection and the impact on the patient's hearing and overall health .

Complications related to skin, including those reported in literature, are relatively low, though they are more common in adults compared to children. Studies have documented skin complications and their impact on patients, emphasizing the importance of appropriate management and follow-up care [47].

Preoperative and postoperative antibiotic treatments are critical in preventing postoperative skin infections associated with cochlear implantation. These treatments help minimize the risk of infection and support overall surgical success. Proper antibiotic use is part of a broader strategy to prevent complications and ensure the long-term functionality and safety of the cochlear implant.

In summary, while extrusion and electrode exposure are rare complications of cochlear implantation, they require careful management and, in some cases, surgical intervention. Monitoring, preventive measures, and appropriate use of antibiotics play crucial roles in managing these complications and ensuring successful outcomes for patients undergoing cochlear implantation.

6. Otitis Media and Cholesteatoma as Complications of Cochlear Implantation

Chronic otitis media (COM) can significantly impact the outcomes of cochlear implantation, elevating the risk of postoperative infections. Proper management of COM preoperatively is crucial to mitigate these risks. If infections recur postoperatively, a strategy focused on preserving the implant, addressing recurrent infections, and obliterating the cavity is essential [48].

Acute mastoiditis is a notable complication, particularly in children post-cochlear implantation. Literature often recommends explantation in these cases. Subperiosteal abscess formation occurs in approximately 14.3% of cases. Initial treatment typically involves intravenous antibiotic therapy.

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Surgical intervention may be necessary to ensure a favorable outcome and prevent implant extrusion. The high rate of acute mastoiditis and subperiosteal abscesses after cochlear implantation is partly due to mastoidectomy, which is a standard surgical technique but can increase complication risks. Prompt management of any post-surgical infection, even years after the procedure, is crucial, and ventilation tube insertion may be required [49].

Acute otitis media and/or acute mastoiditis are frequent complications after cochlear implantation. Administration of cephalosporins and insertion of a ventilation tube is a method of treatment of postoperative complications. Special attention is given to children under 4 years [50].

Cholesteatoma, though rare, can be a severe complication post-cochlear implantation. It poses a risk to the implant, often due to excessive drilling into the bony wall of the auditory canal during surgery, leading to a weakened wall. This increased pressure can affect the implant and potentially damage it. Patients with cholesteatoma should be monitored closely postoperatively, particularly if the external auditory canal or tympanic ring is damaged [51].

Cholesteatoma is rarely seen in adults compared to children after cochlear implantation. In children, it may appear sooner. Treatment strategies typically include subtotal petrosectomy, explantation of the implant, and simultaneous reimplantation if necessary [52].

When cochlear implantation is performed in the context of chronic otitis media, it is essential to follow two key principles:

1. Control of Chronic Suppuration: Ensuring that chronic suppuration is managed and controlled before implantation is crucial. This includes having a healthy protective plan in place before the surgery.

2. Prevention of Infection Spread: Closing the Eustachian tube and obliterating the mastoid cavity are procedures designed to prevent the spread of infection and protect the implant. Complete removal of affected mucosa and closing the Eustachian tube in two stages can enhance the success of the surgery. However, maintaining an open cavity can facilitate better clinical examination but increases the risk of electrode exposure and extrusion [53].

In summary, both otitis media and cholesteatoma are serious considerations in the management of cochlear implantation. Chronic otitis media requires thorough preoperative and postoperative care to minimize infection risks, while cholesteatoma, though rare, necessitates vigilant monitoring and specific treatment strategies to protect the implant and ensure successful outcomes.

Conclusions

The analysis of several studies on complications that can arise after cochlear implantation demonstrates that, although cochlear implants are recognized as relatively simple interventions, they carry a series of postoperative risks. Postoperative complications, although considered quite rare, are related not necessarily to the surgical technique but rather to the risk of postoperative infections (whether cutaneous or mastoid), in addition to foreign body reactions and implant damage with the risk of extrusion. Summarizing everything in one sentence, we can affirm that the surgical limits and long-term evolution of cochlear implants cannot be concretely established, despite the fact that this intervention is considered safe in the medium and long term.

Future Directions

Given that cochlear implants represent the most modern surgical technique for auditory rehabilitation in adults and children, with massive implications for quality of life, there is a tendency to extend surgical indications in the future, and especially to inform doctors in related specialties about the benefits of this medical device. The improvement in the quality of life for patients with cochlear implants will simultaneously increase the number of surgical interventions, which will also lead to a rise in the rate of complications. In this context, surgeons must be knowledgeable about cochlear implantation methods, as well as the methods for managing complications that can arise immediately postoperatively, as well as in the medium and long term.

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