

## Review

# Duration of Antibiotic Prophylaxis for Cochlear Implantation: A Systematic Review

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Antibiotic prophylaxis is commonly given to all patients undergoing cochlear implant surgery. However, currently, there is no consensus if prophylactic usage of antibiotics in cochlear implantation accords any benefit and if the duration of such use varies according to the surgeon's experience or institutional preference. A systematic review was conducted to gather evidence on ideal duration for antibiotic prophylaxis recommended for patients undergoing cochlear implantation. We registered the protocol in the International Prospective Register of Systematic Reviews (CRD42021235079) and reported the systematic review following the Preferred Reporting Items for Systematic Reviews and Meta-Analysis statement. Of the 278 screened articles, 6 full-text original articles satisfied the inclusion criteria and were included. There were a total of 2081 participants in these 6 retrospective studies and all studies except 1 included both adult and pediatric populations. Antibiotic therapy was given as intervention, either as single dose or multiple doses, and compared with other group(s) receiving either no antibiotic prophylaxis or a different duration of prophylaxis. Three studies did not find any significant difference between infection rates when a different duration of antibiotic prophylaxis was given, while 2 studies found a single dose to be more efficacious, and yet another study concluded that a longer duration of antibiotic prophylaxis was more beneficial. Based on the available data, the ideal duration of post-operative antibiotic therapy to be given after cochlear implant surgery could not be defined. However, administering a single dose of intraoperative antibiotic seems to be the most consistent practice so far.

**KEYWORDS:** Antibiotic prophylaxis, cochlear implantation, systematic review, duration of prophylaxis

## INTRODUCTION

Surgery for cochlear implantation is a well-established treatment to restore hearing. It was approved by the Food and Drug Administration of United States of America (FDA) in 1984 for adults and in 1990 for children.<sup>1-4</sup> Surgical site infections, device exposure, infection leading to device failure, and even meningitis are all common Cochlear implant (CI)-related infections. Although improvements in surgical methods and smaller incisions have reduced the infection rate from 40% to 1.7%-4%, it can still have a significant impact on the patient and family, in addition to the apparent health difficulties, especially if the infection progresses to meningitis or device failure.<sup>5,6</sup> The current literature is contentious on the benefits of pre-, peri-, and/or post-operative prophylactic antibiotic therapy in cochlear implant patients. Definitive antibiotic therapy is not of much use once a post-operative infection has set in, due to the development of biofilm. Hence, the medical, psychological, and financial stakes are high in CI surgery.<sup>7-12</sup> Therefore, even when there is no consensus on the benefit of prophylactic usage of antibiotics currently, FDA recommends the usage of intraoperative antibiotic prophylaxis in CI surgery as there might be cataclysmic consequences to this surgery, if an infection follows.<sup>13</sup> However, appropriate duration of such prophylaxis is based on the experience of treating surgeons. To date, there has been no agreement on the ideal duration of antibiotic prophylaxis to prevent infections following surgery for cochlear implantation. Thus, to establish the ideal period of prophylaxis, we reviewed original articles focusing on the duration of antibiotic prophylaxis in CI surgery.

## CLINICAL AND RESEARCH CONSEQUENCES

### Methods

The titles were screened initially, and then abstracts and full text of the article were reviewed by 3 reviewers (SK, AM, and PG). Disagreements were resolved after consultation with AKK. The protocol was registered at the International Prospective Register of Systematic Reviews with registration no. CRD42021235079.

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4.0 International License.

### Selection Criteria for Screening

Searches included all studies in English language, published digitally or in print and ahead of print. The articles were not restricted by year of publication, region, or material of implant. The search was restricted to original research, whether interventional or observational.

### Eligibility Criteria

Studies addressing the duration of preoperative, intraoperative, or postoperative antibiotic prophylaxis given in patients receiving cochlear implants and then comparing the effectiveness of different duration of antibiotic prophylaxis were included. Articles that did not address the duration of antibiotic therapy were excluded.

### Type of Participants

Patients of all age groups receiving cochlear implant (of any model available on the market) either first time or as revision surgery.

### Intervention

Studies comparing 2 or more groups with each receiving a different duration of antibiotic prophylaxis or 1 receiving antibiotic prophylaxis and other receiving no antibiotic prophylaxis.

### Outcome Measures

The rate of infection between different groups was compared.

### Search Strategy

We searched the PubMed, OVID, and Cochrane library for published literature and International Clinical Trials Registry platform database for unpublished articles from the beginning till February 2021 following MeSH terms and Boolean operator strategy. The search terms were (“cochlear implants” [MeSH Terms] OR (“cochlear” [All Fields] AND “implants” [All Fields]) OR “cochlear implants” [All Fields] OR (“cochlear” [All Fields] AND “implant” [All Fields]) OR “cochlear implant” [All Fields] OR “cochlear implantation” [MeSH Terms] OR (“cochlear” [All Fields] AND “implantation” [All Fields]) OR “cochlear implantation” [All Fields] OR (“cochlear” [All Fields] AND “implant” [All Fields])) AND (“anti-bacterial agents” [Pharmacological Action] OR “anti-bacterial agents” [MeSH Terms] OR (“anti-bacterial” [All Fields] AND “agents” [All Fields]) OR “anti-bacterial agents” [All Fields] OR “antibiotic” [All Fields] OR “antibiotics” [All Fields] OR “antibiotic s” [All Fields] OR “antibiotical” [All Fields]). References of the selected articles were also searched for any publication on the above-mentioned subject.

### Risk of Bias Assessment

It was done using the Critical Appraisal Skills Programme (CASP) tool for cohort and case–control studies. It consists of questions in broad domains of validity, applicability, and direction of results (Tables 2 and 3) Risk of bias assessment was performed by 2 reviewers (SK and AM) in consultation with the third reviewer (PG).<sup>14</sup>

### RESULTS

The initial search yielded 278 articles for which title and abstracts were screened. Of these, 272 articles were excluded (Figure 1). Role of antibiotics in CI surgery was not addressed in 216 articles, 42 articles focused on post-operative antibiotic therapy for the treatment of infection/complication, and 14 articles focussed on the role of antibiotic prophylaxis in the peri-operative period, but they did not evaluate the duration of antibiotic regimens used in different studies. There were 2 systematic reviews that discussed the role of antibiotic therapy in cochlear implant surgery.

Six full-text original articles met the inclusion–exclusion criteria and were included. All 6 were retrospective studies. Because of the variability in research design across the included studies, quantitative analysis (meta-analysis) was not possible. The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) recommended flow chart is given in Figure 1.

### Type of population

There were total of 2081 participants in all 6 studies included. The details of study population, antibiotic therapy given along with duration, and outcome in different subpopulations are given in Table 1. All studies except 1 included both adult and pediatric population. The study by Saied et al<sup>15</sup> included only pediatric patients (<12 years). Hassan et al<sup>16</sup> defined adult and pediatric age groups as >16 years and <16 years, respectively, Basavaraj et al<sup>17</sup> did not define the age groups, and Valdecasas et al<sup>18</sup> categorized adult and pediatric age groups as >14 years and <14 years, respectively. Almosnino et al<sup>19</sup> and Hirsch et al<sup>20</sup> categorized adults as >18 years and pediatric population as <18 years.

### Intervention and Comparison

Antibiotic therapy was given as intervention, either as single dose or multiple doses, and then compared with other group(s) receiving either no antibiotic prophylaxis or different duration of prophylaxis. Saied et al<sup>15</sup> compared the effect of post-operative antibiotics for 1 week (in addition to intraoperative dose of antibiotic) with intraoperative antibiotic plus 2 more doses in the first 24 hours. Three studies compared different duration of antibiotic prophylaxis—Hassan et al<sup>16</sup> compared >48 hours with <48 hours; Basvaraj et al<sup>17</sup> compared single-dose antibiotic with 5 days antibiotic and also 7 days antibiotic; and Valdecasas et al<sup>18</sup> compared pre-operative ceftriaxone prophylaxis with course of 6 weeks post-operative clarithromycin in addition to pre-operative ceftriaxone prophylaxis. Almosnino et al<sup>19</sup> and Hirsch et al<sup>20</sup> included a control group with no antibiotic prophylaxis and then compared its outcome (infection rate) with the group with antibiotic prophylaxis.

### Type of antibiotic given

Saied et al<sup>15</sup> reported that amoxicillin-clavulanic acid was given to all patients in both groups. Patients in the study by Hassan et al<sup>16</sup> received amoxicillin-clavulanic acid combination, cefazolin, and cloxacillin. The name of antibiotics used was not specified in the study by Basavaraj et al.<sup>17</sup> Ceftriaxone was given to patients in the study by Valdecasas et al.<sup>18</sup> while it was single-dose cefazolin in studies by Almosnino et al<sup>19</sup> and Hirsch et al.<sup>20</sup>

### Material of implant used

The material of implant (ceramic vs. titanium-silicon) was considered for comparison only by Valdecasas et al.<sup>18</sup> Other studies did not compare material/type of the implant with infection rate.

### Definition of outcome measures

Local complications were defined by Saied et al<sup>15</sup> as any wound inflammation. Those within the first month of surgery were classified as early and those after that were considered late; however, the length of follow-up was not specified. Other studies did not define surgical site infection for their study. The infection rate between different groups was taken as the outcome measure. Major surgical site infection was defined by Hassan et al<sup>16</sup> as infection up to 1 year after implantation that required hospitalization. Basavaraj et al<sup>17</sup> classified postoperative

Table 1. Summary of 6 Studies Included in the Review

Sr. No.	Author	Type of Study	Population (No. of Patients)	Intervention (Antibiotic Therapy)	Outcome (Infections)
1.	Saied et al <sup>15</sup>	Retrospective cohort	130 (All children <12 years)	<ul style="list-style-type: none"> <li>Group 1 (n = 44) Before skin incision: intraoperative intravenous antibiotic prophylaxis (amoxicillin-clavulanic acid 25 mg/kg) and 2 more doses were administered during the next 24 hours. Followed by 25 mg/kg BD orally for 1 week.</li> <li>Group 2 (n = 86): intraoperative plus 2 doses during 24 hours (oral doses not given)</li> </ul>	<ul style="list-style-type: none"> <li>Group 1: 2 patients developed local complication</li> <li>Group 2: 8 patients developed local complication;</li> <li>25 patients developed early post-operative fever; 6 in group 1 and 19 in group 2 (P = .26)</li> </ul>
2.	Hassan AS et al <sup>16</sup>	Retrospective cohort	1180 patients; 509 children (<16 years) and 671 adults (>16 years)	<ul style="list-style-type: none"> <li>23 (1.9%): no prophylaxis; no prolonged treatment</li> <li>634 (53.7%): antibiotic treatment &gt; 48 hours (prolonged treatment)</li> <li>523 (44.3%): antibiotic prophylaxis ≤ 48 hours</li> <li>For patients who developed infection –</li> </ul> <p><b>In children:</b></p> <ul style="list-style-type: none"> <li>Prolonged antibiotic group: augmentin 80 mg/kg/day for 7 days in two-fourth patients; for 10 days in one-fourth patients, and augmentin 1.5 g/day for 7 days in one-fourth patients</li> <li>Antibiotic prophylaxis group (single dose): one-fifth was given augmentin 360 mg, one-fifth cefazolin 250 mg, one-fifth cefazolin 1 g, one-fifth augmentin 80 mg/kg, one-fifth cloxacillin sodium 100 mg/kg.</li> </ul> <p><b>In adults:</b></p> <ul style="list-style-type: none"> <li>Antibiotic prophylaxis group: augmentin 80 mg/kg/day for 7 days in two-fourth patients; for 10 days in one-fourth patients, and augmentin 1.5 g/day for 7 days in one-fourth patients</li> <li>Antibiotic prophylaxis group: 0/3</li> <li>Antibiotic prophylaxis group: 3/3</li> </ul>	<p>12 patients developed major surgical site infection (9 children and 3 adults) –</p> <p><b>In children:</b></p> <ul style="list-style-type: none"> <li>Prolonged antibiotic group: 4/9</li> <li>Antibiotic prophylaxis group: 5/9</li> </ul> <p><b>In adults:</b></p> <ul style="list-style-type: none"> <li>Prolonged antibiotic group: 0/3</li> <li>Antibiotic prophylaxis group: 3/3</li> </ul>
3.	Basavaraj S et al <sup>17</sup>	Retrospective cohort	292 patients; 141 pediatric and 152 adult patients	<ul style="list-style-type: none"> <li>Antibiotic prophylaxis group (single dose): augmentin 3 g in one-third patients and cefazolin 2 g in two-third patients. No patients in the prolonged antibiotic group.</li> <li>153/292 patients had single-dose antibiotic, 107/292 patients had 5 days antibiotics, and 30/292 patients had 7 days of antibiotic therapy.</li> </ul> <p><b>In adults:</b></p> <ul style="list-style-type: none"> <li>Antibiotic prophylaxis group (single dose): augmentin 3 g in one-third patients and cefazolin 2 g in two-third patients. No patients in the prolonged antibiotic group.</li> </ul>	<ul style="list-style-type: none"> <li>12 patients had developed infection; 2 minor wound complications in single-dose antibiotic (1.3%), 6 in 5 days antibiotics (5.6%) group (2/6 had major and 4/6 had minor wound complications), and 4 in 7 days antibiotics (13%) group (2/4 had major and 2/4 had minor wound complications)</li> </ul>
4.	Valdecasas JG et al <sup>18</sup>	Retrospective cohort	196 patients; 117 paediatric (<14 years) and 79 adults patients (>14 years)	<ul style="list-style-type: none"> <li>pre-operative prophylaxis with ceftriaxone given (dosing not mentioned) in 96 patients</li> <li>clarithromycin added in post-operative period for 6 weeks (in addition to already administered pre-operative dose of ceftriaxone) in rest of the 100 patients</li> </ul>	<p>9 patients developed surgical site infection:</p> <ul style="list-style-type: none"> <li>Ceramic/ceftriaxone group (n = 21): 0</li> <li>Titanium silicon/ceftriaxone group (n = 75): 8/9</li> <li>Ceramic/clarithromycin + ceftriaxone group (n = 24): 0/9</li> <li>Titanium-silicon/clarithromycin + ceftriaxone group (n = 76): 1/9</li> </ul>
5.	Almosnino G et al <sup>19</sup>	Retrospective case-control	188 patients; 9 children (<18 years) and 179 adults (>18 years)	<ul style="list-style-type: none"> <li>Group 1 (n = 95) : retrospective control group (94.7% &gt; 18 years and 5.3% &lt; 18 years): single weight-based dose of intravenous antibiotic 30 minutes prior to skin incision (cephazolin, clindamycin, or vancomycin in penicillin-allergic patients). Oral cefalexin 500 mg given for 5 days post-operatively in all patients (dose adjusted for children; clindamycin in those with penicillin allergy)</li> <li>Group 2 (n = 49): (91.8% &gt; 18 years and 8.2% &lt; 18 years): No pre-op or post-op antibiotics</li> <li>Group 3 (n = 44)—concurrent control group (all &gt; 18 years): single weight-based dose of intravenous antibiotic (cephazolin, clindamycin, or vancomycin in penicillin-allergic patients) 30 minutes prior to skin incision. Oral ceftin 500 mg given for 5 days post-operatively in all patients (dose adjusted for children; trimethoprim/sulfamethoxazole 160/800 mg in those with penicillin allergy)</li> </ul>	<ul style="list-style-type: none"> <li>No patient developed systemic infection in 30-day post-surgery period</li> </ul>
6.	Hirsch et al <sup>20</sup>	Retrospective cohort	95; 14 children (<18 years) and 81 adults (>18 years) with total 98 implants (3 patients had bilateral implant)	<ul style="list-style-type: none"> <li>81/98 patients had cefazolin; 67 had single preoperative dose; 14 had 2-4 perioperative doses</li> <li>3/98 patients had single dose of 2 antibiotics; cefazolin + either trimethoprim/sulfamethoxazole, levofloxacin, or amoxicillin</li> <li>12/98 patients had other antibiotics; 4 had ampicillin (3 single dose, 1 had 2 doses); 1 had single dose trimethoprim/sulfamethoxazole; 5 had single-dose clindamycin; 2 had single-dose vancomycin</li> <li>2/98 had no prophylaxis</li> <li>Overall: 78/98 had single-dose antibiotics</li> </ul>	<ul style="list-style-type: none"> <li>1 erythema and 2 ecchymosis; extruding suture</li> <li>Total rate: 3/98 (~3%)</li> </ul>

Table 2. Risk of Bias Assessment Using Critical Appraisal Skills Programme (CASP) Questionnaire for Cohort Studies (14)

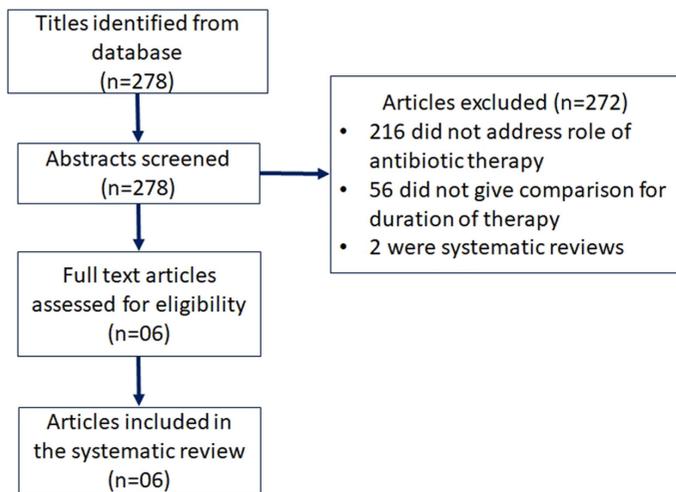
Study no.	Did the Study Address Clearly Focused Issue?	Was the Cohort recruited an Acceptable Way?	Was the Exposure Accurately Measured to Minimize Bias?	Was the Outcome Accurately Measured to Minimize Bias?	Have the Authors Identified All Important Confounding Factors?	Have they Taken Account of Confounding Factors in Design/Analysis?	Was the Follow-Up of Subjects Complete Enough?	Was the Follow-Up of Subjects Long Enough?	Are Result Precise?	Do You Believe the Results?	Can the Results be Applied to Local Population?	Do Results of This Study Fit with Other Evidence?	Implications of This Study for Practice?
Saied et al <sup>15</sup>	Yes	Yes	Yes	Yes	Yes	No	No	No	*	Yes	Yes	Yes	Yes
Hassan AS et al <sup>16</sup>	Yes	Yes	Yes	Yes	Yes	No	*	*	*	Yes	Yes	Yes	Yes
Basavaraj S et al <sup>17</sup>	Yes	Yes	Yes	Yes	Yes	No	No	No	*	Yes	Yes	Yes	Yes
Valdecasas JG et al <sup>18</sup>	Yes	Yes	Yes	Yes	Yes	No	No	No	*	Yes	Yes	Yes	Yes
Hirsch et al <sup>20</sup>	Yes	Yes	Yes	Yes	Yes	No	No	No	*	Yes	Yes	Yes	Yes

\*Could not be evaluated.

Table 3. Risk of Bias Assessment Using Critical Appraisal Skills Programme (CASP) Questionnaire for Case-Control Studies

Study	Did the Study Address a Clearly Focused Issue?	Did the Authors Use an Appropriate Method to Answer Their Question?	Were the Cases Recruited an Acceptable Way?	Were the Controls Selected in an Acceptable Way?	Was the Exposure Accurately Measured to Minimize Bias?	Aside from the Experimental Intervention, Were the Groups Treated Equally?	Have the Authors Taken Account of the Potential Confounding Factors in the Design and/or Analysis?	Has the Treatment Made Large Effect?	Are Result Precise?	Do You Believe the Results?	Can the Results be Applied to the Local Population?	Do the Results of This Study Fit with Other Available Evidence?
Almosnino G et al <sup>19</sup>	Yes	Yes	Yes	Yes	Yes	Yes	No	No	*	Yes	Yes	Yes

\*Could not be evaluated.



**Figure 1.** The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) recommended flowchart for our study.

site infections as major and minor. Major included wound debridement, explantation, and those requiring hospitalization for parenteral antibiotics. Minor included superficial wound infection (not requiring hospitalization), seroma, and hematoma. However, the duration of follow-up was not specified. Hirsch et al.<sup>20</sup> considered major wound infections as those requiring wound debridement, explantation, hospital admission, or intravenous antibiotics. Minor infections included superficial infection, seroma, hematoma, or documented oral antibiotic administration. Complications occurring within 1 month were early and those beyond were delayed, but the duration of follow-up was not specified.

### Comparison of outcome measures

Saied et al.<sup>15</sup> found no statistically significant difference between the development of local complications between 2 groups—the first group which received antibiotics for only 24 hours and the second which received antibiotics for more than 24 hours. A correlation between local complications and the presence of fever in the early post-operative period was not found. Hassan et al.<sup>16</sup> reported that children (<16 years) were at higher risk of infection if not given prolonged antibiotic therapy (>48 hours). They also mentioned co-morbidities in patients who had infections. In contrast, Basavaraj et al.<sup>17</sup> concluded that the patients on long-term antibiotics showed a greater infection rate (5.6% and 13% in 5-day and 7-day regimens, respectively) than those on short-term (single-dose) antibiotics. Hassan et al.<sup>16</sup> recommended giving antibiotic prophylaxis to adults as a single dose and to children for 7 days, while Basavaraj et al.<sup>17</sup> concluded that unless warranted, such as in individuals with pre-existing medical issues, long-term antibiotic prophylaxis provided no significant benefit over a single perioperative dosage.

Valdecasas et al.<sup>18</sup> studied the role of post-operative clarithromycin in addition to an intra-operative single dosage of ceftriaxone in skin flap problems after CI surgery, and they found that a 6-week post-operative clarithromycin regimen was beneficial.

Antibiotics given after cochlear implantation had no effect on perioperative infection rates, according to Almosnino et al.<sup>19</sup> They reported no impact of postoperative antibiotics on perioperative infection rates for cochlear implantation. None of their patients developed post-operative systemic infection in 30 days period.

In a study by Hirsch et al.<sup>20</sup> only 3 patients had minor wound-related complications. Antibiotic prophylaxis was not found to be effective in surgery for cochlear implantation, but a single dosage of antibiotics for 30 minutes prior to skin incision was advocated unless the procedure takes more than 6 hours. When compared to the potential complication of a serious early wound infection that could lead to meningitis or device explantation, they thought that the expense of one antibiotic dose was insignificant.

### Association of infection with co-morbidities

In the study by Hassan et al.<sup>16</sup> 4 children (2 in antibiotic prophylaxis group and 2 in prolonged antibiotic group) had associated co-morbidities (in antibiotic prophylaxis group, 1 patient had mitochondrial cytopathy and 1 had otogenic meningitis and in prolonged antibiotic group, 1 patient had growth failure and 1 had eczema). In adult patients who had infection, 1 patient had history of surgically treated cholesteatoma. Similarly, Basavaraj et al.<sup>17</sup> found that the rate of infection was more for patients having a pre-existing medical condition. Out of 4 patients who developed major complication, 1 had psoriasis and 1 had history of previous surgical site radiotherapy. The infection was not controlled with intravenous antibiotics and explantation was to be done. In contrast, the infection in other 2 patients without co-morbidities settled with intravenous antibiotic therapy in one patient and with repositioning of implant in addition to intravenous antibiotic therapy in the second. Valdecasas et al.<sup>18</sup> reported that 2 out of 9 patients, who got surgical site infection, had co-morbidity (1 patient had low birth weight and premature birth and 1 patient had hydrocephaly and psychomotor deficiency). However, the difference in the incidence of infection with and without comorbidities was not statistically significant. Almosnino et al.<sup>19</sup> addressed associated comorbidity and found that despite the higher prevalence of diabetes in group that did not receive antibiotic prophylaxis, there was no increased rate of infection as compared to other groups which received antibiotic prophylaxis.

### DISCUSSION

The current practices do not recommend routine antibiotic prophylaxis in clean otologic surgeries (tympanoplasty, tympanostomy with tube placement, mastoidectomy, and stapedectomy), while 24-48 hours of antibiotic prophylaxis is recommended for clean-contaminated otologic surgeries (purulent otorrhea and cholesteatoma). For cochlear implant surgery, FDA recommends the use of intraoperative antibiotic prophylaxis despite the inconsistent evidence.<sup>13</sup>

The sterile middle ear is connected with the middle ear mucosa and mastoid. Thus, surgery for cochlear implantation is considered clean-contaminated.<sup>21</sup> Respiratory pathogens may reach the implant site through eustachian tube. There is also a risk of meningitis via the cochlear aqueduct, a risk of dural exposure during implant bed creation, particularly in children with thin skulls, and overall high risk of surgical site infection when a prosthetic implant is inserted.<sup>17</sup>

All the studies included in our review were retrospective. No systematic review or meta-analysis has focused on the duration of antibiotic use for prophylaxis in patients with CI surgery. Studies by Saied et al.<sup>15</sup> Valdecasas et al.<sup>18</sup> Almosnino et al.<sup>19</sup> and

Hirsch et al<sup>20</sup> included in this review did not show significant difference between different duration of antibiotics, whereas the studies by Hassan et al<sup>16</sup> and Basavaraj et al<sup>17</sup> had contrasting results as mentioned above.

The clarithromycin regimen used in the study by Valdecasas et al<sup>18</sup> is, unheard of, has not been validated in literature and is not clinically practiced. According to Almosnino et al.<sup>19</sup> the surgeons soaked CI devices in vancomycin and irrigated the wound prior to implantation. However, this is not a common practice, and the validity of its benefits is debatable. There are few case reports as mentioned by Buijs et al<sup>22</sup> in their report of 4 cases in which salvage surgery using gentamicin sponges was found to prevent device explantation in severe soft tissue infection.

The study population and treatment protocol across the studies were not homogenous, and hence, data could not be statistically analyzed using meta-analysis. The risk of bias was low as assessed by the CASP tool questionnaire.

Meningitis is more common in cochlear implant recipients than in age-matched general population, especially if the implant is performed in a patient with cochlea-vestibular abnormalities, intraoperative cerebrospinal fluid leaking, or surgery with a 2-part electrode system.<sup>23,24</sup> Although no studies have been done to show that antibiotics can prevent meningitis in these patients, an infection that leads to device removal or meningitis is unwelcoming and troubling, especially since CI surgery is expensive, and requires extensive pre-operative workup and counseling, a multidisciplinary team, and consistent post-operative follow-up. Infections are reported to be the second most common cause of explantation in the pediatric population, after device failure; hence, infection-related problems must be avoided at all costs. Otitis media, though quite prevalent in children, does not cause cochlear implant difficulties unless the infection progresses to the scalp and implant site, at which point antibiotics must be used to control the infection.<sup>25</sup> During CI surgery, the cost of perioperative antibiotic prophylaxis outweighs the cost of explantation and reimplantation surgery.<sup>20</sup>

In the 1980s, there was an attempt to develop a technique for preventing infection associated with cochlear implantation by Clark et al<sup>26</sup> Prophylactic antibiotics (intravenous ampicillin and cloxacillin) were used at incision, every 2 hours during surgery and 4-6 hourly thereafter for 4 days. Then 500 mg probenecid was given postoperatively once the patient was allowed oral intake. In 1989, one of the first trials to test the benefit of antibiotics for cochlear implantation was reported (n = 1030) in which 56.4% implanted patients received antibiotic prophylaxis and 43.6% did not receive any antibiotic prophylaxis. Overall, 2.9% of devices were removed because of infection, and out of this, 4.5% were those who had received prophylaxis and 0.9% were without prophylaxis. Hence, the authors concluded that there was no added benefit of prophylactic antibiotics.<sup>27</sup>

Vijendren et al<sup>28</sup> in their systematic review on the prevention and management of cochlear implant wound infections concluded that because of absence of evidence on CI-related wound infection prevention and management procedures, it is impossible to develop a consensus or formulate recommendations on the best treatment strategy and tactics to reduce explantation rates. Another

systematic review on prophylactic versus perioperative antibiotics by Anne et al<sup>29</sup> concluded that there was not enough evidence to support the use of perioperative antibiotics in cochlear implant surgery.

The risk of implant surgery-related infection is common with other implantable medical devices like heart valves, endovascular stents, joint prostheses, implantable meshes, artificial lenses, dental implants, and neurosurgical implants. These affect the quality of life and add significantly to healthcare costs. Indwelling medical devices are responsible for 50%-70% of the almost 2 million healthcare-associated infections documented by the Centres for Disease Control.<sup>30,31</sup> The beneficial role of prophylactic antibiotics has been described in the literature for some of these devices, but the duration is not defined yet. For instance, antibiotic prophylaxis significantly reduces the risk of implant failure in dental implants and reduces the risk of infection in cardiac implantable electronic devices, total hip arthroplasty, and intracranial ventricular shunt surgery.<sup>32-38</sup> However, there is no conclusive evidence on the duration of such prophylactic antibiotic therapy in implant surgery.

## CONCLUSION

The beneficial role of postoperative antibiotic prophylaxis is not proven in cochlear implant surgery, but it is recommended by FDA. Administering a single dose of intraoperative antibiotic is the most consistent practice. Based on the available data, the duration of postoperative antibiotic therapy to be given after cochlear implant surgery is not defined. The longer duration may not be better from a societal perspective as it may promote resistance. However, postoperative antibiotic therapy may have a specific role in high-risk patients and patients with intraoperative cerebrospinal fluid gushers (CSF). The benefit of prescribing a short course of antibiotic therapy in these patients outweighs the psychological impact and high cost involved in device explantation and reimplantation. Studies included in the review were less, heterogenous, and retrospective in nature. Well-defined randomized-controlled trials, stratified for risk factors, are needed to validate the duration of peri-operative antibiotic therapy in cochlear implant surgery.

**Peer-review:** Externally peer-reviewed.

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