



# Long-term complications of the transmeatal approach (Open Transcanal) in cochlear implants: A follow-up study

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## ABSTRACT

**Objective:** Multiple alternative approaches of cochlear implant surgery have been described, such as the suprameatal approach, transcanal approach, transmeatal approach and middle cranial fossa approach. Transmeatal (open transcanal) approach has not been adapted since first described in the clinical field. we aimed to assess the long-term complications of the transmeatal approach in a series of 131 patients at our center between 2004 and 2008.

**Methods:** This study was a retrospective case series of all patients who underwent cochlear implants with the transmeatal (open transcanal) approach from May 2004 to December 2008 at King Faisal Specialist and Research Hospital (Riyadh, Saudi Arabia), which were conducted by the same surgeon.

**Results:** Complications were observed often with various combinations—recurrent otitis externa, posterior tympanic membrane perforation, electrode extrusion, cholesteatoma, and chronic mastoiditis. The overall long-term complication rate was 16% (21/131). The gap between the implantation and the diagnosis of a complication ranged from <1 year to 11 years. Major complications were as follows: cholesteatoma in 5 (3.8%) patients, extrusion of the electrode in 5 (3.8%) patients, and tympanic membrane perforation or deep retractions in 5 (3.8%) patients. Minor complications were as follows: recurrent mastoiditis with/without concomitant temporary facial nerve palsy in 4 (3%) patients, recurrent otitis externa infections in 7 (5%) patients, and weakness of the posterior canal wall in 1 patient.

**Conclusion:** The transmeatal approach posed an high rate of complications on long-term follow-up such as cholesteatoma formation, extrusion of electrode or perielectrode reaction formation to tympanic membrane and external auditory canal

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## 1. Introduction

From the earliest days of multichannel cochlear implantation, the standard approach for accessing the cochlea has been through posterior tympanotomy (Kronenberg et al., 2001). This approach involves working close to the facial nerve in the facial recess, with most surgeons using facial nerve monitoring during the procedure

**Abbreviations:** CT, computed tomography; MRI, magnetic resonance imaging; SNHL, sensorineural hearing loss.

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(Kronenberg et al., 2001). The incidence of facial nerve injury using this approach is very low, ranging from 0.7% to 2% (El-Anwar et al., 2016; Daniel and Zeitler, 2010; Bruijnzeel et al., 2016a). Since the advent of this approach, multiple alternative approaches have been described, such as the suprameatal approach, transcanal approach, transmeatal approach, middle cranial fossa approach, and pericanal electrode insertion technique (El-Anwar et al., 2016; Daniel and Zeitler, 2010). Several systematic reviews comparing the traditional posterior tympanotomy and suprameatal techniques concluded that there was no difference in the major and minor complications observed, except for a slightly higher incidence of facial nerve injury with the posterior tympanotomy approach (Bruijnzeel et al., 2016a; Xu et al., 2014).

The transmeatal approach was first described by Taibah in 2009 as an open tunnel transcanal approach that overcame the closed

tunnel transcanal approach in the suprumeatal technique with the same benefit of being remote from the facial recess (Taibah, 2009). No major complications were reported in that study, with a follow-up ranging from 2 months to 46 months (Taibah, 2009). Furthermore, audiological outcomes and activation following surgery were adequate in the initial description by Taibah in 2009 (Taibah, 2009).

Both the suprumeatal and transmeatal approaches are similar in terms of postauricular incision, tympanomeatal flap elevation, and chorda tympani identification and preservation intraoperatively (Daniel and Zeitler, 2010; Taibah, 2009; Kronenberg and Migirov, 2006). However, the main difference between the suprumeatal and transmeatal approaches is that the mastoid is not accessed in the former technique and the tunnel for the electrode insertion is drilled blindly (Daniel and Zeitler, 2010; Taibah, 2009; Kronenberg and Migirov, 2006). On the other hand, the transmeatal approach relies on a small cortical mastoidectomy, followed by creation of a groove in the external auditory canal, from the annulus superior to the chorda tympani to the mastoid cavity with a 2-mm diamond burr, followed by a tunnel from the mastoid cavity to the middle ear, parallel and underneath the previously made groove; hence, the approach is named as open tunnel transcanal. (Taibah, 2009).

Due to lack of background information about this surgical technique, we report the first study on long-term complications arising in a series of transmeatal cochlear implant operations performed by the same surgeon at our center between 2004 and 2008.

## 2. Patients and methods

After the approval of the research committee, a chart review was conducted of all patients who underwent cochlear implantation at the King Faisal Specialist Hospital and Research Center (KFSHRC) (Riyadh, Saudi Arabia) from the start of the program in 1994 until the end of 2017. The requirement for informed consent was waived owing to the retrospective design of the study. Four hundred seventy-seven patients were reviewed in the study, which included patients who underwent the transmeatal cochlear implant

approach between May 2004 and December 2008. Of these, 131 patients were identified and included in the study. Patient charts were accessed from 2017 to 2022 after the study was approved by the research and ethics committee. All charts were examined for demographics (age [years/months] and sex [male/female]), indication for implantation (congenital sensorineural hearing loss [SNHL] or acquired SNHL), date (month/day/year) of cochlear implant, side (left/right/bilateral) of implant, computerized operative reports, date (month/day/year) of complication, method of diagnosis (i.e., magnetic resonance imaging [MRI] findings, computed tomography [CT] temporal findings, or physical examination findings), complication classification (minor, major, or combined), and treatment type (surgical and/or medical treatment).

Major complications were defined as events requiring active surgical/medical intervention (e.g., cholesteatoma, electrode extrusion into the ear canal, perforation of the posterosuperior ear canal with chronic mastoiditis, petrous apicitis, or tympanic membrane perforation/deep retraction). Other complications were categorized as minor (e.g., acute otitis media, transient facial nerve palsy, wound infection, and recurrent otitis externa).

The frequency of recurrent otitis externa (two infections in 1 year as the reference point) was defined before labeling it as a complication. In addition, recurrent mastoiditis was defined if the patient developed an infection more than twice after implantation.

Patients were followed-up in otology and audiology clinics. In case of loss to follow-up, the patients or patients' relatives were contacted, and the status of the patient was obtained.

Furthermore, the transmeatal approach was abandoned in our center since the end of 2008 and has not been used after. Categorical variables expressed in terms of frequencies. Numerical variables expressed in terms of means, percentage and range.

## 3. Results

In total, 131 patients underwent surgery with the transmeatal

**Table 1**  
List of patients with demographic details, results, and complications.

Patient number	Age at implantation	Years between implantation and the development of complications	Complication	
			Minor	Major
1 right	1	8	–	TM perforation posterior- marginal with keratin depositions
2 left	33	9	–	Extrusion of electrode in canal + subsequent canal cholesteatoma eroding the posterior canal and mastoid
3 right	4	1	Recurrent otitis externa	–
4 right	4	7	–	Deep TM retraction
5 right	1	11	–	Deep TM retraction
6 right	5	3	Electrode touching the TM	–
7 right	5	4	–	Extrusion of the electrode in the canal
8 right	2	2	Acute transient facial nerve palsy + mastoiditis + Recurrent otitis externa	TM perforation central
9 right	2	3	Recurrent otitis externa	TM perforation
10 right	5	1	Recurrent mastoiditis	–
11 left	3	8	Weakness of posterior canal wall intraoperative	–
12 right	3	10	Recurrent otitis externa	–
13 bilateral	3	1	Recurrent otitis externa	Implant infection
14 right	1	6	–	Cholesteatoma
15 left	3	1	Recurrent otitis externa	Implant infection
16 left	1	2	Recurrent otitis infection	–
17 right	4	4	–	Cholesteatoma
18 right	3	7	–	Extrusion of electrode in canal
19 left	1	8	–	Recurrent mastoiditis leading to infected CI
20 left	3	2 months	–	Extrusion of electrode in canal
21 left	24	7	Recurrent Otitis externa	Cholesteatoma

TM: tympanic membrane, CI: cochlear implant.

approach (115 pediatric and 16 adult patients) between May 2004 and December 2008. Of these, 21 patients were identified with complications (19 pediatric and 2 adult patients). The mean age of patients is 5.2 years. Eleven patients were female, and 10 patients were male. The age at implantation ranged from 1 year to 33 years. The long-term complication rate was 16% (21/131). The gap between the implantation and the diagnosis of a complication ranged from <1 year to 11 years (Table 1). The mean time occurrence of complication is 4.9 years.

The major complications observed were as follows: cholesteatoma in 5 (3.8%) patients, extrusion of the electrode in 5 (3.8%) patients, and tympanic membrane perforation or deep retractions in 5 (3.8%) patients (Table 1).

The minor complications observed were as follows: recurrent mastoiditis with/without concomitant facial nerve palsy in 4 (3%) patients (only 2 patients developed non-permanent facial nerve palsy), recurrent otitis externa infections in 7 (5%) patients, and weakness of the posterior canal wall in 1 patient (Table 1).

Cholesteatoma developed between 2 years and 11 years post-implantation, and extrusion of electrode occurred between 1 year and 8 years. Most patients with recurrent mastoiditis were treated medically with intravenous antibiotics. However, in one patient, mastoiditis led to implant infection, for which explantation was required. Temporary facial nerve palsy developed in conjunction with mastoiditis in two patients. Recurrent otitis externa was mostly localized to the posterior canal wall where the tunnel was created. Nonetheless, in one patient, otitis externa resulted in an implant infection.

Cultures were taken at different presentations and settings. The most reported organisms were *Staphylococcus* (3 patients), methicillin-resistant *Staphylococcus* (1 patient), and *Pseudomonas* (6 patients). Other organisms reported included *Escherichia coli* in one patient, *Klebsiella pneumoniae* in one patient, and fungal *Candida albicans* and *Aspergillus terreus* in one patient each.

#### 4. Discussion

Treatment plans were tailored for each patient, while considering hearing and patient morbidity (Table 2). For cholesteatoma or electrode extrusion cases, surgery was the preferred choice of treatment (e.g., explantation, canal wall-down mastoidectomy, modified radical mastoidectomy, and reimplantation on same side after 1 year with evidence of no recurrence or implantation of the opposite side) (Figs. 1–4). Patients with tympanic membrane perforation were treated with myringoplasty with cartilage graft.

In this paper, we reviewed a series of long-term complications arising from transmeatal cochlear implant operations. This approach was first described by Taibah in 2009, the adaptation of this approach was null in the literature. These complications were observed in various combinations.

Multiple alternative approaches to cortical mastoidectomy with



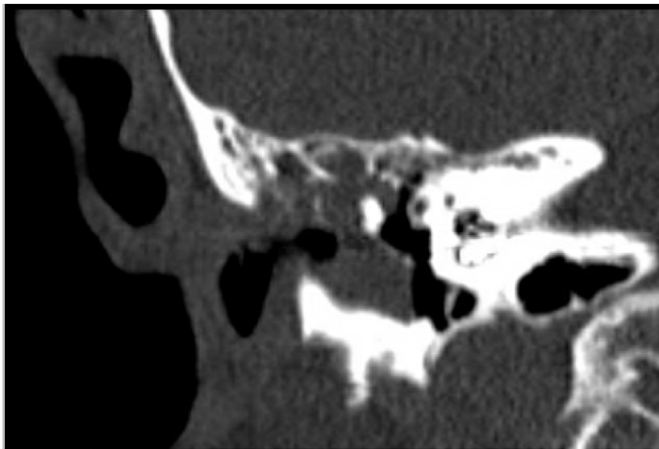
**Fig. 1.** Imaging findings of patient 2. (A) The computed tomography (CT) image (coronal view) shows the left-sided electrode extrusion canal. (B) The axial CT images show left-sided electrode extrusion in the canal with suspected erosion of the posterior canal wall. The patient underwent removal of the left cochlear implant as the electrode was exposed by the modified radical mastoid. The intraoperative finding was a small cholesteatoma sac eroding into the posterior canal.

facial recess have been described to avoid inadvertent injury to the facial nerve, such as the suprameatal, transmeatal, transcanal (i.e., Veria operation), middle cranial fossa, and pericanal electrode insertion techniques (El-Anwar et al., 2016; Daniel and Zeitler,

**Table 2**  
List of patient complications with corresponding treatment.

Type of complication	Treatment options
Cholesteatoma	Intact wall mastoidectomy + CI explantation followed with CI implantation on the contralateral side or same side (after 1 year disease free)
Extrusion of the electrode	CI explantation followed with CI reimplantation either on the same side or contralateral side
Recurrent mastoiditis with/without concomitant facial nerve palsy	Medical treatment±abscess drainage±VT
Recurrent otitis externa	Medical treatment
Tympanic membrane perforation or deep retractions	Tympanoplasty + cartilage graft
Weakness of the posterior canal wall	Conservative management

CI = cochlear implantation, VT = ventilation tube.

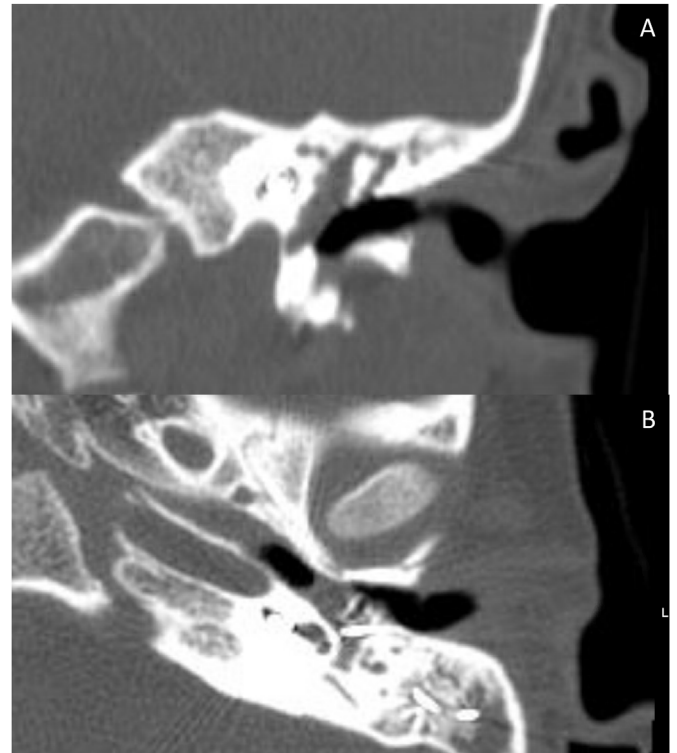


**Fig. 2.** Imaging findings of Patient 14. The computed tomography (CT) scan (coronal view) shows right-sided erosion of the posterior wall with extensive opacification in the mastoid and attic area.

2010). The transmeatal approach was designed in 2009 as an alternative to the aforementioned approaches to avoid facial nerve injuries, especially in narrow posterior tympanostomy windows, or anatomical difficulties, such as a high jugular bulb, congenital abnormality, labyrinthine ossifications, and inferiorly placed round window niche; it has no short-term significant complications (Taibah, 2009).

A review of multiple meta-analysis studies (Bruijnzeel et al., 2016a; Xu et al., 2014) comparing the mastoidectomy/facial recess approach with the non-mastoidectomy suprameatal approach (primarily because it was popularized at certain times) concluded that no differences existed in the major and minor complications, except for a slightly higher incidence of facial nerve injury in the posterior tympanostomy approach. A review of the suprameatal complications, published in 2016 by El-Anwar et al. (2016), revealed that 13 (1.3%) of 1014 patients had major complications in the form of electrode extrusion owing to infection (n = 4), misdirected electrode (n = 4), device failure (n = 4), and exploration required because of psychiatric illness and pain sensations (1 patient). By contrast, minor complications occurred in 9.8% (99/1014) of patients.

Furthermore, a study (Bruijnzeel et al., 2016b), which compared the suprameatal technique and mastoidectomy with posterior



**Fig. 4.** Imaging findings of Patient 19. (A) The coronal computed tomography (CT) scan illustrates left middle ear opacification, suspected of being a cholesteatoma; however, the intraoperative findings were negative. (B) The axial CT scan of the same patient shows extrusion of the electrode in the canal and middle ear opacification.

tympanostomy in a pediatric population younger than 5 years, demonstrated that the suprameatal approach has a higher risk of postoperative complications in younger patients, compared to classic mastoidectomy with posterior tympanostomy. In relation to this point, the transmeatal approach showed a long-term risk of complications in the pediatric group in our study, with 19 pediatric patients developing long-term complications. This suggests that an alternative approach to the mastoidectomy/facial recess should be undertaken with caution in the pediatric age group.

In addition, a comparison of our results with those of non-mastoidectomy approaches (El-Anwar et al., 2016; Daniel and



**Fig. 3.** Imaging finding of Patient 17. (A) The axial computed tomography (CT) scan illustrates right-sided opacification of the mastoid with area of erosion of posterior canal. (B) The coronal view shows right-sided opacification of the mastoid and attic. The patient underwent canal wall-up mastoidectomy with repair of the posterior canal wall and tympanoplasty and cochlear implant removal. After 2 years of being disease-free, reimplantation was performed on the same side.

Zeitler, 2010; Bruijnzeel et al., 2016a, 2016b; Xu et al., 2014; Taibah, 2009; Yin et al., 2008) revealed that complications with regard to the facial nerve had similar results with no intraoperative facial nerve injury.

In comparison with the literature (El-Anwar et al., 2016; Daniel and Zeitler, 2010; Bruijnzeel et al., 2016a, 2016b; Xu et al., 2014; Taibah, 2009; Yin et al., 2008; Santa Maria et al., 2014; Migirov et al., 2006), the transmeatal approach has a higher risk of long-term complications (16%) compared to other non-mastoidectomy approaches. Our hypothesis is that the reoccurrence of otitis externa could be linked to the use of bone wax and/or small burr holes in the canal, which can induce a rubbing or an eroding mechanism between the electrode and the skin of the canal affecting the skin migration on long term. Cases of tympanic membrane perforation and/or extrusion mostly occurred because of the electrode contacting the tympanic membrane and/or the canal skin.

## 5. Conclusions

The transmeatal approach demonstrated a serious complication profile during long-term follow-up, a with 16% of patients (21/131) showing complications ranging from minor to major. Nevertheless, other non-mastoidectomy approaches may be considered in cases of narrow posterior tympanostomy windows or anatomical difficulties, such as a high jugular bulb, congenital abnormality, labyrinthine ossifications, and inferiorly placed round window niche.

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## Data deposition

None.

## Data availability

Information regarding the data supporting the results or analyses presented in the paper can be reviewed and shared with the

journal review committee if needed. However, the authors would do not wish share it publicly owing to institutional confidentiality reasons.

## Declarations of competing interest

None.

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