

# Electrode Migration: A Review Article



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## Abstract

Cochlear implant (CI) is considered as safe, and effective surgical procedure for patients with Sensory Neural Hearing Loss (SNHL). The cochlear implant is an electronic device implanted behind the ear, with electrode arrays which are inserted into the Scala Tympani of the cochlea to stimulate the auditory pathway. The complications rate of cochlear implant surgery is very low, and more common in pediatrics. Furthermore, electrode migration is one of the complications which are defined as gradual slipping out of electrode from cochlea or extrusion from tympanic membrane. Data were being collected through search engines included PUBMED, Google Scholar, and BMJ. The process of sorting out of articles as per inclusion criteria which has an outcome related to electrode migration in post cochlear implant. After removal of duplicate studies, total of 12 articles were found eligible for review analysis. Electrode migration is more common as previously reported, it has shown that fixation techniques should be more reliable to avoid migration of electrode. The purpose of this study is to get a detailed review of electrode migration causes and prevalence in post cochlear implant patients and what factors can lead to migration intraoperative and post-operative cases.

**Keywords:** Electrode migration; Sensory neural hearing Loss; Cochlear implant

## Introduction

Cochlear implant (CI) is a well-known, safe, and effective surgical procedure for patients with Sensory Neural Hearing Loss (SNHL), which is a type of hearing loss due to either inner ear pathologies, or Vestibulocochlear nerve (VIII) damage [1]. Moreover, it is reported that 20% of patients with congenital SNHL have a concurrent inner ear malformation [2]. Despite of multiple treatment options have been applied; however, cochlear implant (CI) surgery is the mainstay of surgical treatment. In addition, Cochlear implant is an electronic device implanted behind the ear, with electrode arrays which are inserted into the scala tympani of the cochlea to stimulate the auditory pathway [3,4]. Moreover, cochlear implant device has two types of electrodes: Straight lateral wall (LW) electrode arrays, and Perimodiolar electrode arrays [5].

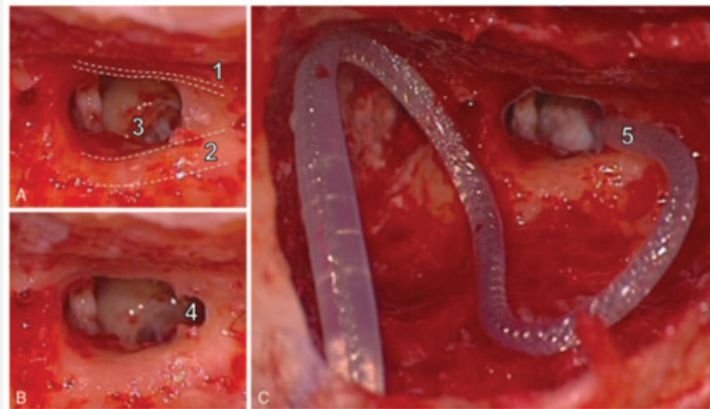
As any other surgical procedures, the complication rate of cochlear implant surgery is very low, and reported around 3-10% of all CI surgeries, common in pediatric patients [6]. Furthermore, electrode migration or extrusion is an important complication in CI surgery, which affects the hearing level, and induce facial nerve stimulation, that may require a revision. Electrode migration is defined as a complication due to gradually slip out of electrodes

from cochlea or extrusion from the tympanic membrane [7] due to raise the level of impedance values in basal side electrodes. As well as, it can be due to cochlear ossification (Figure 1) [8]. Moreover, it has been reported that 1-15% of patients who underwent revision CI surgery have had an electrode migration [9,10]. The purpose of this study is to get a detailed review of electrode migration causes and prevalence in post cochlear implant patients and what factors can lead to migration intraoperative and post-operative cases.

## Material and Methodology

The study design was cross sectional review study. Data were being collected through search engines included PUBMED, Google Scholar, and BMJ. Quality assessment of an article done as per defined criteria. Previously published article searched based on electrode migration post Cochlear implant (CI). An electronic search as per medical subject headings (Mesh) was carried out and by using different search engines like Google scholar, PUB MED, WEBMED to increase sensitivity of electrode migration after CI. A Literature search done and in a systematic way of previously published articles and limited to English language.

Each article was critically analyzed and appraised as per study inclusion criteria and fulfilling the following criteria.



**Figure 1:** Bone groove created in facial recess to fixate the electrode. 1) Chorda tympani, 2) facial nerve, 3) round window membrane, In panel B of figure showed the recommended position of bone while panel c showed electrode fixation through sigmoidal course of sigmoid lead [8].

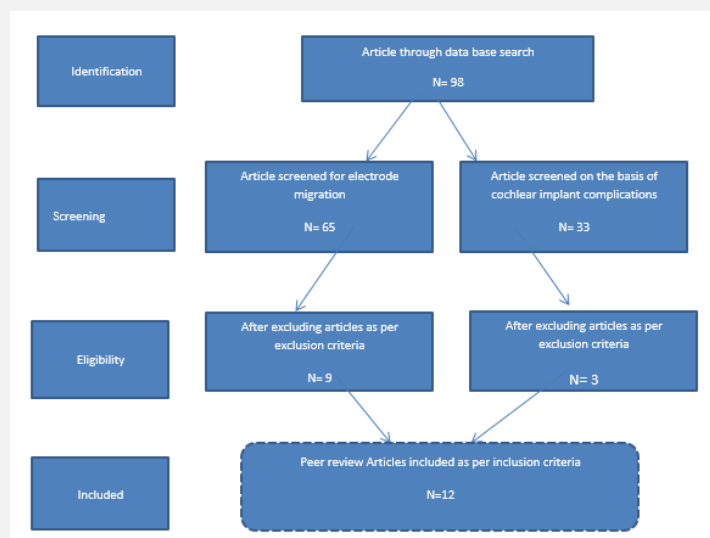
- a) Article published between in 2008-2019.
- b) Article in which complications of CI are found.
- c) Article which emphasize on electrode migration post CI.
- d) Article gives prevalence and incidence of complications in post CI and clearly
- e) Found with respect of duration of the implant.
- f) Article published in English language.

Articles published during 2008 to 2019 duration were added as their electrode migration considered as a rare and underrated complication after CI, therefore better approach and to understand the possible factors affecting on electrode migration. While conference papers, articles in abstract form and duplicated were excluded from the search. The authors extracted data in the form of sample size, study settings, publication year, study point and overall theme of article from articles which was included in study.

Authors also confirmed the quality of articles in term of the title and contents.

**Result**

Of the first 98 peer review articles found on electrode migration in post cochlear implant in which include bone grove electrode migration and perimodiolar electrode migration were segregated as per search method in (Figure 2). Furthermore, Figure 2 summarizes the process of choice of articles as per inclusion criteria and which has an outcome and comparison related to electrode migration in post cochlear implant. After removal of duplicated studies and those studies which are inappropriate and irrelevant to do with electrode emigration in post cochlear implant. A total of 12 articles were found eligible for review analysis. These articles included of 583 total patients. The patient age range is from 2.5 years to 79 years, with duration of follow up period in selected studies were 6 months to five years.



**Figure 2:** Literature review process on electrode migration post cochlear implant.

A total of 10 peer reviewed publication reported on electrode migration in post cochlear implant was found from the database. All these articles applied to electrode migration either it is bone grooving or perimodiolar electrode migration. Characteristics of each study given in Table 1 which summarizes the electrode migration with different and advance strategy for cochlear

implant. Studies by J holder et al. and sunde et al. [12] in which 262 patients were observed after implantation, out of which 9 (25.7%) patients had incomplete insertion of electrodes, and in 2 (6.0%) patients reported with electrode migration which was observed through CT scan and 0.9% device failure due to electrode migration respectively [11,12].

**Table 1:** characteristics of selected studies.

Study & Year	Method	Sample Size	Reason for Reimplantation	Electrode Migration Measurement	Type of Electrodes	P Value	Frequency of Clinical Symptoms
Vander marel K S, et al. [14]	Metanalysis	N= 35	Device failure and drop in performance	>1mm in HiFocusI <1mm in HiFocusI	HiFocusI	0	5%
Dietz et al. [15]	Case Control	N= 12	Drop in performance	>1mm	Lateral wall electrodes	0.03	2%
Connell et al. [10]	Systematic review	N= 08	Drop in performance	>1mm	Modiolur electrodes	0.05	3.80%
Leinung et al. [8]	Cross sectional observational	N= 29	Drop in performance	>1mm in Modiolur electrodes <1mm in lateral electrodes	Modiolur electrodes	0.03	4.20%
Mittman et al. [7]	Case control	N= 27	Drop in performance	>1mm	Modiolur electrodes	0.05	3.20%
Wamna et al. 2014	Metanalysis	N= 116	Painful stimulation	>1mm	Modiolur electrodes	0.03	2%
Waltzman et al. [21]	Observational	N= 133	Drop in performance	>2mm	Modiolur electrodes	0.05	4%
Fischer et al. [19]	Retrospective review	N= 63	Drop in performance	>1mm in HiFocusI <1mm in HiFocusI	HiFocusI	0.02	1.70%
Grolmela et al. [13]	Retrospective review	N= 72	Drop in performance	>1mm	Lateral wall electrodes	0.04	3.40%
Bennink et al. 2017	Metanalysis	N=65	Drop in performance and painful stimulation	>1mm	Modiolur electrodes	0.05	3.00%
Spari et al. [10]	Cross sectional	N= 23	Drop in performance	>1mm in Modiolur electrodes <1mm in lateral electrodes	Modiolur electrodes	0.01	5.20%
Holder et al. [11]	Retrospective	N=35	Prevalence of electrode migration	>1mm	Modular electrode	0	Not objected in study.

Additionally, Kevin D Brown et al has followed up 806 patients with cochlear implant and it has been found that most common reason for reimplantation is device failure which is 78% out of which 55% is hard failure and 23% soft failure which is further followed by electrode migration that is reported around 9% [13]. In another study published by Van der et al. [14] it was analyzed that electrode positioning evaluated in 35 patients with cochlear implant out of which 16 patients were with non-positioner C11 Hi Focus 1 and 19 were with HiRes 90K using multiplanar reconstruction [14]. This study was a retrospective study and out of 35 patients, 5 patients were evaluated with complaints like vertigo, tinnitus and headache and electrode migration may correlate with implant type, insertion depth or presence of complaints. It is found that Migrations were detected in 10 patients (29%).

There was a significant effect of the implant type in favor of the HiFocus1, but there is no relation to the original insertion depth of the device. Out of 35 there are 5 patients scanned because of signs and symptoms of tinnitus and vertigo, 2 patients with migrations were detected. Comparison of different electrode types with clinical symptoms or without complaints is shown in (Figure 3). The issues of electrode migration of post CI are associated with lateral wall electrodes by Dietz et al. [15] and Vaid et al. [16] described the factors which are involved in electrode extrusion or migration, which are classified on the basis of intracochlear which pushes the electrode, like cochlear ossification [15,16].

Furthermore, extracochlear causes like wire coiling, mastoid adhesion, electrode type, and electrode depth of insertion. To elaborate it, electrode with deeper insertion has least chances of migration after implant while partially inserted electrodes are

more prone to migrate. Frequency of electrode migration, and causative factors after cochlear implant are shown in (Figure 4). In addition, case report by J Otol et al. 2019 discussed about the cholesteatoma effect on electrode migration if there are any signs,

symptoms related to it or before going to cochlear implant, must consider it as it later on causes device failure due to electrode migration [17].

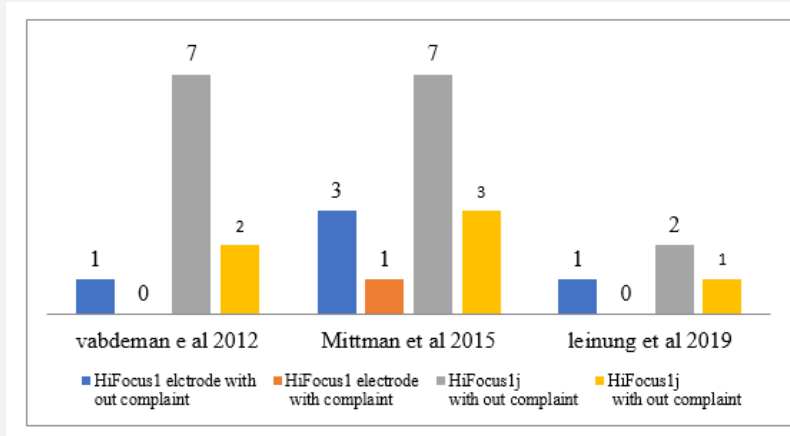


Figure 3: Comparison of electrode (HiFocus1 type electrode) migration in respect of different electrode with and without clinical symptoms.

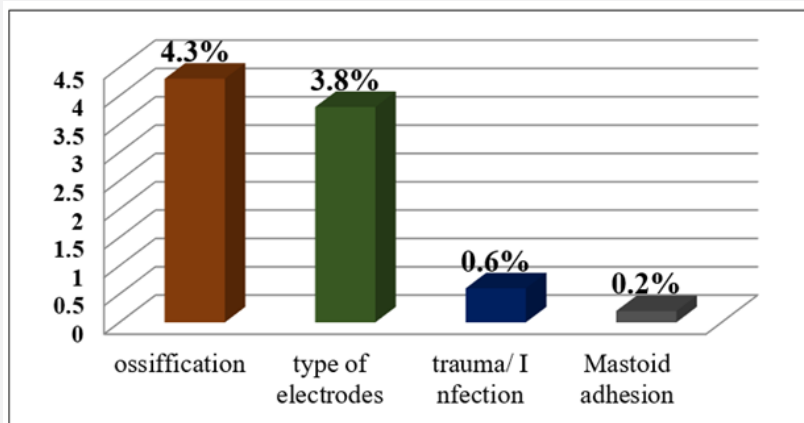


Figure 4: Frequency of factors causing electrode migration post cochlear implant.

Discussion

Electrode migration is an underrated complication of post cochlear implant; therefore, it is the least discussed topic remained in research. A review study by Green et al described that 6.25% complications reported in post cochlear implant out of which 1.25% were of electrode migration in first 6 months of duration [18]. A study conducted by Ronald et al showed that in 5 years of duration patients follow up post cochlear implant and there is no electrode migration reported as in cochlear implant they have used titman clip and split bridge and it is known for stable fixation in cochlear implant [19]. In current review it has been cleared that electrode migration is cause of device failure although use stable fixation because it is least effective in fully ossified cochlea [20].

As electrode related device failure like migration, misplacement and excursion is not a well-known complication,

because sound awareness must detect electrode migration in post CI patients. A First study by Waltzman et al. [21] that proved electrode migration without pain and symptoms can be occurred [21]. There are advance bionics computerized tomography (CT scan) considered as important in the measurement of electrode migration. In this study it has been observed that migration is irrelevant to insertion depth, and it is shown that only two patients developed a drop in speech perception to those patients who had electrode migration more than >1mm [8,18] and Fixation clip techniques can minimize electrode migration issue.

In a study conducted by Mittman et al has described those fixation techniques like fixation clips can be thought to minimize the risk of electrode migration or misplacement [7]. In one study by Kubo et al described that electrode extrusion is although rare complication but it can lead to re implantation surgery and it may occur after a few years from surgery but fixation of the electrode

into split made in the buttress part may prevent electrode migration [22]. If external bony canal has become thinner during facial recess approach it would be repaired with bone or cartilage plate [11,12]. Current study gives detailed review about importance of electrode migration as this is a neglected complication in post cochlear implant patients. Advance research design and more precise scientific study is needed to know more details about possible causative factors for electrode migration.

## Conclusion

Electrode migration is not well defined in the literature. Moreover, different fixation techniques are more reliable to avoid migration and extrusion of electrode which could cause device failure. However, there is a need for special attention, particularly on the fixation of straight electrode arrays. Reducing the force of migration in the form of advance fixation technique can reduce the incidence of electrode migration.

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